

Gaia Data Release 1: Datamodel description

Documentation release 1.1

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and
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Chapter 1

Main tables

1.1 GAIA_SOURCE

This table has an entry for every Gaia observed source as listed in the Main Database accumulating catalogue version from which the catalogue release has been generated. It contains the basic source parameters, that is only final data (no epoch data) and no spectra (neither final nor epoch).

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source.

For the contents of Gaia DR1, which does not include Solar System objects, the source ID consists of a 64-bit integer, least significant bit = 1 and most significant bit = 64, comprising:

- a HEALPix index number (sky pixel) in bits 36 – 63; by definition the smallest HEALPix index number is zero.
- a 2-bit Data Processing Centre code in bits 34 – 35; for example $\text{MOD}(\text{source_id} / 4294967296, 8)$ can be used to distinguish between sources initialised via the Initial Gaia Source List by the Torino DPC (code = 0) and sources otherwise detected and assigned by Gaia observations (code > 0)
- a 25-bit plus 7 bit sequence number within the HEALPix pixel in bits 1 – 32 split into:
 - a 25 bit running number in bits 8 – 32; the running numbers are defined to be positive, i.e. never zero (except in the case of forced empty windows)

– a 7-bit component number in bits 1 – 7

- one spare bit in bit 33

This means that the HEALpix index level 12 of a given source is contained in the most significant bits. HEALpix index of 12 and lower levels can thus be retrieved as follows:

- HEALpix level 12 = $\text{source_id} / 34359738368$
- HEALpix level 11 = $\text{source_id} / 137438953472$
- HEALpix level 10 = $\text{source_id} / 549755813888$
- HEALpix level n = $\text{source_id} / 2^{35} * 4^{(12 - \text{level})}$.

Additional details can be found in the Gaia DPAC public document *Source Identifiers — Assignment and Usage throughout DPAC* (document code GAIA-C3-TN-ARI-BAS-020) available from <http://www.cosmos.esa.int/web/gaia/public-dpac-documents>

RANDOM_INDEX : Random index used to select subsets (long)

Random index which can be used to select smaller subsets of the data that are still representative. The column contains a random permutation of the numbers from 0 to N-1, where N is the number of rows.

The random index can be useful for validation (testing on 10 different random subsets), visualization (displaying 1% of the data), and statistical exploration of the data, without the need to download all the data.

REF_EPOCH : Reference epoch (double, Time[Julian Years])

Reference epoch to which the astrometric source parameters are referred, expressed as a Julian Year in TCB.

RA : Right ascension (double, Angle[deg])

Barycentric right ascension α of the source in ICRS at the reference epoch `ref_epoch`

RA_ERROR : Standard error of right ascension (double, Angle[mas])

Standard error $\sigma_{\alpha^*} \equiv \sigma_{\alpha} \cos \delta$ of the right ascension of the source in ICRS at the reference epoch `ref_epoch`.

DEC : Declination (double, Angle[deg])

Barycentric declination δ of the source in ICRS at the reference epoch `ref_epoch`

DEC_ERROR : Standard error of declination (double, Angle[mas])

Standard error σ_{δ} of the declination of the source in ICRS at the reference epoch `ref_epoch`

PARALLAX : Parallax (double, Angle[mas])

Absolute barycentric stellar parallax ϖ of the source at the reference epoch `ref_epoch`

PARALLAX_ERROR : Standard error of parallax (double, Angle[mas])

Standard error σ_{ϖ} of the stellar parallax at the reference epoch `ref_epoch`

PMRA : Proper motion in right ascension direction (double, Angular Velocity[mas/year]

)

Proper motion in right ascension μ_{α^*} of the source in ICRS at the reference epoch `ref_epoch`. This is the projection of the proper motion vector in the direction of increasing right ascension.

PMRA_ERROR : Standard error of proper motion in right ascension direction (double, Angular Velocity[mas/year])

Standard error $\sigma_{\mu\alpha^*}$ of the proper motion vector in right ascension at the reference epoch `ref_epoch`

PMDEC : Proper motion in declination direction (double, Angular Velocity[mas/year])

Proper motion in declination μ_δ of the source at the reference epoch `ref_epoch`. This is the projection of the proper motion vector in the direction of increasing declination.

PMDEC_ERROR : Standard error of proper motion in declination direction (double, Angular Velocity[mas/year])

Standard error $\sigma_{\mu\delta}$ of the proper motion in declination at the reference epoch `ref_epoch`

RA_DEC_CORR : Correlation between right ascension and declination (float, Dimensionless[see description])

Correlation between right ascension and declination, in dimensionless units [-1:+1]

RA_PARALLAX_CORR : Correlation between right ascension and parallax (float, Dimensionless[see description])

Correlation between right ascension and parallax, in dimensionless units [-1:+1]

RA_PMRA_CORR : Correlation between right ascension and proper motion in right ascension (float, Dimensionless[see description])

Correlation between right ascension and proper motion in right ascension, in dimensionless units [-1:+1]

RA_PMDEC_CORR : Correlation between right ascension and proper motion in declination (float, Dimensionless[see description])

Correlation between right ascension and proper motion in declination, in dimensionless units [-1:+1]

DEC_PARALLAX_CORR : Correlation between declination and parallax (float, Dimensionless[see description])

Correlation between declination and parallax, in dimensionless units [-1:+1]

DEC_PMRA_CORR : Correlation between declination and proper motion in right ascension (float, Dimensionless[see description])

Correlation between declination and proper motion in right ascension, in dimensionless units [-1:+1]

DEC_PMDEC_CORR : Correlation between declination and proper motion in declination (float, Dimensionless[see description])

Correlation between declination and proper motion in declination, in dimensionless units [-1:+1]

PARALLAX_PMRA_CORR : Correlation between parallax and proper motion in right ascension (float, Dimensionless[see description])

Correlation between parallax and proper motion in right ascension, in dimensionless units [-1:+1]

PARALLAX_PMDEC_CORR : Correlation between parallax and proper motion in declination (float, Dimensionless[see description])

Correlation between parallax and proper motion in declination, in dimensionless units [-1:+1]

PMRA_PMDEC_CORR : Correlation between proper motion in right ascension and proper motion in declination (float, Dimensionless[see description])

Correlation between proper motion in right ascension and proper motion in declination, in dimensionless units [-1:+1]

ASTROMETRIC_N_OBS_AL : Total number of observations AL (int)

Total number of AL observations (= CCD transits) used in the astrometric solution of the source, independent of their weight. Note that some observations may be strongly downweighted (see `astrometric_n_bad_obs_al`).

ASTROMETRIC_N_OBS_AC : Total number of observations AC (int)

Total number of AC observations (= CCD transits) used in the astrometric solution of the source, independent of their weight. Note that some observations may be strongly downweighted (see `astrometric_n_bad_obs_ac`). Nearly all sources having $G < 13$ will have AC observations from 2d windows, while fainter than that limit only $\sim 1\%$ of stars (the so-called ‘calibration faint stars’) are assigned 2d windows resulting in AC observations.

ASTROMETRIC_N_GOOD_OBS_AL : Number of good observations AL (int)

Number of AL observations (= CCD transits) that were not strongly downweighted in the astrometric solution of the source. Strongly downweighted observations (with downweighting factor $w < 0.2$) are instead counted in `astrometric_n_bad_obs_al`. The sum of `astrometric_n_good_obs_al` and `astrometric_n_bad_obs_al` equals `astrometric_n_obs_al`, the total number of AL observations used in the astrometric solution of the source.

ASTROMETRIC_N_GOOD_OBS_AC : Number of good observations AC (int)

Number of AC observations (= CCD transits) that were not strongly downweighted in the astrometric solution of the source. Strongly downweighted observations (with downweighting factor $w < 0.2$) are instead counted in `astrometric_n_bad_obs_ac`. The sum of `astrometric_n_good_obs_ac` and `astrometric_n_bad_obs_ac` equals `astrometric_n_obs_ac`, the total number of AC observations used in the astrometric solution of the source.

ASTROMETRIC_N_BAD_OBS_AL : Number of bad observations AL (int)

Number of AL observations (= CCD transits) that were strongly downweighted in the astrometric solution of the source, and therefore contributed little to the determination of the astrometric parameters. An observation is considered to be strongly downweighted if its downweighting factor $w < 0.2$, which means that the absolute value of the astrometric residual exceeds 4.83 times the total uncertainty of the observation, calculated as the quadratic sum of the centroiding uncertainty, excess source noise, and excess attitude noise.

ASTROMETRIC_N_BAD_OBS_AC : Number of bad observations AC (int)

Number of AC observations (= CCD transits) that were strongly downweighted in the astrometric solution of the source, and therefore contributed little to the determination of the astrometric parameters. An observation is considered to be strongly downweighted if its downweighting factor $w < 0.2$, which means that the absolute value of the astrometric residual exceeds 4.83 times the total uncertainty of the observation, calculated as the quadratic sum of the centroiding uncertainty, excess source noise, and excess attitude noise.

ASTROMETRIC_DELTA_Q : Hipparcos/Gaia proper motion difference (Hipparcos subset of TGAS only) (float)

In the TGAS solution `astrometric_delta_q` (ΔQ) indicates the difference between the Hipparcos proper motion and the TGAS proper motion. A large value of ΔQ could indicate non-linear motion (e.g. in a binary).

The precise definition is

$$\Delta Q = \begin{bmatrix} \Delta\mu_{\alpha^*} & \Delta\mu_{\delta} \end{bmatrix} (\vec{C}_{\text{pm,T}} + \vec{C}_{\text{pm,H}})^{-1} \begin{bmatrix} \Delta\mu_{\alpha^*} \\ \Delta\mu_{\delta} \end{bmatrix}$$

where $\Delta\mu_{\alpha^*} = \mu_{\alpha^*,\text{T}} - \mu_{\alpha^*,\text{H}}$, $\Delta\mu_{\delta} = \mu_{\delta,\text{T}} - \mu_{\delta,\text{H}}$, with T and H indicating values from the Gaia DR1 (TGAS) solution and Hipparcos catalogue. $\vec{C}_{\text{pm,T}}$ and $\vec{C}_{\text{pm,H}}$ are the corresponding 2×2 covariance matrices.

In order to compute ΔQ the two sets of proper motions must use the same reference frame and the same reference epoch. Thus, the proper motion components as given in the Hipparcos catalogue were rotated to the Gaia DR1 reference frame, and then propagated to the Gaia reference epoch.

ASTROMETRIC_EXCESS_NOISE : Excess noise of the source (double, Angle[mas])

This is the excess noise ϵ_i of the source. It measures the disagreement, expressed as an angle, between the observations of a source and the best-fitting standard astrometric model (using five astrometric parameters). The assumed observational noise in each observation is quadratically increased by ϵ_i in order to statistically match the residuals in the astrometric solution. A value of 0 signifies that the source is astrometrically well-behaved, i.e. that the residuals of the fit statistically agree with the assumed observational noise. A positive value signifies that the residuals are statistically larger than expected.

The significance of ϵ_i is given by `astrometric_excess_noise_sig` (D). If $D \leq 2$ then ϵ_i is probably not significant, and the source may be astrometrically well-behaved even if ϵ_i is large.

The excess noise ϵ_i may absorb all kinds of modelling errors that are not accounted for by the observational noise (image centroiding error) or the excess attitude noise. Such modelling errors include LSF and PSF calibration errors, geometric instrument calibration errors, and part of the high-frequency attitude noise. These modelling errors are particularly important in the early data releases, but should decrease as the astrometric modelling of the instrument and attitude improves over the years.

Additionally, sources that deviate from the standard five-parameter astrometric model (e.g. unresolved binaries, exoplanet systems, etc.) may have positive ϵ_i . Given the many other possible contributions to the excess noise, the user must study the empirical distributions of ϵ_i and D to make sensible cutoffs before filtering out sources for their particular application.

In Gaia DR1, the excess source noise has the same interpretation as described above for both the primary (TGAS) and secondary data sets. It measures the disagreement

between the five-parameter model and the observations, augmented by the different priors used. Thus, in TGAS the excess noise may be increased if the proper motion seen during the 14 months of Gaia observations are not in agreement with the proper motion inferred from the Tycho-2/Gaia comparison. In the secondary solution the excess noise may be increased if the Gaia observations indicate a proper motion or parallax several times larger than the prior uncertainty.

The excess source noise is further explained in Sects. 3.6 and 5.1.2 of Lindegren et al. (2012).

ASTROMETRIC_EXCESS_NOISE_SIG : Significance of excess noise (double)

A dimensionless measure (D) of the significance of the calculated `astrometric_excess_noise` (ϵ_i). A value $D > 2$ indicates that the given ϵ_i is probably significant.

For good fits in the limit of a large number of observations, D should be zero in half of the cases and approximately follow the positive half of a normal distribution with zero mean and unit standard deviation for the other half. Consequently, D is expected to be greater than 2 for only a few percent of the sources with well-behaved astrometric solutions.

In the early data releases ϵ_i will however include instrument and attitude modelling errors that are statistically significant and could result in large values of ϵ_i and D . The user must study the empirical distributions of these statistics and make sensible cutoffs before filtering out sources for their particular application.

The excess noise significance is further explained in Sect. 5.1.2 of Lindegren et al. (2012).

ASTROMETRIC_PRIMARY_FLAG : Primary or secondary (boolean)

Flag indicating if this source was used as a primary source (`true`) or secondary source (`false`). Only primary sources contribute to the estimation of attitude, calibration, and global parameters. The estimation of source parameters is otherwise done in exactly the same way for primary and secondary sources.

ASTROMETRIC_RELEGATION_FACTOR : Relegation factor (float)

Relegation factor of the source calculated as per Eq. (118) in Lindegren et al. (2012) used for the primary selection process.

ASTROMETRIC_WEIGHT_AL : Mean astrometric weight of the source (float, Angle[mas^{-2}])

Mean astrometric weight of the source in the AL direction.

The mean astrometric weight of the source is calculated as per Eq. (119) in Lindegren et al. (2012).

ASTROMETRIC_WEIGHT_AC : Mean astrometric weight of the source (float, Angle[mas^{-2}])

Mean astrometric weight of the source in the AC direction

The mean astrometric weight of the source is calculated as per Eq. (119) in Lindegren et al. (2012).

ASTROMETRIC_PRIORS_USED : Type of prior used in the astrometric solution (int)

Type of prior used in the astrometric solution:

- 0: No prior used
- 1: Galaxy Bayesian Prior for parallax and proper motion

- 2: Galaxy Bayesian Prior for parallax and proper motion relaxed by factor 10
- 3: Hipparcos prior for position
- 4: Hipparcos prior for position and proper motion
- 5: Tycho2 prior for position
- 6: Quasar prior for proper motion

The Galaxy Bayesian Prior is defined in Michalik et al. (2015), where it is denoted $\sigma_{\varpi,F90}$ (for the parallax) and $\sigma_{\mu,F90} = \mathcal{R}\sigma_{\varpi,F90}$, with $\mathcal{R} = 10 \text{ yr}^{-1}$ (for proper motion). The Galaxy Bayesian Prior relaxed by a factor 10 is $10\sigma_{\varpi,F90}$ and $10\sigma_{\mu,F90}$, respectively.

For Gaia DR1 the only types of priors used are 2 (for the secondary data set), 3 (for the Hipparcos subset of the primary data set), or 5 (for the non-Hipparcos subset of the primary data set). Type 6 was used for internal calibration purposes and alignment of the reference frame, but the corresponding astrometric results are in general not published.

MATCHED_OBSERVATIONS : Amount of observations matched to this source (short)

This field indicates the number of observations (detection transits) that have been matched to a given source during the last internal crossmatch revision.

DUPLICATED_SOURCE : Source with duplicate sources (boolean)

During data processing, this source happened to be duplicated and one source only has been kept. This may indicate observational, cross-matching or processing problems, or stellar multiplicity, and probable astrometric or photometric problems in all cases. In DR1, for close doubles with separations below some 2 arcsec, truncated windows have not been processed, neither in astrometry and photometry. The transmitted window is centred on the brighter part of the acquired window, so the brighter component has a better chance to be selected, even when processing the fainter transit. If more than two images are contained in a window, the result of the image parameter determination is un-predictable in the sense that it might refer to either (or neither) image, and no consistency is assured.

SCAN_DIRECTION_STRENGTH_K1 : Degree of concentration of scan directions across the source (float)

The scanDirectionStrength and scanDirectionMean quantify the distribution of AL scan directions across the source. scanDirectionStrength[$k - 1$] ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the nObs[0] AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The scanDirectionStrength is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by scanAngleMean).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, scanDirectionStrength[0] is the degree

of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K2 : Degree of concentration of scan directions across the source (float)

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionStrength[k - 1]` ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K3 : Degree of concentration of scan directions across the source (float)

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionStrength[k - 1]` ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K4 : Degree of concentration of scan directions across the source (float)

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionStrength[k - 1]` ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the posi-

tion angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_MEAN_K1 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K2 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean di-

rection when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K3 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K4 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

PHOT_G_N_OBS : Number of observations contributing to G photometry (int)

Number of observations (CCD transits) that contributed to the G mean flux and mean flux error.

PHOT_G_MEAN_FLUX : G-band mean flux (double, Flux[e-/s])
Mean flux in the G-band.

PHOT_G_MEAN_FLUX_ERROR : Error on G-band mean flux (double, Flux[e-/s])
Error on the mean flux in the G-band.

PHOT_G_MEAN_MAG : G-band mean magnitude (double, Magnitude[mag])
Mean magnitude in the G band. This is computed from the G-band mean flux applying the magnitude zero-point in the Vega scale.

PHOT_VARIABLE_FLAG : Photometric variability flag (string, Dimensionless[see description])
Flag indicating if variability was identified in the photometric G band:

”NOT_AVAILABLE” = source not processed and/or exported to catalogue

”CONSTANT” = Source not identified as variable

”VARIABLE” = source identified and processed as variable, see tables:
phot_variable_summary,
phot_variable_time_series_gfov,
phot_variable_time_series_gfov_statistical_parameters,
and cepheid or rrlyrae for more details.

Note that for this data release only a small subset of (variable) sources was processed and/or exported, so for many (known) variable sources this flag is set to ”NOT AVAILABLE”. No ”CONSTANT” sources were exported either.

L : Galactic longitude (double, Angle[deg])

Galactic Longitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

B : Galactic latitude (double, Angle[deg])

Galactic Latitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

ECL_LON : Ecliptic longitude (double, Angle[deg])

Ecliptic Longitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

ECL_LAT : Ecliptic latitude (double, Angle[deg])

Ecliptic Latitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

1.2 TGAS_SOURCE

This table is a subset of `gaia_source` comprising those stars in the Hipparcos and Tycho-2 Catalogues for which a full 5-parameter astrometric solution has been possible in Gaia Data Release 1. This is possible because the early Hipparcos epoch positions break some degeneracies due to the limited Gaia time coverage.

This table contains a substantial fraction of the around 2.5 million stars in the Hipparcos and Tycho-2 catalogue. Many stars have been excluded due to several reasons, such as saturation, cross-match errors or bad astrometric solution.

Columns description:

HIP : Hipparcos identifier (int)

Hipparcos identifier (this field will be empty if the source was not in the Hipparcos catalogue).

TYCHO2_ID : Tycho 2 identifier (string)

Tycho 2 identifier. The TYC identifier is constructed from the GSC region number (TYC1), the running number within the region (TYC2) and a component identifier (TYC3) which is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

To see if Hipparcos or Tycho measurements were used as a prior constraint in the astrometric solution for a given source please see `astrometric_priors_used`.

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source.

For the contents of Gaia DR1, which does not include Solar System objects, the source ID consists of a 64-bit integer, least significant bit = 1 and most significant bit = 64, comprising:

- a HEALPix index number (sky pixel) in bits 36 – 63; by definition the smallest HEALPix index number is zero.
- a 2-bit Data Processing Centre code in bits 34 – 35; for example `MOD(source_id / 4294967296, 8)` can be used to distinguish between sources initialised via the Initial Gaia Source List by the Torino DPC (code = 0) and sources otherwise detected and assigned by Gaia observations (code > 0)
- a 25-bit plus 7 bit sequence number within the HEALPix pixel in bits 1 – 32 split into:

- a 25 bit running number in bits 8 – 32; the running numbers are defined to be positive, i.e. never zero (except in the case of forced empty windows)
- a 7-bit component number in bits 1 – 7
- one spare bit in bit 33

This means that the HEALpix index level 12 of a given source is contained in the most significant bits. HEALpix index of 12 and lower levels can thus be retrieved as follows:

- HEALpix level 12 = $\text{source_id} / 34359738368$
- HEALpix level 11 = $\text{source_id} / 137438953472$
- HEALpix level 10 = $\text{source_id} / 549755813888$
- HEALpix level n = $\text{source_id} / 2^{35} * 4^{(12 - \text{level})}$.

Additional details can be found in the Gaia DPAC public document *Source Identifiers — Assignment and Usage throughout DPAC* (document code GAIA-C3-TN-ARI-BAS-020) available from <http://www.cosmos.esa.int/web/gaia/public-dpac-documents>

RANDOM_INDEX : Random index used to select subsets (long)

Random index which can be used to select smaller subsets of the data that are still representative. The column contains a random permutation of the numbers from 0 to N-1, where N is the number of rows.

The random index can be useful for validation (testing on 10 different random subsets), visualization (displaying 1% of the data), and statistical exploration of the data, without the need to download all the data.

REF_EPOCH : Reference epoch (double, Time[Julian Years])

Reference epoch to which the astrometric source parameters are referred, expressed as a Julian Year in TCB.

RA : Right ascension (double, Angle[deg])

Barycentric right ascension α of the source in ICRS at the reference epoch `ref_epoch`

RA_ERROR : Standard error of right ascension (double, Angle[mas])

Standard error $\sigma_{\alpha^*} \equiv \sigma_{\alpha} \cos \delta$ of the right ascension of the source in ICRS at the reference epoch `ref_epoch`.

DEC : Declination (double, Angle[deg])

Barycentric declination δ of the source in ICRS at the reference epoch `ref_epoch`

DEC_ERROR : Standard error of declination (double, Angle[mas])

Standard error σ_{δ} of the declination of the source in ICRS at the reference epoch `ref_epoch`

PARALLAX : Parallax (double, Angle[mas])

Absolute barycentric stellar parallax ϖ of the source at the reference epoch `ref_epoch`

PARALLAX_ERROR : Standard error of parallax (double, Angle[mas])

Standard error σ_{ϖ} of the stellar parallax at the reference epoch `ref_epoch`

PMRA : Proper motion in right ascension direction (double, Angular Velocity[mas/year]

)

Proper motion in right ascension μ_{α^*} of the source in ICRS at the reference epoch `ref_epoch`. This is the projection of the proper motion vector in the direction of increasing right ascension.

PMRA_ERROR : Standard error of proper motion in right ascension direction (double, Angular Velocity[mas/year])

Standard error $\sigma_{\mu_{\alpha^*}}$ of the proper motion vector in right ascension at the reference epoch `ref_epoch`

PMDEC : Proper motion in declination direction (double, Angular Velocity[mas/year])

Proper motion in declination μ_{δ} of the source at the reference epoch `ref_epoch`. This is the projection of the proper motion vector in the direction of increasing declination.

PMDEC_ERROR : Standard error of proper motion in declination direction (double, Angular Velocity[mas/year])

Standard error $\sigma_{\mu_{\delta}}$ of the proper motion in declination at the reference epoch `ref_epoch`

RA_DEC_CORR : Correlation between right ascension and declination (float, Dimensionless[see description])

Correlation between right ascension and declination, in dimensionless units [-1:+1]

RA_PARALLAX_CORR : Correlation between right ascension and parallax (float, Dimensionless[see description])

Correlation between right ascension and parallax, in dimensionless units [-1:+1]

RA_PMRA_CORR : Correlation between right ascension and proper motion in right ascension (float, Dimensionless[see description])

Correlation between right ascension and proper motion in right ascension, in dimensionless units [-1:+1]

RA_PMDEC_CORR : Correlation between right ascension and proper motion in declination (float, Dimensionless[see description])

Correlation between right ascension and proper motion in declination, in dimensionless units [-1:+1]

DEC_PARALLAX_CORR : Correlation between declination and parallax (float, Dimensionless[see description])

Correlation between declination and parallax, in dimensionless units [-1:+1]

DEC_PMRA_CORR : Correlation between declination and proper motion in right ascension (float, Dimensionless[see description])

Correlation between declination and proper motion in right ascension, in dimensionless units [-1:+1]

DEC_PMDEC_CORR : Correlation between declination and proper motion in declination (float, Dimensionless[see description])

Correlation between declination and proper motion in declination, in dimensionless units [-1:+1]

PARALLAX_PMRA_CORR : Correlation between parallax and proper motion in right ascension (float, Dimensionless[see description])

Correlation between parallax and proper motion in right ascension, in dimensionless units [-1:+1]

PARALLAX_PMDEC_CORR : Correlation between parallax and proper motion in declination (float, Dimensionless[see description])

Correlation between parallax and proper motion in declination, in dimensionless units [-1:+1]

PMRA_PMDEC_CORR : Correlation between proper motion in right ascension and proper motion in declination (float, Dimensionless[see description])

Correlation between proper motion in right ascension and proper motion in declination, in dimensionless units [-1:+1]

ASTROMETRIC_N_OBS_AL : Total number of observations AL (int)

Total number of AL observations (= CCD transits) used in the astrometric solution of the source, independent of their weight. Note that some observations may be strongly downweighted (see `astrometric_n_bad_obs_al`).

ASTROMETRIC_N_OBS_AC : Total number of observations AC (int)

Total number of AC observations (= CCD transits) used in the astrometric solution of the source, independent of their weight. Note that some observations may be strongly downweighted (see `astrometric_n_bad_obs_ac`). Nearly all sources having $G < 13$ will have AC observations from 2d windows, while fainter than that limit only $\sim 1\%$ of stars (the so-called ‘calibration faint stars’) are assigned 2d windows resulting in AC observations.

ASTROMETRIC_N_GOOD_OBS_AL : Number of good observations AL (int)

Number of AL observations (= CCD transits) that were not strongly downweighted in the astrometric solution of the source. Strongly downweighted observations (with downweighting factor $w < 0.2$) are instead counted in `astrometric_n_bad_obs_al`. The sum of `astrometric_n_good_obs_al` and `astrometric_n_bad_obs_al` equals `astrometric_n_obs_al`, the total number of AL observations used in the astrometric solution of the source.

ASTROMETRIC_N_GOOD_OBS_AC : Number of good observations AC (int)

Number of AC observations (= CCD transits) that were not strongly downweighted in the astrometric solution of the source. Strongly downweighted observations (with downweighting factor $w < 0.2$) are instead counted in `astrometric_n_bad_obs_ac`. The sum of `astrometric_n_good_obs_ac` and `astrometric_n_bad_obs_ac` equals `astrometric_n_obs_ac`, the total number of AC observations used in the astrometric solution of the source.

ASTROMETRIC_N_BAD_OBS_AL : Number of bad observations AL (int)

Number of AL observations (= CCD transits) that were strongly downweighted in the astrometric solution of the source, and therefore contributed little to the determination of the astrometric parameters. An observation is considered to be strongly downweighted if its downweighting factor $w < 0.2$, which means that the absolute

value of the astrometric residual exceeds 4.83 times the total uncertainty of the observation, calculated as the quadratic sum of the centroiding uncertainty, excess source noise, and excess attitude noise.

ASTROMETRIC_N_BAD_OBS_AC : Number of bad observations AC (int)

Number of AC observations (= CCD transits) that were strongly downweighted in the astrometric solution of the source, and therefore contributed little to the determination of the astrometric parameters. An observation is considered to be strongly downweighted if its downweighting factor $w < 0.2$, which means that the absolute value of the astrometric residual exceeds 4.83 times the total uncertainty of the observation, calculated as the quadratic sum of the centroiding uncertainty, excess source noise, and excess attitude noise.

ASTROMETRIC_DELTA_Q : Hipparcos/Gaia data discrepancy (Hipparcos subset of TGAS only) (float)

In the TGAS solution `astrometric_delta_q` (ΔQ) indicates the discrepancy between the Hipparcos proper motion and the TGAS proper motion. A large value of ΔQ could indicate non-linear motion (e.g. in a binary).

The precise definition is

$$\Delta Q = \begin{bmatrix} \Delta\mu_{\alpha^*} & \Delta\mu_{\delta} \end{bmatrix} (\vec{C}_{\text{pm,T}} + \vec{C}_{\text{pm,H}})^{-1} \begin{bmatrix} \Delta\mu_{\alpha^*} \\ \Delta\mu_{\delta} \end{bmatrix}$$

where $\Delta\mu_{\alpha^*} = \mu_{\alpha^*,\text{T}} - \mu_{\alpha^*,\text{H}}$, $\Delta\mu_{\delta} = \mu_{\delta,\text{T}} - \mu_{\delta,\text{H}}$, with T and H indicating values from the Gaia DR1 (TGAS) solution and Hipparcos catalogue. $\vec{C}_{\text{pm,T}}$ and $\vec{C}_{\text{pm,H}}$ are the corresponding 2×2 covariance matrices.

In order to compute ΔQ the two sets of proper motions must use the same reference frame and the same reference epoch. Thus, the proper motion components as given in the Hipparcos catalogue were rotated to the Gaia DR1 reference frame, and then propagated to the Gaia reference epoch.

ASTROMETRIC_EXCESS_NOISE : Excess noise of the source (double, Angle[mas])

This is the excess noise ϵ_i of the source. It measures the disagreement, expressed as an angle, between the observations of a source and the best-fitting standard astrometric model (using five astrometric parameters). The assumed observational noise in each observation is quadratically increased by ϵ_i in order to statistically match the residuals in the astrometric solution. A value of 0 signifies that the source is astrometrically well-behaved, i.e. that the residuals of the fit statistically agree with the assumed observational noise. A positive value signifies that the residuals are statistically larger than expected.

The significance of ϵ_i is given by `astrometric_excess_noise_sig` (D). If $D \leq 2$ then ϵ_i is probably not significant, and the source may be astrometrically well-behaved even if ϵ_i is large.

The excess noise ϵ_i may absorb all kinds of modelling errors that are not accounted for by the observational noise (image centroiding error) or the excess attitude noise. Such modelling errors include LSF and PSF calibration errors, geometric instrument calibration errors, and part of the high-frequency attitude noise. These modelling errors are particularly important in the early data releases, but should decrease as the astrometric modelling of the instrument and attitude improves over the years.

Additionally, sources that deviate from the standard five-parameter astrometric model (e.g. unresolved binaries, exoplanet systems, etc.) may have positive ϵ_i . Given

the many other possible contributions to the excess noise, the user must study the empirical distributions of ϵ_i and D to make sensible cutoffs before filtering out sources for their particular application.

In Gaia DR1, the excess source noise has the same interpretation as described above for both the primary (TGAS) and secondary data sets. It measures the disagreement between the five-parameter model and the observations, augmented by the different priors used. Thus, in TGAS the excess noise may be increased if the proper motion seen during the 14 months of Gaia observations are not in agreement with the proper motion inferred from the Tycho-2/Gaia comparison. In the secondary solution the excess noise may be increased if the Gaia observations indicate a proper motion or parallax several times larger than the prior uncertainty.

The excess source noise is further explained in Sects. 3.6 and 5.1.2 of Lindegren et al. (2012).

ASTROMETRIC_EXCESS_NOISE_SIG : Significance of excess noise (double)

A dimensionless measure (D) of the significance of the calculated `astrometric_excess_noise` (ϵ_i). A value $D > 2$ indicates that the given ϵ_i is probably significant.

For good fits in the limit of a large number of observations, D should be zero in half of the cases and approximately follow the positive half of a normal distribution with zero mean and unit standard deviation for the other half. Consequently, D is expected to be greater than 2 for only a few percent of the sources with well-behaved astrometric solutions.

In the early data releases ϵ_i will however include instrument and attitude modelling errors that are statistically significant and could result in large values of ϵ_i and D . The user must study the empirical distributions of these statistics and make sensible cutoffs before filtering out sources for their particular application.

The excess noise significance is further explained in Sect. 5.1.2 of Lindegren et al. (2012).

ASTROMETRIC_PRIMARY_FLAG : Primary or secondary (boolean)

Flag indicating if this source was used as a primary source (`true`) or secondary source (`false`). Only primary sources contribute to the estimation of attitude, calibration, and global parameters. The estimation of source parameters is otherwise done in exactly the same way for primary and secondary sources.

ASTROMETRIC_RELEGATION_FACTOR : Relegation factor (float)

Relegation factor of the source calculated as per Eq. (118) in Lindegren et al. (2012) used for the primary selection process.

ASTROMETRIC_WEIGHT_AL : Mean astrometric weight of the source (float, Angle[mas^{-2}])

Mean astrometric weight of the source in the AL direction.

The mean astrometric weight of the source is calculated as per Eq. (119) in Lindegren et al. (2012).

ASTROMETRIC_WEIGHT_AC : Mean astrometric weight of the source (float, Angle[mas^{-2}])

Mean astrometric weight of the source in the AC direction

The mean astrometric weight of the source is calculated as per Eq. (119) in Lindegren et al. (2012).

ASTROMETRIC_PRIORS_USED : Type of prior used in the astrometric solution (int)

Type of prior used in the astrometric solution:

- 0: No prior used
- 1: Galaxy Bayesian Prior for parallax and proper motion
- 2: Galaxy Bayesian Prior for parallax and proper motion relaxed by factor 10
- 3: Hipparcos prior for position
- 4: Hipparcos prior for position and proper motion
- 5: Tycho2 prior for position
- 6: Quasar prior for proper motion

The Galaxy Bayesian Prior is defined in Michalik et al. (2015), where it is denoted $\sigma_{\varpi, F90}$ (for the parallax) and $\sigma_{\mu, F90} = \mathcal{R}\sigma_{\varpi, F90}$, with $\mathcal{R} = 10 \text{ yr}^{-1}$ (for proper motion). The Galaxy Bayesian Prior relaxed by a factor 10 is $10\sigma_{\varpi, F90}$ and $10\sigma_{\mu, F90}$, respectively.

For Gaia DR1 the only types of priors used are 2 (for the secondary data set), 3 (for the Hipparcos subset of the primary data set), or 5 (for the non-Hipparcos subset of the primary data set). Type 6 was used for internal calibration purposes and alignment of the reference frame, but the corresponding astrometric results are in general not published.

MATCHED_OBSERVATIONS : Amount of observations matched to this source (short)

This field indicates the number of observations (detection transits) that have been matched to a given source during the last internal crossmatch revision.

DUPLICATED_SOURCE : Source with duplicate sources (boolean)

During data processing, this source happened to be duplicated and one source only has been kept. This may indicate observational, cross-matching or processing problems, or stellar multiplicity, and probable astrometric or photometric problems in all cases. In DR1, for close doubles with separations below some 2 arcsec, truncated windows have not been processed, neither in astrometry and photometry. The transmitted window is centred on the brighter part of the acquired window, so the brighter component has a better chance to be selected, even when processing the fainter transit. If more than two images are contained in a window, the result of the image parameter determination is un-predictable in the sense that it might refer to either (or neither) image, and no consistency is assured.

SCAN_DIRECTION_STRENGTH_K1 : Degree of concentration of scan directions across the source (float)

The scanDirectionStrength and scanDirectionMean quantify the distribution of AL scan directions across the source. scanDirectionStrength[$k - 1$] ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the nObs[0] AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K2 : Degree of concentration of scan directions across the source (float)

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionStrength[k - 1]` ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K3 : Degree of concentration of scan directions across the source (float)

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionStrength[k - 1]` ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The `scanDirectionStrength` is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by `scanAngleMean`).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionStrength[0]` is the degree of concentration when the sense of direction is taken into account, while `scanDirectionStrength[1]` is the degree of concentration without regard to the sense of direction. A large value of `scanDirectionStrength[3]` indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_STRENGTH_K4 : Degree of concentration of scan directions across the source (float)

The scanDirectionStrength and scanDirectionMean quantify the distribution of AL scan directions across the source. scanDirectionStrength[$k - 1$] ($k = 1, 2, 3, 4$) is the absolute value of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the nObs[0] AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

The scanDirectionStrength is a number between 0 and 1, where 0 means that the scan directions are well spread out in different directions, while 1 means that they are concentrated in a single direction (given by scanAngleMean).

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, scanDirectionStrength[0] is the degree of concentration when the sense of direction is taken into account, while scanDirectionStrength[1] is the degree of concentration without regard to the sense of direction. A large value of scanDirectionStrength[3] indicates that the scans are concentrated in two nearly orthogonal directions.

SCAN_DIRECTION_MEAN_K1 : Mean position angle of scan directions across the source (float, Angle[deg])

The scanDirectionStrength and scanDirectionMean quantify the distribution of AL scan directions across the source. scanDirectionMean[$k - 1$] ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the nObs[0] AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

scanDirectionMean[$k - 1$] is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, scanDirectionMean[0] is the mean direction when the sense of direction is taken into account, while scanDirectionMean[1] is the mean direction without regard to the sense of the direction. For example, scanDirectionMean[0] = 0 means that the scans preferentially go towards North, while scanDirectionMean[1] = 0 means that they preferentially go in the North-South direction, and scanDirectionMean[4] = 0 that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K2 : Mean position angle of scan directions across the source (float, Angle[deg])

The scanDirectionStrength and scanDirectionMean quantify the distribution of AL scan directions across the source. scanDirectionMean[$k - 1$] ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the nObs[0] AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$

towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K3 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDirectionMean[0] = 0` means that the scans preferentially go towards North, while `scanDirectionMean[1] = 0` means that they preferentially go in the North-South direction, and `scanDirectionMean[4] = 0` that they preferentially go either in the North-South or in the East-West direction.

SCAN_DIRECTION_MEAN_K4 : Mean position angle of scan directions across the source (float, Angle[deg])

The `scanDirectionStrength` and `scanDirectionMean` quantify the distribution of AL scan directions across the source. `scanDirectionMean[k - 1]` ($k = 1, 2, 3, 4$) is $1/k$ times the argument of the trigonometric moments $m_k = \langle \exp(ik\theta) \rangle$, where θ is the position angle of the scan and the mean value is taken over the `nObs[0]` AL observations contributing to the astrometric parameters of the source. θ is defined in the usual astronomical sense: $\theta = 0$ when the FoV is moving towards local North, and $\theta = 90^\circ$ towards local East.

`scanDirectionMean[k - 1]` is an angle between $-180^\circ/k$ and $+180^\circ/k$, giving the mean position angle of the scans at order k .

The different orders k are statistics of the scan directions modulo $360^\circ/k$. For example, at first order ($k = 1$), $\theta = 10^\circ$ and $\theta = 190^\circ$ count as different directions, but at second order ($k = 2$) they are the same. Thus, `scanDirectionMean[0]` is the mean direction when the sense of direction is taken into account, while `scanDirectionMean[1]` is the mean direction without regard to the sense of the direction. For example, `scanDi-`

rectionMean[0] = 0 means that the scans preferentially go towards North, while scanDirectionMean[1] = 0 means that they preferentially go in the North-South direction, and scanDirectionMean[4] = 0 that they preferentially go either in the North-South or in the East-West direction.

PHOT_G_N_OBS : Number of observations contributing to G photometry (int)
Number of observations (CCD transits) that contributed to the G mean flux and mean flux error.

PHOT_G_MEAN_FLUX : G-band mean flux (double, Flux[e-/s])
Mean flux in the G-band.

PHOT_G_MEAN_FLUX_ERROR : Error on G-band mean flux (double, Flux[e-/s])
Error on the mean flux in the G-band.

PHOT_G_MEAN_MAG : G-band mean magnitude (double, Magnitude[mag])
Mean magnitude in the G band. This is computed from the G-band mean flux applying the magnitude zero-point in the Vega scale.

PHOT_VARIABLE_FLAG : Photometric variability flag (string, Dimensionless[see description])

Flag indicating if variability was identified in the photometric G band:

”NOT_AVAILABLE” = source not processed and/or exported to catalogue

”CONSTANT” = Source not identified as variable

”VARIABLE” = source identified and processed as variable, see tables:
phot_variable_summary,
phot_variable_time_series_gfov,
phot_variable_time_series_gfov_statistical_parameters,
and cepheid or rrlyrae for more details.

Note that for this data release only a small subset of (variable) sources was processed and/or exported, so for many (known) variable sources this flag is set to ”NOT AVAILABLE”. No ”CONSTANT” sources were exported either.

L : Galactic longitude (double, Angle[deg])

Galactic Longitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

B : Galactic latitude (double, Angle[deg])

Galactic Latitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

ECL_LON : Ecliptic longitude (double, Angle[deg])

Ecliptic Longitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for

the conversion details.

ECL_LAT : Ecliptic latitude (double, Angle[deg])

Ecliptic Latitude of the object at reference epoch `ref_epoch`, see ESA, 1997, 'The Hipparcos and Tycho Catalogues', ESA SP-1200, Volume 1, Section 1.5.3, for the conversion details.

Chapter 2

Variability tables

2.1 CEPHEID

This table describes the Cepheid stars identified in table `variable_summary` as `classification="CEP"`. In the analyses only observations with `rejected_by_variability_processing=false` are included, as found in table `phot_variable_time_series_gfov`.

Columns description:

TYPE_BEST_CLASSIFICATION : Best type classification estimate out of: "DCEP", "T2CEP", "ACEP" (string, Dimensionless[see description])

Classification of a Cepheid into "DCEP", "T2CEP" or "ACEP" using the period-luminosity relations, which are different for the three different types of Cepheids.

TYPE2_BEST_SUB_CLASSIFICATION : Best subclassification estimate for `type_best_classification="T2CEP"` out of: "BL_HER", "W_VIR", "RV_TAU" (string, Dimensionless[see description])

Sub-classification of a T2CEP Cepheids into BL Herculis ("BL_HER"), W Virginis ("W_VIR") or RV Tauris ("RV_TAU") sub-types depending on the source periodicity.

MODE_BEST_CLASSIFICATION : Best mode classification estimate out of: "FUNDAMENTAL", "FIRST_OVERTONE", "SECOND_OVERTONE", "UNDEFINED", "NOT_APPLICABLE" (string, Dimensionless[see description])

Best mode classification estimate:

- "FUNDAMENTAL": fundamental mode for `type_best_classification="DCEP"` or "ACEP"
- "FIRST_OVERTONE": first overtone for `type_best_classification="DCEP"` or "ACEP"
- "SECOND_OVERTONE": second overtone for `type_best_classification="DCEP"` or "ACEP"
- "UNDEFINED": if mode could not be clearly determined for `type_best_classification="DCEP"` or "ACEP"
- "NOT_APPLICABLE": when `type_best_classification="T2CEP"`

Cepheid pulsation mode is assigned using the period-luminosity relations, which are different for the various pulsation modes, and the plot of the Fourier parameter R21 vs Period.

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source obtained from `gaia_source` (for a detailed description see `gaia_source.source_id`)

P1 : Period corresponding to the maximum power peak in the periodogram of G band time series (double, Time[day])

This parameter is filled with the period of the maximum power peak in the frequencygram obtained from the modeling of the time series. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum [A_i \sin(i \times 2\pi \nu_{max} t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

P1_ERROR : Uncertainty on the p1 period (double, Time[day])

This parameter is filled with the uncertainty value of the p1 parameter. Its value is derived with Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. For each of these time series the period is derived from the non linear modeling with a truncated Fourier series of the light curve. The mean of all the periods found and its standard deviation are then computed, and the latter value is kept as value to fill the `p1_error` parameter.

EPOCH_G : Epoch of the maximum of the light curve in the G band (double, Time[Barycentric JD in TCB - 2455197.5 (day)])

The epoch of maximum light for the Gaia integrated G band. It corresponds to the Barycentric Julian day (BJD) of the maximum value of the light curve model which is closest to the BJD of the first observations $-3 \times p1$.

The mentioned BJD is offset by JD 2455197.5 (= J2010.0).

EPOCH_G_ERROR : Uncertainty on the epoch parameter `epoch_g` (double, Time[day])

The uncertainty value of the `epoch_g` parameter. Its value is three times the error on the p1.

INT_AVERAGE_G : Intensity-averaged magnitude in the G band (double, Magnitude[mag])

The intensity-averaged magnitude in the G-band. The intensity-averaged magnitude is obtained by computing the average flux and then converting the average flux to

magnitude.

INT_AVERAGE_G_ERROR : Uncertainty on `int_average_g` parameter (double, Magnitude[mag])

This parameter is filled with the uncertainty value of the `int_average_g` parameter. The uncertainty is computed as the $error(zp)$, where zp is the zero point obtained by the non linear Fourier modeling of the light curve.

PEAK_TO_PEAK_G : Peak-to-peak amplitude of the G band light curve (double, Magnitude[mag])

This parameter is filled with the peak-to-peak amplitude value of the G band light curve. The peak-to-peak amplitude is calculated as the (maximum) - (minimum) of the folded modeled light curve in the G band. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum[A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

PEAK_TO_PEAK_G_ERROR : Uncertainty on the `peak_to_peak_g` parameter (double, Magnitude[mag])

This parameter is filled with the uncertainty value of the `peak_to_peak_g` parameter. The uncertainty is computed as the $\sqrt{2} \times error(zp)$, where zp is the zero point obtained by the non linear Fourier modeling of the light curve.

NUM_HARMONICS_FOR_P1 : Number of harmonics used to model P1 of the light curve (int, Dimensionless[see description])

This parameter is filled with the number of harmonics used to model P1 of the light curve. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum[A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics are determined using the Levenberg-Marquardt non linear fitting algorithm.

R21_G : Fourier decomposition parameter `r21_g`: A_2/A_1 (for G band) (double, Dimensionless[see description])

This parameter is filled with the Fourier decomposition parameter $R_{21} = A_2/A_1$, where A_2 is the amplitude of the 2nd harmonic and A_1 is the amplitude of the fundamental harmonic of the truncated Fourier series defined hereafter. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum[A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, are determined using the Levenberg-Marquardt non linear fitting algorithm.

R21_G_ERROR : Uncertainty on the `r21_g` parameter: A_2/A_1 (for G band) (double, Dimensionless[see description])

This parameter is filled with the uncertainty value on the `r21_g` parameter. Its value is derived by propagation of the errors in the A_2 and A_1 parameters. Errors in A_1, A_2 are computed from Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. The mean for each of these values and their standard deviations are then computed, and the latter values are kept as value to fill the

uncertainty of the A1, A2 parameters.

PHI21_G : Fourier decomposition parameter phi21_g: $\phi_2 - 2\phi_1$ (for G band) (double, Dimensionless[see description])

This parameter is filled with the Fourier decomposition parameter ϕ_{21} : $\phi_2 - 2\phi_1$ value. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum[A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

PHI21_G_ERROR : Uncertainty on the phi21_g parameter: $\phi_2 - 2\phi_1$ (for G band) (double, Dimensionless[see description])

This parameter is filled with the uncertainty of the phi21_g parameter. Its value is derived by propagation of the errors in the phi1 and phi2 parameters. Errors in phi1, phi2 are computed from Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. For each of these time series the phi1, phi2 values are computed. The mean for each of these values and their standard deviation are then computed, and the latter values are kept as value to fill the uncertainty of the phi1 and phi2 parameters.

2.2 PHOT_VARIABLE_TIME_SERIES_GFOV

Field-of-view time series of sources that have `phot_variable_flag = "VARIABLE"` in the `gaia_source` table.

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source obtained from `gaia_source` (for a detailed description see `gaia_source.source_id`)

OBSERVATION_TIME : Barycentric light-travel time corrected timestamp for each FOV observation (double, Time[Barycentric JD in TCB - 2455197.5 (day)])

Field-of-view transit averaged observation time in units of Barycentric JD (in TCB) in days -2455197.5, computed as follows. First the observation time is converted from On-board Mission Time (OBMT) into Julian date in TCB (Temps Coordonnée Barycentrique). Next a correction is applied for the light-travel time to the Solar system barycentre, resulting in Barycentric Julian Date (BJD). Finally, an offset of 2455197.5 days is applied (corresponding to a reference time T_0 at 2010-01-01T00:00:00) to have a conveniently small numerical value. Although the centroiding time accuracy of the individual CCD observations is (much) below 1 ms, this per-FoV observation time is averaged over typically 9 CCD observations taken in a time range of about 44 sec.

G_FLUX : G-band flux for each FOV observation (double, Flux[e-/s])

G-band flux for the field-of-view transit observation.

G_FLUX_ERROR : Estimated G-band flux uncertainty for each FOV observation (double, Flux[e-/s])

Estimated uncertainty of G-band flux for the field-of-view transit observation.

G_MAGNITUDE : G-band magnitude for each FOV observation (double, Magnitude[mag])

G-band magnitude for the field-of-view transit observation, computed from the `g_flux` field using magnitude zero-point defined in `ExtPhotZeroPoint`.

REJECTED_BY_VARIABILITY_PROCESSING : True when this FOV observation was excluded from variability analyses (boolean, Dimensionless[see description])

Observations with this flag true have been excluded from the variability result in tables `variable_summary`, `cepheid`, `rrlyrae`, and `phot_variable_time_series_gfov_statistical_parameters`

2.3 PHOT_VARIABLE_TIME_SERIES_GFOV_STATISTICAL_PARAMETERS

Statistical parameters of field-of-view time series, only including observations with `rejected_by_variability_processing=false` as found in table `phot_variable_time_series_gfov`.

Note that only sources are included that have `phot_variable_flag = "VARIABLE"` in the `gaia_source` table.

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source obtained from `gaia_source` (for a detailed description see `gaia_source.source_id`)

NUM_OBSERVATIONS_PROCESSED : Number of processed G-band observations for variability analyses (int, Dimensionless[see description])

The number of processed observations for variability analyses of this source, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

MEAN_OBS_TIME : Mean observation time (with respect to T_0) of G-band time series (double, Time[day])

Name: The mean observation time

Input: Gaia barycentric light-travel time corrected FOV observation times with respect to reference time $T_0 = 2455197.5$ days (=J2010.0 = 2010-01-01T00:00:00), only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Control parameters: None

Output: Let y_i be a time series of size N at times t_i . The mean \bar{t} is defined as

$$\bar{t} = \frac{1}{N} \sum_{i=1}^N t_i. \quad (2.1)$$

MINIMUM : Minimum magnitude of the G-band time series (double, Magnitude[mag])

Minimum magnitude of the G-band time series, only including observations with `rejected_by_variability_processing=false`, as found in table

phot_variable_time_series_gfov.

MAXIMUM : Maximum magnitude of the G-band time series (double, Magnitude[mag])

Maximum magnitude of the G-band time series, only including observations with rejected_by_variability_processing=false, as found in table phot_variable_time_series_gfov.

MEAN : Mean magnitude of the G-band time series (double, Magnitude[mag])

Name: The mean magnitude of the G-band time series

Input: Gaia time series, only including observations with rejected_by_variability_processing=false, as found in table phot_variable_time_series_gfov.

Control parameters: None

Output: Let y_i be a time series of size N . The mean \bar{y} is defined as

$$\bar{y} = \frac{1}{N} \sum_{i=1}^N y_i. \quad (2.2)$$

MEDIAN : Median magnitude of the G-band time series (double, Magnitude[mag])

Name: Median magnitude of the G-band time series

Input: Gaia time series, only including observations with rejected_by_variability_processing=false, as found in table phot_variable_time_series_gfov.

Control parameters: None

Output: The (unweighted) 50th percentile value.

Let y_i be a time series of size N ordered such as $y_{(1)} \leq y_{(2)} \leq \dots \leq y_{(N)}$. The m -th (per cent) percentile P_m is defined for $0 < m \leq 100$ as follows:

$$P_m = \begin{cases} y_{(1)} & \text{if } 0 < m < p_1 \\ y_{(i)} + \frac{m-p_i}{p_{i+1}-p_i} (y_{(i+1)} - y_{(i)}) & \text{if } p_i \leq m \leq p_{i+1} \\ y_{(N)} & \text{if } p_N < m \leq 100 \end{cases}$$

where $p_i = 100 i / (N + 1)$.

RANGE : Difference between the highest and lowest magnitude of the G-band time series (double, Magnitude[mag])

Name: Magnitude range of the G-band time series

Input: Gaia time series, only including observations with rejected_by_variability_processing=false, as found in table phot_variable_time_series_gfov.

Control parameters: None

Output: Let y_i be a time series, y_{\max} its largest element, and y_{\min} its smallest element, then the range is defined as

$$R = y_{\max} - y_{\min} \quad (2.3)$$

STD_DEV : Square root of the unweighted variance of the G-band time series values (double, Magnitude[mag])

Name: The square root of the unbiased unweighted variance.

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Output: Let y_i be a time series of size N . The unweighted standard deviation $\hat{\sigma}$ is defined as the square root of the sample-size unbiased unweighted variance:

$$\hat{\sigma} = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (y_i - \bar{y})^2}.$$

SKEWNESS : Standardized unweighted skewness of the G-band time series values (double, Dimensionless[see description])

Name: The standardised unbiased unweighted skewness.

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Output: Let y_i be a time series of size N . The sample-size unbiased unweighted skewness moment \mathcal{E} is defined as:

$$\mathcal{E} = \frac{N}{(N-1)(N-2)} \sum_{i=1}^N (y_i - \bar{y})^3.$$

The standardized unbiased skewness E is defined as:

$$E = \frac{\mathcal{E}}{\hat{\sigma}^3}$$

where $\hat{\sigma}$ is the square root of the unbiased unweighted variance around the unweighted mean. While \mathcal{E} is an unbiased estimate of the population value, E becomes unbiased in the limit of large N .

KURTOSIS : Standardized unweighted kurtosis of the G-band time series values (double, Dimensionless[see description])

Name: The standardised unbiased unweighted kurtosis.

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Output: Let y_i be a time series of size N . The sample-size unbiased unweighted kurtosis cumulant \mathcal{K} is defined as:

$$\mathcal{K} = \frac{N(N+1)}{(N-1)(N-2)(N-3)} \sum_{i=1}^N (y_i - \bar{y})^4 - \frac{3}{(N-2)(N-3)} \left[\sum_{i=1}^N (y_i - \bar{y})^2 \right]^2.$$

The standardized unbiased kurtosis K is defined as:

$$K = \frac{\mathcal{K}}{\hat{\sigma}^4}$$

where $\hat{\sigma}^2$ is the unbiased unweighted variance around the unweighted mean. While \mathcal{K} is an unbiased estimate of the population value, K becomes unbiased in the limit of large N .

TIME_DURATION : Time duration of the G-band time series (double, Time[day])
Duration of Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

MEDIAN_ABSOLUTE_DEVIATION : Median Absolute Deviation (MAD) of the G-band time series values (double, Magnitude[mag])

Name: The Median Absolute Deviation (MAD)

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Control parameters: None

Output: Let y_i be a time series of size N . The MAD is defined as the median of the absolute deviations from the median of the data, scaled by a factor of $1/\Phi^{-1}(3/4) \approx 1.4826$ (where Φ^{-1} is the inverse of the cumulative distribution function for the standard normal distribution), so that the expectation of the scaled MAD at large N equals the standard deviation of a normal distribution:

$$\text{MAD} = 1.4826 \text{ median}\{|y_i - \text{median}\{y_j, \forall j \in (1, N)\}|, \forall i \in (1, N)\}. \quad (2.4)$$

ABBE : Abbe value of the G-band time series values (double, Dimensionless[see description])

Name: The Abbe value

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Control parameters: None

Output: Let $\{t_i, y_i\}$ be a time-sorted time series of size N , such that $t_i < t_{i+1}$ for all $i < N$. The Abbe value \mathcal{A} is defined as

$$\mathcal{A} = \frac{N}{2(N-1)} \frac{\sum_{i=1}^{N-1} (y_{i+1} - y_i)^2}{\sum_{i=1}^N (y_i - \bar{y})^2} \quad (2.5)$$

where \bar{y} is the unweighted mean.

IQR : Interquartile range of the time series values (double, Magnitude[mag])

Name: The Interquartile Range (IQR)

Input: Gaia time series, only including observations with `rejected_by_variability_processing=false`, as found in table `phot_variable_time_series_gfov`.

Control parameters: None

Output: The difference between the (unweighted) 75th and 25th percentile values:

$$\text{IQR} = P_{75} - P_{25}.$$

Let y_i be a time series of size N ordered such as $y_{(1)} \leq y_{(2)} \leq \dots \leq y_{(N)}$. The m -th (per cent) percentile P_m is defined for $0 < m \leq 100$ as follows:

$$P_m = \begin{cases} y_{(1)} & \text{if } 0 < m < p_1 \\ y_{(i)} + \frac{m-p_i}{p_{i+1}-p_i} (y_{(i+1)} - y_{(i)}) & \text{if } p_i \leq m \leq p_{i+1} \\ y_{(N)} & \text{if } p_N < m \leq 100 \end{cases}$$

where $p_i = 100 i / (N + 1)$.

2.4 RRLYRAE

This table describes the RR Lyrae stars identified in table `VariableSummary` as `classification="RRLYR"`. In the analyses only observations with `rejectedByVariabilityProcessing=false` are included, as found in table `PhotVariableTimeSeriesGfov`.

Columns description:

BEST_CLASSIFICATION : Best RR Lyrae classification estimate out of: "RRC", "RRAB" (string, Dimensionless[see description])

Classification of an RR Lyrae star according to the pulsation mode: RRC ("RRC") for first overtone and RRab ("RRAB") for fundamental mode, obtained using the period-amplitude diagram in the G-band and the plots of the Fourier parameters R21 and Phi2 vs period.

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source obtained from `gaia_source` (for a detailed description see `gaia_source.source_id`)

p1 : Period corresponding to the maximum power peak in the periodogram of G band time series (double, Time[day])

This parameter is filled with the period of the maximum power peak in the frequencygram obtained from the modeling of the time series. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum [A_i \sin(i \times 2\pi \nu_{max} t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

p1_ERROR : Uncertainty on the p1 period (double, Time[day])

This parameter is filled with the uncertainty value of the p1 parameter. Its value is derived with Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. For each of these time series the period is derived from the non linear modeling with a truncated Fourier series of the light curve. The mean of all the periods found and its standard deviation are then computed, and the latter value is kept as value to fill the `p1_error` parameter.

EPOCH_G : Epoch of the maximum of the light curve in the G band (double, Time[Barycentric JD in TCB - 2455197.5 (day)])

The epoch of maximum light for the Gaia integrated G band. It corresponds to the Barycentric Julian day (BJD) of the maximum value of the light curve model which is

closest to the BJD of the first observations $-3 \times p1$.

The mentioned BJD is offset by JD 2455197.5 (= J2010.0).

EPOCH_G_ERROR : Uncertainty on the epoch parameter epoch_g (double, Time[day])

The uncertainty value of the epoch_g parameter. Its value is three times the error on the p1.

INT_AVERAGE_G : Intensity-averaged magnitude in the G band (double, Magnitude[mag])

The intensity-averaged magnitude in the G-band. The intensity-averaged magnitude is obtained by computing the average flux and then converting the average flux to magnitude.

INT_AVERAGE_G_ERROR : Uncertainty on int_average_g parameter (double, Magnitude[mag])

This parameter is filled with the uncertainty value of the int_average_g parameter. The uncertainty is computed as the $error(zp)$, where zp is the zero point obtained by the non linear Fourier modeling of the light curve.

PEAK_TO_PEAK_G : Peak-to-peak amplitude of the G band light curve (double, Magnitude[mag])

This parameter is filled with the peak-to-peak amplitude value of the G band light curve. The peak-to-peak amplitude is calculated as the (maximum) - (minimum) of the folded modeled light curve in the G band. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum [A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

PEAK_TO_PEAK_G_ERROR : Uncertainty on the peak_to_peak_g parameter (double, Magnitude[mag])

This parameter is filled with the uncertainty value of the peak_to_peak_g parameter. The uncertainty is computed as the $\sqrt{2} \times error(zp)$, where zp is the zero point obtained by the non linear Fourier modeling of the light curve.

NUM_HARMONICS_FOR_P1 : Number of harmonics used to model P1 of the light curve (int, Dimensionless[see description])

This parameter is filled with the number of harmonics used to model P1 of the light curve. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum [A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics are determined using the Levenberg-Marquardt non linear fitting algorithm.

R21_G : Fourier decomposition parameter r21_g: A_2/A_1 (for G band) (double, Dimensionless[see description])

This parameter is filled with the Fourier decomposition parameter $R_{21} = A_2/A_1$, where A_2 is the amplitude of the 2nd harmonic and A_1 is the amplitude of the fundamental harmonic of the truncated Fourier series defined hereafter. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum [A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes

(A_i), and phases (ϕ_i) of the harmonics, are determined using the Levenberg-Marquardt non linear fitting algorithm.

R21_G_ERROR : Uncertainty on the r21_g parameter: $A2/A1$ (for G band) (double, Dimensionless[see description])

This parameter is filled with the uncertainty value on the r21_g parameter. Its value is derived by propagation of the errors in the A2 and A1 parameters. Errors in A1, A2 are computed from Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. The mean for each of these values and their standard deviations are then computed, and the latter values are kept as value to fill the uncertainty of the A1, A2 parameters.

PHI21_G : Fourier decomposition parameter phi21_g: $\phi_2 - 2*\phi_1$ (for G band) (double, Dimensionless[see description])

This parameter is filled with the Fourier decomposition parameter ϕ_{21} : $\phi_2 - 2\phi_1$ value. The light curve of the target star is modeled with a truncated Fourier series ($mag(t_j) = zp + \sum[A_i \sin(i \times 2\pi\nu_{max}t_j + \phi_i)]$). Zero-point (zp), period ($1/\nu_{max}$), number of harmonics (i), amplitudes (A_i), and phases (ϕ_i) of the harmonics, for the G-band light curve are determined using the Levenberg-Marquardt non linear fitting algorithm.

PHI21_G_ERROR : Uncertainty on the phi21_g parameter: $\phi_2 - 2*\phi_1$ (for G band) (double, Dimensionless[see description])

This parameter is filled with the uncertainty of the phi21_g parameter. Its value is derived by propagation of the errors in the phi1 and phi2 parameters. Errors in phi1, phi2 are computed from Monte Carlo simulations that generate several (100) time series with the same time path as the data points but with magnitudes generated randomly around the corresponding data value. For each of these time series the phi1, phi2 values are computed. The mean for each of these values and their standard deviation are then computed, and the latter values are kept as value to fill the uncertainty of the phi1 and phi2 parameters.

2.5 VARIABLE_SUMMARY

Table with variability summary of sources with `photVariableFlag = "VARIABLE"` in the `gaia_source` table.

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source obtained from `gaia_source` (for a detailed description see `gaia_source.source_id`)

PHOT_VARIABLE_FUNDAM_FREQ1 : Fundamental frequency 1 (double, Frequency[day^{-1}])

Identified 1st fundamental frequencies in the photometric G band, copied from either the Cepheid or Rrlyrae table depending on the value of `classification`.

CLASSIFICATION : Photometric variability classification "RRLYR" (RR Lyrae) or "CEP" (Cepheid) (string, Dimensionless[see description])

Photometric variability classification for the types included in this data release: 'RRLYR' (RR Lyrae) or 'CEP' (Cepheid). The tables `Cepheid` and `Rrlyrae` contain detailed results for each type.

Chapter 3

Crossmatch with external catalogues

3.1 ALLWISE_BEST_NEIGHBOUR

AllWISE implementation of BaseBestNeighbour

Columns description:

ALLWISE_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single

object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.2 ALLWISE_NEIGHBOURHOOD

AllWISE implementation of BaseNeighbourhood

Columns description:

ALLWISE_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.3 ALLWISE_ORIGINAL_VALID

AllWISE source catalogue

Reference paper:

Wright et al. 2010, AJ, 140, 1868

Mainzer et al. 2011, ApJ, 731, 53

Original catalogue:

<http://irsadist.ipac.caltech.edu/wise-allwise/>

<http://wise2.ipac.caltech.edu/docs/release/allwise/expsup/index.html>

Columns description:

ALLWISE_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination). This is the only field which was not in the original allWISE catalogue, but was added for cross-match purposes.

DESIGNATION : source Id in original catalog (string)

Sexagesimal, equatorial position-based source name in the form: hhmmss.ss+ddmmss.s.

The full naming convention for AllWISE Source Catalog sources has the form

”WISEA Jhhmmss.ss+ddmmss.s,” where ”WISEA” indicates the source is from the AllWISE Source Catalog, and ”J” indicates the position is J2000. The ”WISEA” acronym is not listed explicitly in the designation column.

RA : RA, ICRS (double, Angle[deg])

J2000 right ascension with respect to the 2MASS PSC reference frame from the non-moving source extraction.

The sky coverage depth for sources in the AllWISE Catalog is approximately twice as large in W1 and W2 as it is in W3 and W4. AllWISE combined W1 and W2 Single-exposure images from the WISE 4-Band Cryo, 3-Band Cryo and NEOWISE Post-Cryo survey phases, and W3 and W4 images from the 4-Band Cryo phase only. The additional epoch of W1 and W2 coverage accenuates the weight of those two bands in determining source properties such as position and motion.

DEC : DEC, ICRS (double, Angle[deg])

J2000 declination with respect to the 2MASS PSC reference frame from the non-moving source extraction.

The sky coverage depth for sources in the AllWISE Catalog is approximately twice as large in W1 and W2 as it is in W3 and W4. AllWISE combined W1 and W2 Single-exposure images from the WISE 4-Band Cryo, 3-Band Cryo and NEOWISE Post-Cryo survey phases, and W3 and W4 images from the 4-Band Cryo phase only. The additional epoch of W1 and W2 coverage accenuates the weight of those two bands in determining source properties such as position and motion.

RA_ERROR : Error in RAcosDEC (double, Angle[arcsec])

One-sigma uncertainty in right ascension coordinate from the non-moving source extraction.

DEC_ERROR : Error in DEC (double, Angle[arcsec])

One-sigma uncertainty in declination coordinate from the non-moving source extraction.

RADEC_CO_ERROR : Co-sigma between position errors (double, Angle[arcsec])

The co-sigma (`radec_co_error`) of the equatorial position uncertainties (`ra_error` and `dec_error`). Unit arcsec.

The covariance between the position errors, $C_{\alpha\delta}$ can be derived from the co-sigma by the formula:

$$C_{\alpha\delta} = \text{radec_co_error} * |\text{radec_error}|.$$

W1MPRO : W1 profile-fitting magnitude (double, Magnitude[mag])

W1 magnitude measured with profile-fitting photometry, or the magnitude of the 95% confidence brightness upper limit if the W1 flux measurement has $\text{SNR} < 2$. This column is null if the source is nominally detected in W1, but no useful brightness estimate could be made. The corresponding error column is null if the W1 profile-fit magnitude is a 95% confidence upper limit.

CAUTION: WISE profile-fit (`w?mpro`) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has `ext.flag > 0`, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

W1MPRO_ERROR : Error on W1 profile-fitting magnitude (double, Magnitude[mag])

W1 profile-fit photometric measurement uncertainty in mag units. This column is null if the W1 profile-fit magnitude is a 95% confidence upper limit or if the source is not measurable.

W2MPRO : W2 profile-fitting magnitude (double, Magnitude[mag])

W2 magnitude measured with profile-fitting photometry, or the magnitude of the 95% confidence brightness upper limit if the W2 flux measurement has $\text{SNR} < 2$. This column is null if the source is nominally detected in W2, but no useful brightness estimate could be made. The corresponding error column is null if the W2 profile-fit magnitude is a 95% confidence upper limit.

CAUTION: WISE profile-fit (`w?mpro`) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has `ext.flag > 0`, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

W2MPRO_ERROR : Error on W2 profile-fitting magnitude (double, Magnitude[mag])

W2 profile-fit photometric measurement uncertainty in mag units. This column is null if the W2 profile-fit magnitude is a 95% confidence upper limit or if the source is not measurable.

W3MPRO : W3 profile-fitting magnitude (double, Magnitude[mag])

W3 magnitude measured with profile-fitting photometry, or the magnitude of the 95% confidence brightness upper limit if the W3 flux measurement has $\text{SNR} < 2$. This column is null if the source is nominally detected in W3, but no useful brightness estimate could be made. The corresponding error column is null if the W3 profile-fit magnitude is a 95% confidence upper limit.

CAUTION: WISE profile-fit (`w?mpro`) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry

has `ext_flag>0`, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

W3MPRO_ERROR : Error on W3 profile-fitting magnitude (double, Magnitude[mag])

W3 profile-fit photometric measurement uncertainty in mag units. This column is null if the W3 profile-fit magnitude is a 95% confidence upper limit or if the source is not measurable.

W4MPRO : W4 profile-fitting magnitude (double, Magnitude[mag])

W4 magnitude measured with profile-fitting photometry, or the magnitude of the 95% confidence brightness upper limit if the W4 flux measurement has $SNR < 2$. This column is null if the source is nominally detected in W4, but no useful brightness estimate could be made. The corresponding error column is null if the W1 profile-fit magnitude is a 95% confidence upper limit.

CAUTION: WISE profile-fit (`w?mpro`) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has `ext_flag>0`, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

W4MPRO_ERROR : Error on W4 profile-fitting magnitude (double, Magnitude[mag])

W4 profile-fit photometric measurement uncertainty in mag units. This column is null if the W4 profile-fit magnitude is a 95% confidence upper limit or if the source is not measurable.

CC_FLAGS : Contamination and confusion flag (string)

Contamination and confusion flag.

Four character string, one character per band [W1/W2/W3/W4], that indicates that the photometry and/or position measurements of a source may be contaminated or biased due to proximity to an image artifact.

The type of artifact that may contaminate the measurements is denoted by the following codes. Lower-case letters correspond to instances in which the source detection in a band is believed to be real but the measurement may be contaminated by the artifact. Upper-case letters are instances in which the source detection in a band may be a spurious detection of an artifact.

- D,d - Diffraction spike. Source may be a spurious detection of (D) or contaminated by (d) a diffraction spike from a nearby bright star on the same image, or
- P,p - Persistence. Source may be a spurious detection of (P) or contaminated by (p) a short-term latent image left by a bright source, or
- H,h - Halo. Source may be a spurious detection of (H) or contaminated by (h) the scattered light halo surrounding a nearby bright source, or
- O,o (letter "o") - Optical ghost. Source may be a spurious detection of (O) or contaminated by (o) an optical ghost image caused by a nearby bright source, or
- 0 (number zero) - Source is unaffected by known artifacts.

A source extraction may be affected by more than one type of artifact or condition. In this event, the `cc_flags` value in each band is set in the following priority order:

D,P,H,O,d,p,h,o,0.

A source can appear in the AllWISE Source Catalog even if it is flagged as a spurious artifact detection in a band if there is a reliable detection in another band that is not flagged as a spurious artifact detection.

CAUTION: Non-zero `cc_flags` values in any band indicate the the measurement in that band may be contaminated and the photometry should be used with caution.

EXT_FLAG : Extended source flag (short)

Extended source flag.

This is an integer flag, the value of which indicates whether or not the morphology of a source is consistent with the WISE point spread function in any band, or whether the source is associated with or superimposed on a previously known extended object from the 2MASS Extended Source Catalog (XSC).

The values of the `ext_flag` indicate the following conditions:

- 0 - The source shape is consistent with a point-source and the source is not associated with or superimposed on a 2MASS XSC source
- 1 - The profile-fit photometry goodness-of-fit is >3.0 in one or more bands.
- 2 - The source falls within the extrapolated isophotal footprint of a 2MASS XSC source.
- 3 - The profile-fit photometry goodness-of-fit is >3.0 in one or more bands, and the source falls within the extrapolated isophotal footprint of a 2MASS XSC source.
- 4 - The source position falls within 5 arcsec of a 2MASS XSC source.
- 5 - The profile-fit photometry goodness-of-fit is >3.0 in one or more bands, and the source position falls within 5 arcsec of a 2MASS XSC source.

CAUTION: WISE profile-fit (`w?mpro`) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has `ext_flag` >0 , you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

VAR_FLAG : Variability flag (string)

Variability flag.

The variability flag is a four-character string, one character per band, in which the value for each band is related to the probability that the source flux measured on the individual WISE exposures was not constant with time.

The probability is computed for a band only when there are at least six single-exposure measurements available that satisfy minimum quality criteria.

A value of "n" in a band indicates insufficient or inadequate data to make a determination of possible variability.

Values of "0" through "9" indicate increasing probabilities of variation. Values of "0" through "5" are most likely not variables.

Sources with values of "6" and "7" are likely flux variables, but are the most susceptible to false-positive variability.

VarFlag values greater than "7" have the highest probability of being true flux variables

in a band.

CAUTION: Estimation of flux variability is unreliable for sources that are extended (`ext_flag>0`), and sources whose measurements are contaminated by image artifacts in a band (`cc_flags[band] != 0`).

PH_QUAL : Photometric quality flag (string)

Photometric quality flag.

Four character flag, one character per band [W1/W2/W3/W4], that provides a shorthand summary of the quality of the profile-fit photometry measurement in each band, as derived from the measurement signal-to-noise ratio.

- A - Source is detected in this band with a flux signal-to-noise ratio >10 .
- B - Source is detected in this band with a flux signal-to-noise ratio $3 < snr < 10$.
- C - Source is detected in this band with a flux signal-to-noise ratio $2 < snr < 3$.
- U - Upper limit on magnitude. Source measurement has $w?snr < 2$. The profile-fit magnitude $w?mpro$ is a 95% confidence upper limit.
- X - A profile-fit measurement was not possible at this location in this band. The value of $w?mpro$ and $w?sigmpro$ will be "null" in this band.
- Z - A profile-fit source flux measurement was made at this location, but the flux uncertainty could not be measured. The value of $w?sigmpro$ will be "null" in this band. The value of $w?mpro$ will be "null" if the measured flux, $w?flux$, is negative, but will not be "null" if the flux is positive. If a non-null magnitude is present, it corresponds to the true flux, and not the 95% confidence upper limit. This occurs for a small number of sources found in a narrow range of ecliptic longitude which were covered by a large number of saturated pixels from 3-Band Cryo single-exposures.

W1MJD_MEAN : Average mJD of W1 observation (double, Time[Julian Date (day)])

The average modified Julian Date (mJD) of the W1 single-exposures covering the source.

W2MJD_MEAN : Average mJD of W2 observation (double, Time[Julian Date (day)])

The average modified Julian Date (mJD) of the W2 single-exposures covering the source.

W3MJD_MEAN : Average mJD of W3 observation (double, Time[Julian Date (day)])

The average modified Julian Date (mJD) of the W3 single-exposures covering the source.

W4MJD_MEAN : Average mJD of W4 observation (double, Time[Julian Date (day)])

The average modified Julian Date (mJD) of the W4 single-exposures covering the source.

W1GMAG : W1 elliptical aperture magnitude (double, Magnitude[mag])

W1 magnitude of source measured in the elliptical aperture.

WISE profile-fit ($w?mpro$) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has

ext_flag>0, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

w1GMAG_ERROR : Error on W1 elliptical aperture magnitude (double, Magnitude[mag])

Uncertainty in the W1 magnitude of source measured in elliptical aperture.

CAUTION: A w1gerr value of 9.999 indicates that the measurement uncertainty is very large, or the uncertainty could not be computed. In either case, the w1gmag measurement should be considered highly suspect.

w2GMAG : W2 elliptical aperture magnitude (double, Magnitude[mag])

W2 magnitude of source measured in the elliptical aperture.

WISE profile-fit (w?mpro) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has ext_flag>0, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

w2GMAG_ERROR : Error on W2 elliptical aperture magnitude (double, Magnitude[mag])

Uncertainty in the W2 magnitude of source measured in elliptical aperture.

CAUTION: A w2gerr value of 9.999 indicates that the measurement uncertainty is very large, or the uncertainty could not be computed. In either case, the w2gmag measurement should be considered highly suspect.

w3GMAG : W3 elliptical aperture magnitude (double, Magnitude[mag])

W3 magnitude of source measured in the elliptical aperture.

WISE profile-fit (w?mpro) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has ext_flag>0, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

w3GMAG_ERROR : Error on W3 elliptical aperture magnitude (double, Magnitude[mag])

Uncertainty in the W3 magnitude of source measured in elliptical aperture.

CAUTION: A w3gerr value of 9.999 indicates that the measurement uncertainty is very large, or the uncertainty could not be computed. In either case, the w3gmag measurement should be considered highly suspect.

w4GMAG : W4 elliptical aperture magnitude (double, Magnitude[mag])

W4 magnitude of source measured in the elliptical aperture.

WISE profile-fit (w?mpro) measurements are optimized for point sources and will systematically underestimate the true flux of resolved objects. If a source entry has ext_flag>0, you may wish to examine the elliptical aperture photometry which are measured using areas that are scaled from 2MASS XSC morphologies.

w4GMAG_ERROR : Error on W4 elliptical aperture magnitude (double, Magnitude[mag])

Uncertainty in the W4 magnitude of source measured in elliptical aperture.

CAUTION: A w4gerr value of 9.999 indicates that the measurement uncertainty is very large, or the uncertainty could not be computed. In either case, the w4gmag

measurement should be considered highly suspect.

TMASS_KEY : 2MASS PSC association (long)
2MASS PSC association.

Unique identifier of the closest source in the 2MASS Point Source Catalog (PSC) that falls within 3 arcsec of the non-motion fit position of this WISE source. This is equivalent to the pts_key in the 2MASS PSC entry.

This column is "null" if there is no 2MASS PSC source within 3 arcsec of the WISE source position.

3.4 GSC23_BEST_NEIGHBOUR

GSC2.3 implementation of BaseBestNeighbour

Columns description:

GSC23_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.5 GSC23_NEIGHBOURHOOD

GSC2.3 implementation of BaseNeighbourhood

Columns description:

GSC23_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.6 GSC23_ORIGINAL_VALID

GSC 2.3 Catalogue

Reference paper: Lasker et al. 2008, AJ 136,735

Original catalogue: R. Smart private communication

Columns description:

GSC23_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination). This is the only field which was not in the original GSC2.3 catalogue, but was added for cross-match purposes.

GSC23_IDENTIFIER : source Id in original catalog (string)

The GSC2.3 identification is made of 10 characters, the first four representing the level-6 HTM (Hierarchical Triangular Mesh) coded in base 36 (0..9 and A..Z), and the last 6 represent a zero-filled sequence number assigned to each source upon initial detection.

RA : RA, ICRS (double, Angle[deg])

J2000 right ascension with respect to the ICRS.

DEC : DEC, ICRS (double, Angle[deg])

J2000 declination with respect to the ICRS.

POSITION_EPOCH : Position Epoch (double, Time[Julian Years])

Plate epoch for GSC-II objects. For Tycho-2 objects, for which RA epoch and DEC epoch are different, the RA epoch is given.

RA_ERROR : Reference error in RAcosDEC (double, Angle[arcsec])

Reference error in $RA \cdot \cos(DEC)$ at position epoch (position_epoch). These astrometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

DEC_ERROR : Reference error in DEC (double, Angle[arcsec])

Reference error in DEC at position epoch (position_epoch). These astrometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

FPG_MAG : Rf photographic magnitude (double, Magnitude[mag])

Magnitude in Rf photographic band (red).

FPG_MAG_ERROR : Reference error on Rf (double, Magnitude[mag])

Reference error in Rf photographic band (red).

These photometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

FPG_MAG_CODE : Rf filter Code (short)

coded emulsion / bandpass / filter:

bcode Name Emulsion/Filter

35 Fpg IIIaF+RG610 (POSS-II Red)
36 Fpg IIIaF+OG590 (SERC-ER/SR, AAO-R/GR)

JPG_MAG : B_j photographic magnitude (double, Magnitude[mag])
Magnitude in B_j photographic band (blue).

JPG_MAG_ERROR : Reference error on B_j (double, Magnitude[mag])
Reference error in B_j photographic band (blue).
These photometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

JPG_MAG_CODE : B_j filter Code (short)
coded emulsion / bandpass / filter:

bcode Name Emulsion/Filter

0 Jpg IIIaJ+GG395 (SERC-J/EJ)
18 Jpg IIIaJ+GG385 (POSS-II Blue)

V_MAG : V (photographic) magnitude (double, Magnitude[mag])
Magnitude in V band.

This magnitude may include:

- photographic V₁₂ or V₄₈₅ from IIaD plates,
- V_T of Tycho-2 stars, or
- Johnson V from SKY2000

V_MAG_ERROR : Reference error on V (double, Magnitude[mag])
Reference error in V band.

These photometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

V_MAG_CODE : V filter Code (short)
coded emulsion / bandpass / filter:

bcode Name Emulsion/Filter

1 V IIaD+W12 (Pal Quick-V)
4 V (Johnson)
6 V495 IIaD+GG495 (Pal QV/AAO XV)
42 VT TYCHO-V

NPG_MAG : In photographic magnitude (double, Magnitude[mag])
Magnitude in In photographic band.

NPG_MAG_ERROR : Reference error on In (double, Magnitude[mag])
Reference error in In photographic band.
These photometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

NPG_MAG_CODE : In filter Code (short)
coded emulsion / bandpass / filter:

bcode Name Emulsion/Filter

37 Npg IVN+RG9 (POSS-II IR)
38 Npg IVN+RG715 (SERC-IR)

B_MAG : B magnitude (double, Magnitude[mag])
Magnitude in B band.
This filter may include:

- B_T of Tycho-2 stars,
- Johnson B from SKY2000, or
- photographic O from pOSS-I.

B_MAG_ERROR : Reference error on B (double, Magnitude[mag])
Reference error in B band.
These photometric errors are not formal statistical uncertainties but raw and conservative estimates to be used for telescope operations.

B_MAG_CODE : B filter Code (short)
coded emulsion / bandpass / filter:

bcode Name Emulsion/Filter

3 B (Johnson)
7 O 103aO+no filter (POSS-I Blue)
41 BT TYCHO-B

CLASSIFICATION : Morphological classification (short)
Image classification:
0 = "star", i.e. point-like object
3 = "nonstar", i.e. extended object

STATUS : Object processing status flag (string)

The status code is a 10-digit field encoding the properties of the catalog object.
This flag is 99999900 for a Tycho object and 88888800 for SKY2000 object.

digit	explanation	values
.....xx	Number of plates on which the object appeared	
.....x..	Centroid type associated with the exported position	0 = barycenter 1 = circular gaussian 2 = elliptical gaussian 3 = FPA-applied barycenter 4 = multicircular 5 = multielliptical 6 = FPA + circular 7 = FPA + elliptical
.....x...	Quality of exported J magnitude	0 = not present 1 = fit 2 = extrapolated
.....x....	Quality of exported F magnitude	0 = not present 1 = fit 2 = extrapolated
....x.....	Quality of exported V magnitude	0 = not present 1 = fit 2 = extrapolated
...x.....	Classification unanimity	0 = mixed vote 1 = unanimous vote 2 = unanimous defect
..x.....	Classification voters	0 = several 15um scan 1 = one 15um scan 2 = several 25um scan 3 = one 25um scan
.x.....	Processing status	0 = complete processing on all plates 1 = object too big (>2562 pix) on at least one plate
x.....	Deblending	0 = single object on all plates 1 = child (deblended) object on at least one plate.

FPA = Fractional Pixel Allocation)

MULT_FLAG : Multiple object flag (short)

This flag concerns only the Tycho stars (Status=99999900).

3.7 PPMXL_BEST_NEIGHBOUR

PPMXL implementation of BaseBestNeighbour

Columns description:

PPMXL_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.8 PPMXL_NEIGHBOURHOOD

PPMXL implementation of BaseNeighbourhood

Columns description:

PPMXL_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.9 PPMXL_ORIGINAL_VALID

PPMXL Catalogue

Reference papers:

PPMXL: Roeser et al. 2010, AJ 139, 2440

PPMX: Roeser et al. 2008, A&A 488, 401

Original Catalogue:

VO access: <http://vo.uni-hd.de/ppmxl>

Columns description:

PPMXL_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination). This field was not in the original PPMXL catalogue, but was added for cross-match purposes.

IPIX : source Id in original catalog (long)

Identifier (Q3C ipix of the USNO-B 1.0 object)

RA : RA, ICRS, epoch J2000.0 (double, Angle[deg])

J2000 right ascension with respect to the ICRS, epoch 2000.0

DEC : DEC, ICRS, epoch J2000.0 (double, Angle[deg])

J2000 declination with respect to the ICRS, epoch 2000.0.

RA_ERROR_EPRA : mean error at mean epoch in $RA\cos DEC$ (double, Angle[mas])

Mean error in $RA\cos(DEC)$ at mean epoch.

DEC_ERROR_EPDE : mean error at mean epoch in DEC (double, Angle[mas])

Mean error in DEC at mean epoch.

PMRA : proper motion in $RA\cos DEC$ (double, Angular Velocity[mas/year])

Proper motion in $RA\cos(DEC)$.

PMDE : proper motion in DEC (double, Angular Velocity[mas/year])

Proper motion in Declination.

PMRA_ERROR : mean error in proper motion in $RA\cos DEC$ (double, Angular Velocity[mas/year])

Mean error in proper motion in $RA\cos(DEC)$.

PMDE_ERROR : mean error in proper motion in DEC (double, Angular Velocity[mas/year])

Mean error in proper motion in DEC.

N_EPOCHS : number of epochs used for proper motions (short)

Number of catalogs (epoch) used for proper motions.

May be blank (null) for stars coming from ARIHIP or Tycho-2 via PPMX (i.e. bit#1 is set in "fl").

EPRA : Mean RA Epoch (double, Time[Julian Years])
Mean Epoch for RA.

EPDE : Mean DEC Epoch (double, Time[Julian Years])
Mean Epoch for DEC.

B1MAG : USNO B mag first epoch (double, Magnitude[mag])
B mag from USNO-B, first epoch.

Magnitudes from USNO-B should be used with care, photometric calibration may be severely off for some plates.

For objects from PPMX (bit#1 set in "fl"), these magnitudes have a special meaning:

Column [PPMX] Content

b1mag [Cmag] Catalogue magnitude from source
b2mag [Bmag] Johnson B magnitude
r1mag [Rmag] calculated Ru (UCAC) magnitude from source
r2mag — (always empty)
imag [Vmag] Johnson V magnitude

B2MAG : USNO B mag second epoch (double, Magnitude[mag])
B mag from USNO-B, second epoch.

Magnitudes from USNO-B should be used with care, photometric calibration may be severely off for some plates.

For objects from PPMX (bit#1 set in "fl"), these magnitudes have a special meaning:

Column [PPMX] Content

b1mag [Cmag] Catalogue magnitude from source
b2mag [Bmag] Johnson B magnitude
r1mag [Rmag] calculated Ru (UCAC) magnitude from source
r2mag — (always empty)
imag [Vmag] Johnson V magnitude

R1MAG : USNO R mag first epoch (double, Magnitude[mag])
R mag from USNO-B, first epoch.

Magnitudes from USNO-B should be used with care, photometric calibration may be severely off for some plates.

For objects from PPMX (bit#1 set in "fl"), these magnitudes have a special meaning:

Column [PPMX] Content

b1mag [Cmag] Catalogue magnitude from source
b2mag [Bmag] Johnson B magnitude
r1mag [Rmag] calculated Ru (UCAC) magnitude from source

r2mag — (always empty)
imag [Vmag] Johnson V magnitude

R2MAG : USNO R mag second epoch (double, Magnitude[mag])
R mag from USNO-B, second epoch.

Magnitudes from USNO-B should be used with care, photometric calibration may be severely off for some plates.

For objects from PPMX (bit#1 set in "fl"), these magnitudes have a special meaning:

Column [PPMX] Content

b1mag [Cmag] Catalogue magnitude from source
b2mag [Bmag] Johnson B magnitude
r1mag [Rmag] calculated Ru (UCAC) magnitude from source
r2mag — (always empty)
imag [Vmag] Johnson V magnitude

IMAG : USNO I mag (double, Magnitude[mag])
I mag from USNO-B.

Magnitudes from USNO-B should be used with care, photometric calibration may be severely off for some plates.

For objects from PPMX (bit#1 set in "fl"), these magnitudes have a special meaning:

Column [PPMX] Content

b1mag [Cmag] Catalogue magnitude from source
b2mag [Bmag] Johnson B magnitude
r1mag [Rmag] calculated Ru (UCAC) magnitude from source
r2mag — (always empty)
imag [Vmag] Johnson V magnitude

FLAGS : flags (short)

The flag is a bitwise or number ($\Sigma 2^i$) where each bit number (i) has the meaning:

#0 (1) = if set, one of the coordinates had an excessively large chi square.

#1 (2) = Row is from PPMX. These objects are mostly Tycho stars that were masked out of USNO-B. When this bit is set, the USNO magnitudes (b1mag through imag) have special meanings.

#2 (4) = Row is from PPMX and replaces a single row from USNO-B. This is done when the astrometry from PPMX was better (in terms of error estimates) than the astrometry of the corresponding PPMXL object.

#3 (8) = Row replaces multiple USNO-B1.0 objects. When PPMX contains an object that has more than one counterpart in PPMXL, all such counterparts are discarded on the assumption that they should have been matched in USNO-B1.0 or result from erroneous matches. For these rows, bit#1 is always 1.

3.10 RAVE4_BEST_NEIGHBOUR

RAVE-4 implementation of BaseBestNeighbour

Columns description:

RAVE4_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

RAVE_IDENTIFIER : Original Object ID (string)
Object ID (RA-DEC)

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.11 RAVE4_NEIGHBOURHOOD

RAVE-4 implementation of BaseNeighbourhood

Columns description:

RAVE4_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

RAVE_IDENTIFIER : Original Object ID (string)

Object ID (RA-DEC)

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.12 RAVE4_ORIGINAL_VALID

RAVEdr4 original catalog subset: stellar atmospheric parameters (effective temperature, surface gravity, overall metallicity), radial velocities, individual abundances, and distances determined for 482194 stars. See 2013AJ....146..134K and https://www.rave-survey.org/project/documentation/dr4/rave_dr4/

Columns description:

HRV : Heliocentric radial velocity (double, Velocity[km/s])
Heliocentric radial velocity

E_HRV : Error of Heliocentric radial velocity (double, Velocity[km/s])
Error of Heliocentric radial velocity

TEFF_K : Effective Temperature (double, Temperature[K])
Effective temperature from Stellar Parameter Pipeline (TeffK)

E_TEFF_K : Effective Temperature error (double, Temperature[K])
Effective Temperature error

LOGG_K : Gravity (double)
Log gravity from Stellar Parameter Pipeline (logg_k)

E_LOGG_K : Gravity error (double)
Error on logg_k

MET_K : Metallicity (double)
Metallicity [m/H] from Stellar Parameter Pipeline ([M/H]K)

MET_NK : Metallicity matisse calib (double)
Calibrated Metallicity [m/H] from Stellar Parameter Pipeline

E_MET_K : Metallicity error (double)
Error on [M/H]K

SNR_K : Signal to noise (double)
Signal/Noise Ratio of Pipelinem Kordopatis Pipeline

AL : Abundance of Al (double)
[Al/H] abundance of Al

AL_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Al/H]

SI : Abundance of Si (double)
[Si/H] abundance of Si

SI_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Si/H]

FE : Abundance of Fe (double)
[Fe/H] abundance of Fe

FE_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Fe/H]

TI : Abundance of Ti (double)
[Ti/H] abundance of Ti

TI_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Ti/H]

NI : Abundance of Ni (double)
[Ni/H] abundance of Ni

NI_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Ni/H]

MG : Abundance of Mg (double)
[Mg/H] abundance of Mg

MG_N : Number of used spectral lines (short)
Number of used spectral lines in calc. of [Mg/H]

CHL_SQ_C : Chi square (double)
chi square [Chemical pipeline]

TEFF_SPARV : Effective Temperature (double, Temperature[K])
SPARV effective temperature

LOGG_SPARV : Gravity (double)
SPARV Log gravity

ALPHA_SPARV : [Alpha/Fe] (double)
SPARV alpha-elements enhancement

PARALLAX : Parallax (double, Angle[mas])
Spectrophotometric Parallax

E_PARALLAX : Parallax error (double, Angle[mas])
Error on Parallax

AV : Extinction (double)
log₁₀(A_v) optical extinction, see p4 ff, Mon. Not. R. Astron. Soc. 000, 1-8 (2012)

E_AV : Extinction error (double)
error log₁₀(A_v) optical extinction, see p4 ff, Mon. Not. R. Astron. Soc. 000, 1-8 (2012)

AGE : Age (double)

log10(age) Age estimation

E_AGE : Age error (double)
error log10(age) error of age estimation

MASS : Mass (double, Mass[Solar Mass])
See Binney et al. (2014MNRAS.437..351B)

E_MASS : Mass error (double, Mass[Solar Mass])
See Binney et al. (2014MNRAS.437..351B)

RAVE4_OID : Unique Numeric Identifier (long)
Incremental unique numeric identifier (increasing with declination). This is the only field which was not in the original RAVE catalogue, but was added for cross-match purposes.

RAVE_OBS_ID : Original Unique identifier (string)
Unique Identifier for RAVE objects: Observation Date, Fieldname, Fibernumber

RAVE_IDENTIFIER : Original Object ID (string)
Object ID (RA-DEC)

RA : Right Ascension (double, Angle[deg])
RAVEDr4 right ascension.

E_RA : Right Ascension error (double, Angle[arcsec])
right ascension error, fixed to 3 arcsec (not in original data, estimated for XM purposes).

DEC : Declination (double, Angle[deg])
RAVEDr4 declination.

E_DEC : Declination error (double, Angle[arcsec])
declination error, fixed to 3 arcsec (not in original data, estimated for XM purposes).

REF_EPOCH : Mean epoch (double, Time[Julian Years])
Mean epoch of RAVE DR4 observations.

3.13 SDSS_DR9_BEST_NEIGHBOUR

URAT-1 implementation of BaseBestNeighbour

Columns description:

SDSSDR9_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.14 SDSS_DR9_NEIGHBOURHOOD

URAT-1 implementation of BaseNeighbourhood

Columns description:

SDSSDR9_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.15 SDSSDR9_ORIGINAL_VALID

SDSS DR9 Catalogue, primary object only, extracted from photoObj fits files.

Reference paper: Ahn et al. 2012, ApJS 203,21

Original catalogue: <http://data.sdss3.org/sas/dr9/boss/photoObj/>

Columns description:

SDSSDR9_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination). This is the only field which was not in the original SDSS DR9 catalogue, but was added for cross-match purposes.

OBJ_ID : Unique SDSS identifier (string)

A number identifying an object in the image catalog for DR9. It is a bit-encoded integer of run, rerun, camcol, field, object.

The bits are assigned in objid as follows:

- **63** 0, unassigned
- **59–62** skyVersion resolved sky version
- **48–58** rerun, number of pipeline rerun
- **32–47** run, run number
- **29–31** camcol, camera column (1-6)
- **28** 0, unassigned
- **16–27** field, field number within run
- **0–15** id, object number within field

THING_ID : Unique identifier from global resolve (long)

Each unique source in the SDSS catalog is identified by the **thing.id**. Each source may have been observed more than once in multiple runs, and might therefore have multiple detections listed in the catalog. Only one detection is considered primary.

RA : RA (double, Angle[deg])

J2000 Right Ascension (from r-band, or best other band if r-band if too faint or saturated in r).

DEC : DEC (double, Angle[deg])

J2000 Declination (from r-band, or best other band if r-band if too faint or saturated in r).

RA_ERROR : Reference error in RAcosDEC (double, Angle[arcsec])

Error in $RA \cdot \cos(DEC)$

DEC_ERROR : Reference error in DEC (double, Angle[arcsec])

Error in DEC.

MJD : Date of observation (double, Time[day])
Modified Julian Date, used to indicate the date that a given piece of SDSS data (image or spectrum) was taken.

U_MAG : PSF magnitude in the u band (double, Magnitude[mag])
For isolated stars, which are well-described by the point spread function (PSF), the optimal measure of the total flux is determined by fitting a PSF model to the object.

U_MAG_ERROR : error on PSF magnitude in the u band (double, Magnitude[mag])
PSF magnitude error.

G_MAG : PSF magnitude in the g band (double, Magnitude[mag])
For isolated stars, which are well-described by the point spread function (PSF), the optimal measure of the total flux is determined by fitting a PSF model to the object.

G_MAG_ERROR : error on PSF magnitude in the g band (double, Magnitude[mag])
PSF magnitude error.

R_MAG : PSF magnitude in the r band (double, Magnitude[mag])
For isolated stars, which are well-described by the point spread function (PSF), the optimal measure of the total flux is determined by fitting a PSF model to the object.

R_MAG_ERROR : error on PSF magnitude in the r band (double, Magnitude[mag])
PSF magnitude error.

I_MAG : PSF magnitude in the i band (double, Magnitude[mag])
For isolated stars, which are well-described by the point spread function (PSF), the optimal measure of the total flux is determined by fitting a PSF model to the object.

I_MAG_ERROR : error on PSF magnitude in the i band (double, Magnitude[mag])
PSF magnitude error.

Z_MAG : PSF magnitude in the z band (double, Magnitude[mag])
For isolated stars, which are well-described by the point spread function (PSF), the optimal measure of the total flux is determined by fitting a PSF model to the object.

Z_MAG_ERROR : error on PSF magnitude in the z band (double, Magnitude[mag])
PSF magnitude error.

OBJC_TYPE : type classification of the object (int)
Distinguishes stars (type=6) and galaxies (type=3) based on their morphology. It is quantified on the basis of the difference between the PSF and model magnitudes.

CLEAN_FLAG : clean photometry flag for point sources (int)
Clean photometry flag for point sources (1=clean, 0=unclean).

3.16 TMASS_BEST_NEIGHBOUR

2MASS implementation of BaseBestNeighbour

Columns description:

TMASS_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.17 TMASS_NEIGHBOURHOOD

2MASS implementation of BaseNeighbourhod

Columns description:

TMASS_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.18 TMASS_ORIGINAL_VALID

2MASS PSC Catalogue

Reference paper: Skrutskie et al. 2006, AJ 131, 1163

Documentation: <http://www.ipac.caltech.edu/2mass/releases/allsky/doc/explsup.html>

Original catalogue: <ftp://ftp.ipac.caltech.edu/pub/2mass/allsky>

Columns description:

PH_QUAL : JHKs Photometric quality flag (string)

Photometric quality flag. Three character flag, one character per band [JHKs], that provides a summary of the net quality of the default photometry in each band. The value for ph_qual is set for a band according to the precedence of the table below. For example, a source that is tested and meets the conditions for category "X" is not tested for subsequent qualities.

- "X" - There is a detection at this location, but no valid brightness estimate can be extracted using any algorithm. Default magnitude is null.
- "U" - Upper limit on magnitude. Source is not detected in this band, or it is detected, but not resolved in a consistent fashion with other bands. A value of ph_qual="U" does not necessarily mean that there is no flux detected in this band at the location.
- "F" - This category includes sources where a reliable estimate of the photometric error could not be determined. The uncertainties reported for these sources in [jhk]_msigcom are flags and have numeric values >8.0.
- "E" - This category includes detections where the goodness-of-fit quality of the profile-fit photometry was very poor, or detections where psf fit photometry did not converge and an aperture magnitude is reported, or detections where the number of frames was too small in relation to the number of frames in which a detection was geometrically possible.
- "A" - Detections in any brightness regime where valid measurements were made with [jhk]_snr>10 AND [jhk]_cmsig<0.10857.
- "B" - Detections in any brightness regime where valid measurements were made with [jhk]_snr>7 AND [jhk]_cmsig<0.15510.
- "C" - Detections in any brightness regime where valid measurements were made with [jhk]_snr>5 AND [jhk]_cmsig<0.21714.
- "D" - Detections in any brightness regime where valid measurements were made with no [jhk]_snr or [jhk]_cmsig requirement.

TMASS_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination). This is the only field which was not in the original 2MASS catalogue, but was added for cross-match purposes.

DESIGNATION : source Id in original catalog (string)

Sexagesimal, equatorial position-based source name in the form: hhmssss+ddmmsss[ABC...]
The prefix "2MASS J" is not explicitly listed in the designation.

RA : RA, ICRS (double, Angle[deg])
J2000 right ascension with respect to the ICRS

DEC : DEC, ICRS (double, Angle[deg])
J2000 declination with respect to the ICRS

ERR_MAJ : semi-major axis pos uncertainty (float, Angle[arcsec])
Semi-major axis length of the one sigma position uncertainty ellipse

ERR_MIN : semi-minor axis pos uncertainty (float, Angle[arcsec])
Semi-minor axis length of the one sigma position uncertainty ellipse

ERR_ANG : position angle (int, Angle[deg])
Position angle on the sky of the semi-major axis of the position uncertainty ellipse
(East of North)

J_M : Band J magnitude (float, Magnitude[mag])
Default J-band magnitude.
In case of a source not detected in the J-band, it is an upper limit and the corresponding total photometric uncertainty is NULL.
In case of a source detected in the J-band and with no useful brightness estimate, it is set to NULL.

J_MSIGCOM : J magnitude uncertainty (float, Magnitude[mag])
Total photometric uncertainty for the default J-band magnitude. This column is NULL if the default magnitude is a 95% confidence upper limit (i.e. the source is not detected, or inconsistently deblended in the J-band).

H_M : Band H magnitude (float, Magnitude[mag])
Default H-band magnitude.
In case of a source not detected in the H-band, it is an upper limit and the corresponding total photometric uncertainty is NULL.
In case of a source detected in the H-band and with no useful brightness estimate, it is set to NULL.

H_MSIGCOM : H magnitude uncertainty (float, Magnitude[mag])
Total photometric uncertainty for the default H-band magnitude. This column is NULL if the default magnitude is a 95% confidence upper limit (i.e. the source is not detected, or inconsistently deblended in the H-band).

KS_M : Band Ks magnitude (float, Magnitude[mag])
Default Ks-band magnitude.
In case of a source not detected in the Ks-band, it is an upper limit and the corresponding total photometric uncertainty is NULL.
In case of a source detected in the Ks-band and with no useful brightness estimate, it is set to NULL.

KS_MSIGCOM : Ks magnitude uncertainty (float, Magnitude[mag])

Total photometric uncertainty for the default Ks-band magnitude. This column is NULL if the default magnitude is a 95% confidence upper limit (i.e. the source is not detected, or inconsistently deblended in the Ks-band).

EXT_KEY : UID of the record in the XSC (long)

Unique identification number of the record in the XSC (2MASS Extended Source Catalogue) that corresponds to this point source. Can be NULL if no corresponding extended source is present in the XSC.

J_DATE : Julian Date of source measurement (double, Time[Julian Date (day)])

The Julian Date of the source measurement accurate to +30 seconds. This value is extrapolated from the start time of the Survey scan using the difference between the declinations of the source and the first row in the Tile divided by the scanning rate of the telescope (approximately 5sec). The scanning rate of the two 2MASS telescopes was slightly different because of the need to optimize the dithering of images on the arrays.

3.19 UCAC4_BEST_NEIGHBOUR

UCAC4 implementation of BaseBestNeighbour

Columns description:

UCAC4_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTIPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.20 UCAC4_NEIGHBOURHOOD

UCAC4 implementation of BaseNeighbourhood

Columns description:

UCAC4_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.21 UCAC4_ORIGINAL_VALID

UCAC4 Catalogue

Reference paper:

Zacharias N., et al. 2013, AJ 145, 44

Original catalogue:

DVD sent by author.

Columns description:

OBJT : Object type (int)

The object type flag is used to identify possible problems with a star or the source of data.

The object type flag has the following meaning:

- 0 = good, clean star, no known problem
- 1 = largest flag of any image = near overexposed star
- 2 = largest flag of any image = possible streak object
- 3 = high proper motion (HPM) star, match with external PM file
- 4 = actually use external HPM data instead of UCAC4 observ.data (accuracy of positions varies between catalogs)
- 5 = poor proper motion solution, report only CCD epoch position
- 6 = substitute poor astrometric results by FK6/Hip/Tycho-2 data
- 7 = added supplement star (no CCD data) from FK6/Hip/Tycho-2 data, and 2 stars added from high proper motion surveys
- 8 = high proper motion solution in UCAC4, star not matched with PPMXL
- 9 = high proper motion solution in UCAC4, discrepant PM to PPMXL

CDF : Combined double flag (int)

The **cdf** flag is a combined double star flag used to indicate the type/quality of double star fit. It is a combination of 2 flags:

$$\mathbf{cdf} = (10 \cdot \mathbf{dsf}) + \mathbf{dst}$$

where

dsf = double star flag = overall classification

- 0 = single star
- 1 = component #1 of "good" double star
- 2 = component #2 of "good" double star
- 3 = blended image

dst = double star type, from pixel data image profile fits, largest value of all images used for this star

- 0 = no double star, not sufficient #pixels or elongation

- to even call double star fit subroutine
- 1 = elongated image but no more than 1 peak detected
- 2 = 2 separate peaks detected → try double star fit
- 3 = secondary peak found on each side of primary
- 4 = case 1 after successful double fit (small separ. blended image)
- 5 = case 2 after successful double fit (most likely real double)
- 6 = case 3 after successful double fit (brighter secondary picked)

Caution: often a dsf= 1 or 2 image is paired with a dsf= 3. If for a star any of the several images reveals a "blended image", that higher dsf=3 flag is carried into the output file. This can happen for a regular double star with unique components 1 and 2. A flag dsf=3 means this could be component 1 or 2 but at least on one CCD frame a blended image was detected. This blend could be with the other component, or a spurious image or artifact. The double star flags need to be interpreted with caution; anything but a zero means "likely some double star component or blended image".

UCAC4_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination).

This field was not in the original UCAC4 catalogue, but was added for cross-match purposes.

UCAC4_IDENTIFIER : source Id in original catalog (string)

Official UCAC4 star ID, in the following format:

UCAC4-zzz-nnnnnn

where zzz is the 3-digit zone number (from 001 to 900, each 0.2 deg wide) and nnnnnn the 6-digit running record number along the zone file.

RA : RA, ICRS (double, Angle[deg])

Right ascension with respect to the ICRS at epoch J2000.0.

The weighted mean catalog position was updated using the provided proper motions.

NB For objects with no proper motions, the positions are at the central epoch (which actually is UCAC4 mean observation epoch). There are 4 982 212 stars with no proper motions.

DEC : DEC, ICRS (double, Angle[deg])

Declination with respect to the ICRS, at epoch J2000.0.

The weighted mean catalog position was updated using the provided proper motions.

NB For objects with no proper motions, the positions are at the central epoch (which actually is UCAC4 mean observation epoch). There are 4 982 212 stars with no proper motions.

RA_ERROR_MEAN_EPOCH : s.e. at central epoch in RAcosDEC (double, Angle[mas])

There is not 0 mas value; data less than 1 mas have been set to 1 mas. Original data larger than 255 mas have been set to 255.

In order to be able to calculate positional errors at any epoch, the central epoch, i.e. the

weighted mean epoch of the data (UCAC + early epoch other catalogs) is given. At the central epoch (which varies from star to star and is also different for RA and Dec) the positional error has its smallest value; the one given in the catalog for "sigma position". If the astrometric data for a star was substituted from an external catalog like Hipparcos, Tycho or High proper motion data, a mean error in position and proper motion depending on the catalog and magnitude of the star was adopted. For stars with no proper motions only the observed CCD position and its error is reported.

DEC_ERROR_MEAN_EPOCH : s.e. at central epoch in DEC (double, Angle[mas])

There is not 0 mas value; data less than 1 mas have been set to 1 mas. Original data larger than 255 mas have been set to 255.

In order to be able to calculate positional errors at any epoch, the central epoch, i.e. the weighted mean epoch of the data (UCAC + early epoch other catalogs) is given. At the central epoch (which varies from star to star and is also different for RA and Dec) the positional error has its smallest value; the one given in the catalog for "sigma position". If the astrometric data for a star was substituted from an external catalog like Hipparcos, Tycho or High proper motion data, a mean error in position and proper motion depending on the catalog and magnitude of the star was adopted.

For stars with no proper motions only the observed CCD position and its error is reported.

PMRA : proper motion in RAcosDEC (double, Angular Velocity[mas/year])

Proper motion in $RA \cdot \cos(Dec)$.

PMDE : proper motion in DEC (double, Angular Velocity[mas/year])

Proper motion in Declination.

PMRA_ERROR : s.e. in proper motion in RAcosDEC (double, Angular Velocity[mas/year])

For astrometric data copied from the FK6, Hipparcos and Tycho-2 catalogs a mean error in positions was adopted depending on input catalog and the brightness of the star rather than giving the individual star's error quoted in those catalogs.

PMDE_ERROR : s.e. in proper motion in DEC (double, Angular Velocity[mas/year])

For astrometric data copied from the FK6, Hipparcos and Tycho-2 catalogs a mean error in positions was adopted depending on input catalog and the brightness of the star rather than giving the individual star's error quoted in those catalogs.

MEAN_EPOCH_RA : Central epoch for mean RA (double, Time[Julian Years])

Central Epoch for mean RA.

Probably epoch is a Julian epoch expressed as Julian Years with reference J2000.0. For stars with proper motions, the central epoch, i.e. the weighted mean epoch of the data (UCAC + early epoch other catalogs) is given. At the central epoch (which varies from star to star and is also different for RA and Dec) the positional error has its smallest value; the one given in the catalog for "sigma position".

For stars with no proper motions, the central Epoch is the UCAC4 mean observation

epoch.

MEAN_EPOCH_DEC : Central epoch for mean DEC (double, Time[Julian Years])

Central Epoch for mean DEC.

Probably epoch is a Julian epoch expressed as Julian Years with reference J2000.0. For stars with proper motions, the central epoch, i.e. the weighted mean epoch of the data (UCAC + early epoch other catalogs) is given. At the central epoch (which varies from star to star and is also different for RA and Dec) the positional error has its smallest value; the one given in the catalog for "sigma position".

For stars with no proper motions, the central Epoch is the UCAC4 mean observation epoch.

MAGM : fit model magnitude (double, Magnitude[mag])

Fit model magnitude.

Systematic errors are expected to be below 0.1 mag for magm,maga photometric results obtained from the UCAC CCD pixel data. The aperture photometry is considered more robust, particularly for "odd" cases, while the model fit magnitude is expected to be more accurate for "well behaved" stars.

MAGA : aperture magnitude (double, Magnitude[mag])

Aperture magnitude.

Systematic errors are expected to be below 0.1 mag for magm,maga photometric results obtained from the UCAC CCD pixel data. The aperture photometry is considered more robust, particularly for "odd" cases, while the model fit magnitude is expected to be more accurate for "well behaved" stars.

SIGMAG : error of magnitude (double, Magnitude[mag])

For many stars a photometric error based on the scatter from individual observations of that star on different CCD frames could be obtained. A model error was also attempted to be assigned, based on the S/N ratio. The error quoted here is the larger of the two.

If the error exceeds 0.9 mag, the error was set to 0.9 mag in catalog data.

N_EPOCHS : number of epochs used for proper motions (short)

Number of catalogs (epoch) used for proper motions.

3.22 URAT1_BEST_NEIGHBOUR

URAT-1 implementation of BaseBestNeighbour

Columns description:

URAT1_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (int)

Number of sources in the External Catalogue which match the Gaia source within position errors.

The identifiers of all the neighbours can be found in the Neighbourhood table.

NUMBER_OF_MATES : Number of mates in Gaia Catalogue (short)

Number of other Gaia sources that have as best-neighbour the same External Catalogue source.

In case there are no other Gaia sources with the same best-neighbour in the external catalogue, the number of mates is equal to zero.

Given the Gaia high angular resolution, it will happen that what appears as a single object in an external catalogue will be resolved by Gaia and as such will be the best-match of more than one Gaia object.

BEST_NEIGHBOUR_MULTPLICITY : Number of neighbours with same probability as best neighbour (short)

The best-match to a Gaia source in an external catalogue is the source in the external catalogue that has the highest probability to be the best-match.

As the probability is based on positional and density properties, it could happen that there is more than one source in the external catalogue with the same probability.

Even if a single best-match is always chosen, this field tells the user if there were more "best" neighbours. Those neighbours can be found in the Neighbourhood table.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.23 URAT1_NEIGHBOURHOOD

URAT-1 implementation of BaseNeighbourhood

Columns description:

URAT1_OID : External Catalogue source identifier (long)

The additional numeric unique source identifier of the External catalogue, increasing with Declination.

SOURCE_ID : Unique Gaia source identifier (long)

Unique identifier of the Gaia source, the attribute corresponds to `gaia_source.source_id`

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

ANGULAR_DISTANCE : Angular Distance between the two sources (double, Angle[arcsec])

Angular distance between a Gaia source and its nearest neighbour in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.

For the first Gaia release the score will be a likelihood ratio based on geometric distance and local density of the external catalogue: the higher the score, the most probable the match is.

PROPER_MOTION_FLAG : Use of Gaia proper motions (short)

This flag is set to 0 if Gaia proper motions were not available and were thus not used in the XMatch.

This flag is set to 1 if Gaia proper motions were available and were thus used in the XMatch (for the First Gaia release the TGASS sub-sample).

3.24 URAT1_ORIGINAL_VALID

URAT-1 Catalogue

Reference paper:

A URAT-1 release paper for the Astronomical Journal is in preparation.
The first U.S. Naval Observatory Astrometric Robotic Telescope Catalog (URAT1) Zacharias N., Finch C., Subasavage J., Bredthauer G., Crockett C., Divittorio M., Furguson E., Harris F., Harris H., Henden A., Kilian C., Munn J., Rafferty T., Rhodes A., Schultheiss M., Tilleman T., Wieder G. =2015yCat.1329....0Z

Original catalogue:

CDS

Columns description:

URAT1_OID : Unique Numeric Identifier (long)

Incremental unique numeric identifier (increasing with declination).

This is the only field which was not in the original URAT1 catalogue, but was added for cross-match purposes.

URAT1_IDENTIFIER : source Id in original catalog (string)

Official URAT1 star ID numbers consist of 2 parts, the 3-digit zone number (zzz) and the 6-digit running record number (nnnnnn) along a zone.

Thus a URAT1 star number is given by:

URAT1-zzznnnnnn

The main catalog data are arranged in declination zones of 0.2 degree width. Zones are numbered from 1 starting at the South Pole and increasing toward north. The first zone with data in URAT1 is 326 for -25.0 to -24.8 deg Dec. There is a separate file for each zone up to zone 900 near the north celestial pole.

RA : RA, ICRS at mean epoch (double, Angle[deg])

Positions are on the International Celestial Reference System (ICRS) as represented by the UCAC4 catalog.

Mean observed positions are given at mean epoch of URAT observations (epoch). Thus the epoch is slightly different from star to star, but it is always in the range between 2012.311 and 2014.679.

DEC : DEC, ICRS at mean epoch (double, Angle[deg])

Positions are on the International Celestial Reference System (ICRS) as represented by the UCAC4 catalog.

Mean observed positions are given at mean epoch of URAT observations (epoch). Thus the epoch is slightly different from star to star, but it is always in the range between 2012.311 and 2014.679.

RA_ERROR : Position error from model (double, Angle[arcsec])

ra_error = posError

posError gives an estimate of the error of the mean position components (ra and dec).

A mean was taken over RA and DEC component errors because they are very similar for most stars.

Here a model is used which include image profile fit (x,y data) errors, atmospheric

turbulence, and astrometric reduction error propagations. A systematic error floor of 5 mas was added RMS. The model error is likely a better estimate of the true positional errors than the scatter error, at least for small numbers of observations.

DEC_ERROR : Position error from model (double, Angle[arcsec])

dec_error = posError

posError gives an estimate of the error of the mean position components (ra and dec). A mean was taken over RA and DEC component errors because they are very similar for most stars.

Here a model is used which include image profile fit (x,y data) errors, atmospheric turbulence, and astrometric reduction error propagations. A systematic error floor of 5 mas was added RMS. The model error is likely a better estimate of the true positional errors than the scatter error, at least for small numbers of observations.

EPOCH : Epoch for mean URAT1 observation (double, Time[Julian Years])

epoch = mean epoch of URAT observations.

F_MAG : mean observed magnitude in URAT bandpass (double, Magnitude[mag])

This is the mean, observed magnitude in the 680-762 nm URAT bandpass, calibrated by APASS photometry. This bandpass is between R and I, thus further into the red than UCAC. Observations in non-photometric nights *are* included thus the URAT magnitudes need to be taken with caution. Unknown or unrealistic magnitudes are set to NULL. The faintest maybe real celestial object magnitude is about 19.0, while the URAT1 catalog should be complete to about magnitude 18.0.

F_MAG_ERROR : URAT photometry error (double, Magnitude[mag])

The photometric error of URAT bandpass observations is derived from the scatter of individual observations. A systematic error floor of 0.01 mag has been RMS added. Unknown errors are indicated by NULL.

B_MAG : APASS B magnitude (double, Magnitude[mag])

APASS B magnitude.

A custom set of APASS (The AAVSO Photometric All-Sky Survey) data was kindly provided to us by Arne Henden to include the DR8 data plus single photometric observations.

For a total of 71614 stars with no DR8 data the DR6 data was used.

V_MAG : APASS V magnitude (double, Magnitude[mag])

APASS V magnitude.

A custom set of APASS (The AAVSO Photometric All-Sky Survey) data was kindly provided to us by Arne Henden to include the DR8 data plus single photometric observations.

For a total of 71614 stars with no DR8 data the DR6 data was used.

G_MAG : APASS g magnitude (double, Magnitude[mag])

APASS g magnitude.

A custom set of APASS (The AAVSO Photometric All-Sky Survey) data was kindly provided to us by Arne Henden to include the DR8 data plus single photometric observations.

For a total of 71614 stars with no DR8 data the DR6 data was used.

R_MAG : APASS r magnitude (double, Magnitude[mag])

APASS r magnitude.

A custom set of APASS (The AAVSO Photometric All-Sky Survey) data was kindly provided to us by Arne Henden to include the DR8 data plus single photometric observations.

For a total of 71614 stars with no DR8 data the DR6 data was used.

I_MAG : APASS i magnitude (double, Magnitude[mag])

APASS i magnitude.

A custom set of APASS (The AAVSO Photometric All-Sky Survey) data was kindly provided to us by Arne Henden to include the DR8 data plus single photometric observations.

For a total of 71614 stars with no DR8 data the DR6 data was used.

B_MAG_ERROR : Error on APASS B magnitude (double, Magnitude[mag])

Error on APASS B magnitude.

V_MAG_ERROR : Error on APASS V magnitude (double, Magnitude[mag])

Error on APASS V magnitude.

G_MAG_ERROR : Error on APASS g magnitude (double, Magnitude[mag])

Error on APASS g magnitude.

R_MAG_ERROR : Error on APASS r magnitude (double, Magnitude[mag])

Error on APASS r magnitude.

I_MAG_ERROR : Error on APASS i magnitude (double, Magnitude[mag])

Error on APASS i magnitude.

Chapter 4

Other external catalogues

4.1 HIPPARCOS_NEWREDUCTION

Hipparcos New Reduction: The Astrometric Catalogue

Hipparcos, the new Reduction of the Raw data van Leeuwen F. *Astron. Astrophys.* 474, 653 (2007) <http://dx.doi.org/10.1051/0004-6361:20078357>

A new reduction of the astrometric data as produced by the Hipparcos mission has been published, claiming accuracies for nearly all stars brighter than magnitude $H_p=8$ to be better, by up to a factor 4, than in the original catalogue. The new Hipparcos astrometric catalogue is checked for the quality of the data and the consistency of the formal errors as well as the possible presence of error correlations. The differences with the earlier publication are explained. Methods. The internal errors are followed through the reduction process, and the external errors are investigated on the basis of a comparison with radio observations of a small selection of stars, and the distribution of negative parallaxes. Error correlation levels are investigated and the reduction by more than a factor 10 as obtained in the new catalogue is explained. Results. The formal errors on the parallaxes for the new catalogue are confirmed. The presence of a small amount of additional noise, though unlikely, cannot be ruled out. Conclusions. The new reduction of the Hipparcos astrometric data provides an improvement by a factor 2.2 in the total weight compared to the catalogue published in 1997, and provides much improved data for a wide range of studies on stellar luminosities and local galactic kinematics.

Columns description:

HIP : Hipparcos identifier (int)
Hipparcos identifier

IC : Entry in one of the suppl.catalogues (int)
Entry in one of the suppl.catalogues

RA : Right Ascension in ICRS, $E_p=1991.25$ (double, Angle[deg])
Right Ascension in ICRS, $E_p=1991.25$

DEC : Declination in ICRS, Ep=1991.25 (double, Angle[deg])
Declination in ICRS, Ep=1991.25

RA_RAD : Right Ascension in ICRS, Ep=1991.25 (double, Angle[rad])
Right Ascension in ICRS, Ep=1991.25

DE_RAD : Declination in ICRS, Ep=1991.25 (double, Angle[rad])
Declination in ICRS, Ep=1991.25

PLX : Parallax (double, Angle[mas])
Parallax

PM_RA : Proper motion in Right Ascension (double, Angular Velocity[mas/year])
Proper motion in Right Ascension

PM_DE : Proper motion in Declination (double, Angular Velocity[mas/year])
Proper motion in Declination

E_RA_RAD : Formal error on RArad (double, Angle[mas])
Formal error on RArad

E_DE_RAD : Formal error on DErad (double, Angle[mas])
Formal error on DErad

E_PLX : Formal error on Plx (double, Angle[mas])
Formal error on Plx

E_PM_RA : Formal error on pmRA (double, Angular Velocity[mas/year])
Formal error on pmRA

E_PM_DE : Formal error on pmDE (double, Angular Velocity[mas/year])
Formal error on pmDE

F1 : Percentage rejected data (int, Dimensionless[percentage/100])
Percentage rejected data

F2 : Goodness of fit (double)
Goodness of fit

NC : Number of components (int)
Number of components

NTR : Number of field transits used (int)
Number of field transits used

U3 : Upper-triangular weight matrix element 3 (double)
Upper-triangular weight matrix element 3

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as + — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)

— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U4 : Upper-triangular weight matrix element 4 (double)

Upper-triangular weight matrix element 4

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U5 : Upper-triangular weight matrix element 5 (double)

Upper-triangular weight matrix element 5

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U6 : Upper-triangular weight matrix element 6 (double)

Upper-triangular weight matrix element 6

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U7 : Upper-triangular weight matrix element 7 (double)

Upper-triangular weight matrix element 7

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U8 : Upper-triangular weight matrix element 8 (double)

Upper-triangular weight matrix element 8

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U9 : Upper-triangular weight matrix element 9 (double)

Upper-triangular weight matrix element 9

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U^T$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,

plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

SN : [0,159] Solution type new reduction (int)

[0,159] Solution type new reduction

The solution type is a number 10xd+s consisting of two parts d and s: - s describes the type of solution adopted: 1 = stochastic solution (dispersion is given in the 'var' column) 3 = VIM solution (additional parameters in file hipvim.dat) 5 = 5-parameter solution (this file) 7 = 7-parameter solution (additional parameters in hip7p.dat) 9 = 9-parameter solution (additional parameters in hip9p.dat) - d describes peculiarities, as a combination of values: 0 = single star 1 = double star 2 = variable in the system with amplitude ζ 0.2mag 4 = astrometry refers to the photocenter 8 = measurements concern the secondary (fainter) in the double system

SO : [0,5] Solution type old reduction (int)

[0,5] Solution type old reduction

as follows: 0 = standard 5-parameter solution 1 = 7- or 9-parameter solution 2 = stochastic solution 3 = double and multiple stars 4 = orbital binary as resolved in the published catalog 5 = VIM (variability-induced mover) solution

VAR : Cosmic dispersion added (stochastic solution) (double)

Cosmic dispersion added (stochastic solution)

U1 : Upper-triangular weight matrix element 1 (double)

Upper-triangular weight matrix element 1

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U2 : Upper-triangular weight matrix element 2 (double)

Upper-triangular weight matrix element 2

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U10 : Upper-triangular weight matrix element 10 (double)

Upper-triangular weight matrix element 10

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13) — — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec, plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U11 : Upper-triangular weight matrix element 11 (double)

Upper-triangular weight matrix element 11

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular ma-

trix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)
— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,
plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U12 : Upper-triangular weight matrix element 12 (double)

Upper-triangular weight matrix element 12

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)
— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,
plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U13 : Upper-triangular weight matrix element 13 (double)

Upper-triangular weight matrix element 13

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)
— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,
plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U14 : Upper-triangular weight matrix element 14 (double)

Upper-triangular weight matrix element 14

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)
— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,
plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

U15 : Upper-triangular weight matrix element 15 (double)

Upper-triangular weight matrix element 15

The upper-triangular weight matrix U is related to the covariance matrix C by $C^{-1} = U U$ (U represents transposed U) The elements U_i forming the upper triangular matrix are stored as -+ — (1) (2) (4) (7) (11) — — 0 (3) (5) (8) (12) — — 0 0 (6) (9) (13)
— — 0 0 0 (10) (14) — — 0 0 0 0 (15) — -+ on the astrometric parameters RA, Dec,
plx, pmRA, pmDE, and derivatives of proper motions for 7- and 9-parameter solutions.

HP_MAG : Hipparcos magnitude (double, Magnitude[mag])

Hipparcos magnitude

B_V : Colour index (double, Magnitude[mag])

Colour index

V_I : V-I colour index (double, Magnitude[mag])

V-I colour index

E_HP_MAG : Error on mean Hpmag (double, Magnitude[mag])

Error on mean Hpmag

E_B_V : Formal error on colour index (double, Magnitude[mag])

Formal error on colour index

S_HP : Scatter of Hpmag (double, Magnitude[mag])
Scatter of Hpmag

VA : [0,2] Reference to variability annex (int)
[0,2] Reference to variability annex

4.2 IGSL_SOURCE

The Initial Gaia Source List (IGSL) was commissioned by DPAC to fulfil the following broad requirements: all-sky positions, proper motions, and magnitudes for objects to a limit of Gaia magnitude $G = 21$ where possible, e.g., where there are large (>10000 square degrees) catalogs that reach that limit. The proper motions and magnitudes are provided on a best effort basis, nominally with precisions of 10 mas yr^{-1} and 0.3 magnitudes, respectively, but obviously limited by the currently available large catalogs. The DPAC Quasar and the Ecliptic Pole catalogs are included with no selection on magnitudes. HIPPARCOS objects were also included with no selection on magnitudes. The IGSL has been used as the starting point for the Initial Data Treatment (IDT) cross-matching routines (see Smart, R.L. and Nicastrò, L., *A&A*, 570, A87 (2014) for further details).

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : source identifier (long)

A unique single numerical identifier of the source (for a detailed description see `gaia_source.source_id`)

RA : Right Ascension at catalogue epoch (double, Angle[deg])

The right ascension at epoch and equinox J2000

DEC : Declination at catalogue epoch (double, Angle[deg])

The declination at epoch and equinox J2000

RA_ERROR : Error in Right Ascension (float, Angle[mas])

The mean error in the right ascension at mean epoch

DEC_ERROR : Error in Declination (float, Angle[mas])

The mean error in the declination at mean epoch

RA_EPOCH : Mean Epoch of Right Ascension (float, Time[GaiaTime])

The mean epoch of the right ascension Julian Year in TCB. Note if there are proper motions the actual position will be at J2000 to have a consistent catalog and this is provided if the user wishes to add new information or find the best position.

DEC_EPOCH : Mean Epoch of Declination (float, Time[GaiaTime])

The mean epoch of the declination Julian Year in TCB. Note if there are proper motions the actual position will be at J2000 to have a consistent catalog and this is

provided if the user wishes to add new information or find the best position.

SOURCE_POSITION : Source of the position estimate (byte)

The code that appears in the IgsIReferences that describes where the positional information comes from.

PM_RA : Proper motion in RA * at catalogue epoch (float, Angular Velocity[mas/year])
Proper motion in right ascension multiplied by cos(declination).

PM_DEC : Proper motion in DEC at catalogue epoch (float, Angular Velocity[mas/year])
Proper motion in declination

PM_RA_ERROR : Error in Proper motion in RA (float, Angular Velocity[mas/year])
Mean error of proper motion in RA * cos(declination)

PM_DEC_ERROR : Error in proper motion in DEC (float, Angular Velocity[mas/year])
Mean error of proper motion in declination

SOURCE_MU : Source of the proper motions (byte)

The code that appears in the IgsIReferences that describes where this data point comes from.

GALACTIC_LON : Galactic Longitude (float, Angle[deg])
Galactic Longitude calculated in float to use for indexing

GALACTIC_LAT : Galactic Latitude (float, Angle[deg])
Galactic Latitude calculated in float to use for indexing

ECLIPTIC_LON : Ecliptic Longitude (float, Angle[deg])
Ecliptic Longitude calculated in float to use for indexing

ECLIPTIC_LAT : Ecliptic Latitude (float, Angle[deg])
Ecliptic Latitude calculated in float to use for indexing

MAG_BJ : B mag measure, GSC23 system (float, Magnitude[mag])

The B_J magnitude from the GSC23 when present or estimated from transformations when not present in the GSC23 or too bright to be reliable from GSC23. Very similar to B Johnson.

MAG_BJ_ERROR : Error in B mag measure (float, Magnitude[mag])
Error in the B_J magnitude

SOURCE_MAG_BJ : source B mag (byte)

Code in IgsIReferences that describes where this magnitude comes from.

MAG_RF : R mag measure, GSC23 system (float, Magnitude[mag])

The R_F magnitude from the GSC23 when present or estimated from transformations when not present in the GSC23 or too bright to be reliable from GSC23. Very similar to R cousins.

MAG_RF_ERROR : Error in R mag measure (float, Magnitude[mag])
Error in R_F

SOURCE_MAG_RF : source of R mag (byte)
Code in IgsIReferences that describes where this magnitude comes from.

MAG_G : G mag estimate (float, Magnitude[mag])
Estimated G magnitude based on transformations in livelink document RLS 001

MAG_G_ERROR : Error in G mag estimate (float, Magnitude[mag])
Estimated of error on G magnitude

SOURCE_MAG_G : Source G mag (byte)
Code in IgsIReferences that describes which transformation used.

MAG_GRVS : Grvs mag estimate (float, Magnitude[mag])
Estimated $G_{r,vs}$ magnitude based on transformations in livelink document RLS 004

MAG_GRVS_ERROR : Error in Grvs mag estimate (float, Magnitude[mag])
Estimated of error on $G_{r,vs}$ magnitude

SOURCE_MAG_GRVS : Source Grvs mag (byte)
Code in SourceCatalogIDs that describes where base magnitudes came from

CLASSIFICATION : Classification (boolean)
Classification, simply a 0=star and 1=nonstar taken from different sources as given in the souceClass field

SOURCE_CLASSIFICATION : source of Classification (byte)
Code in IgsIReferences that describes where this datapoint comes from.

TOGGLE_ASC : Toggle for Atitude Star Catalog (boolean)
A boolean that indicates if the objects is to be used for the Atitude Star Catalog.

AUX_GSC23 : Present in the GSC2.3 catalog (boolean)
A boolean that indicates if the objects is present in the GSC2.3 cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the GSC2.3 id is in the SourceCatalogIDs as idGSC23.

AUX_SDSS : Present in the SDSS catalog (boolean)
A boolean that indicates if the objects is present in the SDSS cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idSDSS

AUX_UCAC : Present in the UCAC3 catalog (boolean)
A boolean that indicates if the objects is present in the UCAC cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the iSourceCatalogIDs as idUCAC.

AUX_LQRF : Present in the LQRF QSO aux catalog (boolean)

A boolean that indicates if the objects is present in the CU3 QSO Aux cat GIQC, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idLQRF.

AUX_TYCHO : Present in the TYCHO2 catalog (boolean)

A boolean that indicates if the objects is present in theTYCHO2 cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idTYCHO

AUX_HIP : Present in the Hipparcos catalog (boolean)

A boolean that indicates if the objects is present in the Hipparcos catalog, 0=no, 1=yes=true.

AUX_PPMXL : Present in the PPMXL catalog (boolean)

A boolean that indicates if the objects is present in the PPMXL cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idPPMXL

AUX_OGLE : Present in the OGLE catalog (boolean)

A boolean that indicates if the objects is present in the OGLE cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idOGLE

AUX_TMASS : Present in the Two MASS PSC catalog (boolean)

A boolean that indicates if the objects is present in the Two-MASS cat, 0=no, 1=yes. Version and catalog details in the SourceCatalogReferences table. If yes the ID is in the the SourceCatalogIDs as idTMASS.

AUX_EPC : Present in the Ecliptic Poles Catalog (boolean)

A boolean that indicates if the objects is present in the EPC, false=no, true=yes. Version and catalog details in the SourceCatalogReference table. If yes, the number in the SourceCatalogIDs table is the number in EPC.

4.3 IGSL_SOURCE_CATALOG_IDS

SourceId in original catalogues

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Gaia source id from IGSL2 (long)

A unique single numerical identifier of the source (for a detailed description see `gaia_source.source_id`)

ID_GSC23 : Identifier in ref. catalogs (long)

These are the IDs as published in the various input catalogs converted to a big integer. For the GSC23 we have had to alter slightly the name, specifically: GSC2.3 objects have original names that are combination of region names and running number, e.g. S00000001 is the first object in the region S0000000, we have converted the region names to the "official" numerical values in the htm level 6 structure, hence the smallest is S0000000 = 32768 and N3333333 = 65535 is the highest.

ID_SDSS : Identifier in ref. catalogs (long)

These are the IDs as published in the SDSS DR9 in big integer format.

ID_UCAC : Identifier in ref. catalogs (int)

These are the IDs as published in the UCAC4 specifically a running star ID number.

ID_LQRF : Identifier in ref. catalogs (int)

These are the running number in the Gaia Initial Quasar Catalog - version 4 - updated September 2011 - GIQC_4.

ID_TYCHO : Identifier in ref. catalogs (long)

These are the IDs as published in Tycho2. In TYCHO-2 objects were identified by 3 numbers (TYC1, TYC2 and TYC3) and we have combined these into one complete number given by $(TYC1 * 1000000.0d0) + (TYC2 * 10.0d0) + (TYC3 * 1.0d0)$

ID_HIP : Hipparcos number (int)

If the source is a Hipparcos star this field contains the Hipparcos number.

ID_PPMXL : PPMXL Identifier (long)

These are the IDs as published in the PPMXL, the ipix Identifier (Q3C ipix of the USNO-B 1.0 object) converted to a big integer.

ID_OGLE : OGLE Identifier (long)

The OGLE ID is given by a combination of
A region of sky identifier (RI) equal to 10, 11, 12, 13, 14 corresponding to map names
blg, car, cen, lmc, mus.
The file running number (NNN.N)
The running number in the file (RN)
The ID is defined as: $\text{long}(\text{string}(\text{RI})+\text{string}(\text{NNN.N} * 10000))+\text{RN}$.

ID_TMASS : Identifier in ref. catalogs (long)

The Two Mass provided the names in a IAU standard fashion of 2MASS JHH-MMSS.S +DDMMSS.S these were codeified as +HHMMSSSDDMMSSS.

ID_EPC : Identifier in ref. catalogs (string)

The IDs in the Gaia Ecliptic Pole Catalogue Version (GEPC 3.0) given as IAU standards:
JHHMMSS.SS+DDMMSS.S.

4.4 TYCHO2

The Tycho-2 Catalogue is an astrometric reference catalogue containing positions and proper motions as well as two-colour photometric data for the 2.5 million brightest stars in the sky. The Tycho-2 positions and magnitudes are based on precisely the same observations as the original Tycho Catalogue (hereafter Tycho-1; see Cat. I/239) collected by the star mapper of the ESA Hipparcos satellite, but Tycho-2 is much bigger and slightly more precise, owing to a more advanced reduction technique. Components of double stars with separations down to 0.8 arcsec are included. Proper motions precise to about 2.5 mas/yr are given as derived from a comparison with the Astrographic Catalogue and 143 other ground-based astrometric catalogues, all reduced to the Hipparcos celestial coordinate system. Tycho-2 supersedes in most applications Tycho-1, as well as the ACT (Cat. I/246) and TRC (Cat. I/250) catalogues based on Tycho-1. Supplement-1 lists stars from the Hipparcos and Tycho-1 Catalogues which are not in Tycho-2. Supplement-2 lists 1146 Tycho-1 stars which are probably either false or heavily disturbed. For more information, please consult the Tycho-2 home page: <http://www.astro.ku.dk/erik/Tycho-2>

Columns description:

ID : Tycho 2 identifier. The TYC identifier is constructed from the GSC region number (string)

Tycho 2 identifier. The TYC identifier is constructed from the GSC region number (TYC1), the running number within the region (TYC2) and a component identifier (TYC3) which is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

HIP : [1,120404]? Hipparcos number (int)
[1,120404]? Hipparcos number

TYC1 : [1,9537]+= TYC1 from TYC or GSC (string)
[1,9537]+= TYC1 from TYC or GSC

The TYC identifier is constructed from the GSC region number (TYC1), the running number within the region (TYC2) and a component identifier (TYC3) which is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

TYC2 : [1,12121] TYC2 from TYC or GSC (string)
[1,12121] TYC2 from TYC or GSC

The TYC identifier is constructed from the GSC region number (TYC1), the running number within the region (TYC2) and a component identifier (TYC3) which is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

TYC3 : [1,3] TYC3 from TYC (string)
[1,3] TYC3 from TYC

The TYC identifier is constructed from the GSC region number (TYC1), the running number within the region (TYC2) and a component identifier (TYC3) which is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

ID_TYCHO : Numeric Tycho2 identifier (long)

These are the IDs as published in Tycho2. In TYCHO-2 objects were identified by 3 numbers (TYC1,TYC2 and TYC3) and we have combined these into one complete number given by

$(TYC1*1000000.0d0)+(TYC2*10.0d0)+(TYC3*1.0d0)$

TYC : [T] Tycho-1 star (string)

[T] Tycho-1 star

' ' = no Tycho-1 star was found within 0.8 arcsec (quality 1-8) or 2.4 arcsec (quality 9). 'T' = this is a Tycho-1 star. The Tycho-1 identifier is given in the beginning of the record. For Tycho-1 stars, resolved in Tycho-2 as a close pair, both components are flagged as a Tycho-1 star and the Tycho-1 TYC3 is assigned to the brightest (VT) component. The HIP-only stars given in Tycho-1 are not flagged as Tycho-1 stars.

RA : Observed Tycho-2 Right Ascension, ICRS (double, Angle[deg])

Observed Tycho-2 Right Ascension, ICRS

DEC : Observed Tycho-2 Declination, ICRS (double, Angle[deg])

Observed Tycho-2 Declination, ICRS

RA_DEG : Observed Tycho-2 Right Ascension, ICRS (double, Angle[deg])

Observed Tycho-2 Right Ascension, ICRS

DE_DEG : Observed Tycho-2 Declination, ICRS (double, Angle[deg])

Observed Tycho-2 Declination, ICRS

RA_MDEG : []? Mean Right Asc, ICRS, epoch=J2000 (double, Angle[deg])

[]? Mean Right Asc, ICRS, epoch=J2000

The mean position is a weighted mean for the catalogues contributing to the proper motion determination. This mean has then been brought to epoch 2000.0 by the computed proper motion. See Note(2) above for details. Tycho-2 is one of the several catalogues used to determine the mean position and proper motion. The observed Tycho-2 position is given in the fields RAdeg and DEdeg.

DE_MDEG : []? Mean Decl, ICRS, at epoch=J2000 (double, Angle[deg])

[]? Mean Decl, ICRS, at epoch=J2000

The mean position is a weighted mean for the catalogues contributing to the proper motion determination. This mean has then been brought to epoch 2000.0 by the computed proper motion. See Note(2) above for details. Tycho-2 is one of the several catalogues used to determine the mean position and proper motion. The observed Tycho-2 position is given in the fields RAdeg and DEdeg.

PM_RA : ? Proper motion in RA*cos(dec) (float, Angular Velocity[mas/year])

? Proper motion in RA*cos(dec)

Some Hipparcos stars (having a positive number in the HIP column) have no proper motions; these are virtually all in multiple systems.

PM_DE : ? Proper motion in Dec (float, Angular Velocity[mas/year])

? Proper motion in Dec

Some Hipparcos stars (having a positive number in the HIP column) have no proper motions; these are virtually all in multiple systems.

EP_RA1990 : [0.81,2.13] epoch-1990 of RAdeg (float, Time[year])

[0.81,2.13] epoch-1990 of RAdeg

EP_DE1990 : [0.72,2.36] epoch-1990 of DEdeg (float, Time[year])

[0.72,2.36] epoch-1990 of DEdeg

EP_RA_M : [1915.95,1992.53]? mean epoch of RA. The mean epochs are given in Julian years. (float, Time[year])

[1915.95,1992.53]? mean epoch of RA. The mean epochs are given in Julian years.

EP_DE_M : [1911.94,1992.01]? mean epoch of Dec. The mean epochs are given in Julian years. (float, Time[year])

[1911.94,1992.01]? mean epoch of Dec. The mean epochs are given in Julian years.

NUM : [2,36]? Number of positions used (short)

[2,36]? Number of positions used

E_RA_DEG : s.e.RA*cos(dec), of observed Tycho-2 RA. The errors are based on error models. (double, Angle[mas])

s.e.RA*cos(dec), of observed Tycho-2 RA. The errors are based on error models.

E_DE_DEG : s.e. of observed Tycho-2 Dec. The errors are based on error models. (double, Angle[mas])

s.e. of observed Tycho-2 Dec. The errors are based on error models.

CORR : [-1,1] correlation (RAdeg,DEdeg) (double)

[-1,1] correlation (RAdeg,DEdeg)

E_RA_MDEG : [3,183]? s.e. RA*cos(dec),at mean epoch. The errors are based on error models. (double, Angle[mas])

[3,183]? s.e. RA*cos(dec),at mean epoch. The errors are based on error models.

E_DE_MDEG : [1,184]? s.e. of Dec at mean epoch. The errors are based on error models. (double, Angle[mas])

[1,184]? s.e. of Dec at mean epoch. The errors are based on error models.

E_PM_RA : [0.2,11.5]? s.e. prop mot in RA*cos(dec).The errors are based on error models. (float, Angular Velocity[mas/year])

[0.2,11.5]? s.e. prop mot in RA*cos(dec).The errors are based on error models.

E_PM_DE : [0.2,10.3]? s.e. of proper motion in Dec. The errors are based on error models. (float, Angular Velocity[mas/year])

[0.2,10.3]? s.e. of proper motion in Dec. The errors are based on error models.

Q_RA_MDEG : [0.0,9.9]? Goodness of fit for mean RA (float)

[0.0,9.9]? Goodness of fit for mean RA

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when Num \geq 2. Values exceeding 9.9 are truncated to 9.9.

Q_DE_MDEG : [0.0,9.9]? Goodness of fit for mean Dec (float)

[0.0,9.9]? Goodness of fit for mean Dec

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when Num \geq 2. Values exceeding 9.9 are truncated to 9.9.

Q_PM_DE : [0.0,9.9]? Goodness of fit for pmDE (float)

[0.0,9.9]? Goodness of fit for pmDE

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when Num \geq 2. Values exceeding 9.9 are truncated to 9.9.

Q_PM_RA : [0.0,9.9]? Goodness of fit for pmRA (float)

[0.0,9.9]? Goodness of fit for pmRA

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when Num \geq 2. Values exceeding 9.9 are truncated to 9.9.

PFLAG : [PX] mean position flag (string)

[PX] mean position flag

' ' = normal mean position and proper motion. 'P' = the mean position, proper motion, etc., refer to the photocentre of two Tycho-2 entries, where the BT magnitudes were used in weighting the positions. 'X' = no mean position, no proper motion.

POSFLG : [DP] type of Tycho-2 solution (string)

[DP] type of Tycho-2 solution

' ' = normal treatment, close stars were subtracted when possible. 'D' = double star treatment. Two stars were found. The companion is normally included as a separate Tycho-2 entry, but may have been rejected. 'P' = photocentre treatment, close stars were not subtracted. This special treatment was applied to known or suspected doubles which were not successfully (or reliably) resolved in the Tycho-2 double star processing.

CCDM : CCDM component identifier for HIP stars (string)

CCDM component identifier for HIP stars

The CCDM component identifiers for double or multiple Hipparcos stars contributing to this Tycho-2 entry. For photocentre solutions, all components within 0.8 arcsec contribute. For double star solutions any unresolved component within 0.8 arcsec contributes. For single star solutions, the predicted signal from close stars were normally subtracted in the analysis of the photon counts and such stars therefore do not contribute to the solution. The components are given in lexical order.

PROX : [3,999] proximity indicator (short, Angle[100mas])

[3,999] proximity indicator

Distance in units of 100 mas to the nearest entry in the Tycho-2 main catalogue or supplement. The distance is computed for the epoch 1991.25. A value of 999 (i.e. 99.9 arcsec) is given if the distance exceeds 99.9 arcsec.

BT_MAG : [2.183,16.581]? Tycho-2 BT magnitude (float, Magnitude[mag])
[2.183,16.581]? Tycho-2 BT magnitude

Blank when no magnitude is available. Either BTmag or VTmag is always given. Approximate Johnson photometry may be obtained as: $V = VT - 0.090*(BT-VT)$ $B-V = 0.850*(BT-VT)$ Consult Sect 1.3 of Vol 1 of "The Hipparcos and Tycho Catalogues", ESA SP-1200, 1997, for details.

VT_MAG : [1.905,15.193]? Tycho-2 VT magnitude (float, Magnitude[mag])
[1.905,15.193]? Tycho-2 VT magnitude

Blank when no magnitude is available. Either BTmag or VTmag is always given. Approximate Johnson photometry may be obtained as: $V = VT - 0.090*(BT-VT)$ $B-V = 0.850*(BT-VT)$ Consult Sect 1.3 of Vol 1 of "The Hipparcos and Tycho Catalogues", ESA SP-1200, 1997, for details.

E_BT_MAG : [0.014,1.977]? s.e. of BT (float, Magnitude[mag])
[0.014,1.977]? s.e. of BT

Blank when no magnitude is available. Either BTmag or VTmag is always given. Approximate Johnson photometry may be obtained as: $V = VT - 0.090*(BT-VT)$ $B-V = 0.850*(BT-VT)$ Consult Sect 1.3 of Vol 1 of "The Hipparcos and Tycho Catalogues", ESA SP-1200, 1997, for details.

E_VT_MAG : [0.009,1.468]? s.e. of VT (float, Magnitude[mag])
[0.009,1.468]? s.e. of VT

Blank when no magnitude is available. Either BTmag or VTmag is always given. Approximate Johnson photometry may be obtained as: $V = VT - 0.090*(BT-VT)$ $B-V = 0.850*(BT-VT)$ Consult Sect 1.3 of Vol 1 of "The Hipparcos and Tycho Catalogues", ESA SP-1200, 1997, for details.

Chapter 5

Miscellaneous tables

5.1 AUX_QSO_ICRF2_MATCH

This table has an entry for all sources in the auxiliary QSO solution matched to the ICRF2 sources and passing all quality filters discussed in the corresponding documentation.

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

SOURCE_ID : Unique source identifier (long)

A unique single numerical identifier of the source.

For the contents of Gaia DR1, which does not include Solar System objects, the source ID consists of a 64-bit integer, least significant bit = 1 and most significant bit = 64, comprising:

- a HEALPix index number (sky pixel) in bits 36 - 63; by definition the smallest HEALPix index number is zero.
- a 2-bit Data Processing Centre code in bits 34 - 35; for example $\text{MOD}(\text{source_id} / 4294967296, 8)$ can be used to distinguish between sources initialised via the Initial Gaia Source List by the Torino DPC (code = 0) and sources otherwise detected and assigned by Gaia observations (code > 0)
- a 25-bit plus 7 bit sequence number within the HEALPix pixel in bits 1 - 32 split into:
 - a 25 bit running number in bits 8 - 32; the running numbers are defined to be positive, i.e. never zero (except in the case of forced empty windows)
 - a 7-bit component number in bits 1 - 7

- one spare bit in bit 33

This means that the HEALpix index level 12 of a given source is contained in the most significant bits. HEALpix index of 12 and lower levels can thus be retrieved as follows:

- HEALpix level 12 = $\text{source_id} / 34359738368$
- HEALpix level 11 = $\text{source_id} / 137438953472$
- HEALpix level 10 = $\text{source_id} / 549755813888$
- HEALpix level n = $\text{source_id} / 2^{35} * 4^{(12 - \text{level})}$.

Additional details can be found in the Gaia DPAC public document *Source Identifiers — Assignment and Usage throughout DPAC* (document code GAIA-C3-TN-ARI-BAS-020) available from <http://www.cosmos.esa.int/web/gaia/public-dpac-documents>

REF_EPOCH : Reference epoch (double, Time[Julian Years])

Reference epoch to which the astrometric source parameters are referred, expressed as a Julian Year in TCB.

RA : Right ascension (double, Angle[deg])

Barycentric right ascension α of the source in ICRS at the reference epoch `ref_epoch`

RA_ERROR : Standard error of right ascension (double, Angle[mas])

Standard error $\sigma_{\alpha^*} \equiv \sigma_{\alpha} \cos \delta$ of the right ascension of the source in ICRS at the reference epoch `ref_epoch`.

DEC : Declination (double, Angle[deg])

Barycentric declination δ of the source in ICRS at the reference epoch `ref_epoch`

DEC_ERROR : Standard error of declination (double, Angle[mas])

Standard error σ_{δ} of the declination of the source in ICRS at the reference epoch `ref_epoch`

RA_DEC_CORR : Correlation between right ascension and declination (float, Dimensionless[see description])

Correlation between right ascension and declination, in dimensionless units [-1:+1]

PHOT_G_MEAN_MAG : G-band mean magnitude (double, Magnitude[mag])

Mean magnitude in the G band. This is computed from the G-band mean flux applying the magnitude zero-point in the Vega scale.

ASTROMETRIC_PRIORS_USED : Type of prior used in in the astrometric solution (int)

Type of prior used in the astrometric solution:

- 0: No prior used
- 1: Galaxy Bayesian Prior for parallax and proper motion
- 2: Galaxy Bayesian Prior for parallax and proper motion relaxed by factor 10
- 3: Hipparcos prior for position

- 4: Hipparcos prior for position and proper motion
- 5: Tycho2 prior for position
- 6: Quasar prior for proper motion

The Galaxy Bayesian Prior is defined in Michalik et al. (2015), where it is denoted $\sigma_{\varpi,F90}$ (for the parallax) and $\sigma_{\mu,F90} = \mathcal{R}\sigma_{\varpi,F90}$, with $\mathcal{R} = 10 \text{ yr}^{-1}$ (for proper motion). The Galaxy Bayesian Prior relaxed by a factor 10 is $10\sigma_{\varpi,F90}$ and $10\sigma_{\mu,F90}$, respectively.

For Gaia DR1 the only types of priors used are 2 (for the secondary data set), 3 (for the Hipparcos subset of the primary data set), or 5 (for the non-Hipparcos subset of the primary data set). Type 6 was used for internal calibration purposes and alignment of the reference frame.

ICRF2_MATCH : ICRF2 designation of the source matched to this Gaia source (string)

ICRF2 designation of the source matched to this Gaia source.

ROT_FLAG : Flag indicating how this source was used to fix the orientation of the reference frame of the Gaia DR1 solution (int)

Flag indicating how this source was used to fix the orientation of the reference frame of the Gaia DR1 solution:

- 0: Not used
- 1: Only right ascension is used
- 2: Only declination is used
- 3: Both right ascension and declination are used

5.2 EXT_PHOT_ZERO_POINT

Definition of the Gaia photometric system: for GDR1 only zero-points will be computed, one for G and one for each integrated BP and integrated RP. The adopted photometric system will be Vega.

Columns description:

SOLUTION_ID : Solution Identifier (long)

The data in the MDB will be described by means of a "Solution identifier" parameter. This will be a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that were used in the generation of the data as well as the input data used. Each DPC generating the data will have the freedom to choose the Solution identifier number, but they must ensure that given the Solution identifier they can provide detailed information about the "conditions" used to generate the data: versions of the software, version of the data used...

G_MAG_ZERO_POINT : G magnitude zero point (double, Magnitude[mag])

The magnitude zero point on the Vega scale for the G passband.

G_MAG_ZERO_POINT_ERROR : Error on the G magnitude zero point (double, Magnitude[mag])

Error on the magnitude zero point for the G passband.

BP_MAG_ZERO_POINT : BP magnitude zero point (double, Magnitude[mag])

The magnitude zero point on the Vega scale for the BP passband.

BP_MAG_ZERO_POINT_ERROR : Error on the BP magnitude zero point (double, Magnitude[mag])

Error on the magnitude zero point for the G passband.

RP_MAG_ZERO_POINT : RP magnitude zero point (double, Magnitude[mag])

The magnitude zero point on the Vega scale for the RP passband.

RP_MAG_ZERO_POINT_ERROR : Error on the RP magnitude zero point (double, Magnitude[mag])

Error on the magnitude zero point for the RP passband.

Bibliography

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Michalik D., Lindgren L., Hobbs D., Butkevich A.G., Nov. 2015, *Astronomy and Astrophysics*, 583, A68