Gaia EDR3: draft catalogue data model

prepared by: CU9 Data Model Team
affiliation : Gaia DPAC CU9

approved by: CU9-L
reference: N/A
issue: 1
revision: 0
date: 2020-07-28
status: Draft

Abstract

The draft data model for Gaia early Data Release 3 is described in the following pages. Please note that this is a draft only: the final published catalogue data model is subject to change with respect to that described herein without any public notification. Note also that this draft contains links to external resources (e.g. the body of the full documentation set for EDR3) that are inactive presently. The document is provided for advance information and will be supported on a best–efforts basis only prior to the formal release.

Contents

Datamodel description **Author(s): Nigel Hambly, Frédéric Arenou, Carine Babusiaux, Jorgo Bakker, Alex Bombrun, Orlagh Creevey, Francesca De Angeli, Javier Duran, Claus Fabricius, Krzysztof Findeisen, Gonzalo Gracia-Abril, Jose Hernandez, David Hobbs, Alexander Hutton, Sergei Klioner, Lennart Lindegren, Xavier Luri, Paola Maria Marrese, Silvia Marinoni, Eduard Masana, Daniel Michalik, Alcione Mora, Paola Sartoretti, David Teyssier, Enrique Utrilla Molina, Albert Masip Vela,**

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)

All Gaia data processed by the Data Processing and Analysis Consortium comes tagged with a solution identifier. This is a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that where used in the generation of the data as well as the input data used. It is mainly for internal DPAC use but is included in the published data releases to enable end users to examine the provenance of processed data products. To decode a given solution ID visit `https://gaia.esac.esa.int/decoder/solnDecoder.jsp`

DESIGNATION : Unique source designation (unique across all Data Releases) (string)

A source designation, unique across all Gaia Data Releases, that is constructed from the prefix "Gaia DRx " followed by a string of digits corresponding to source_id (3 space–separated words in total). Note that the integer source identifier source_id is **not** guaranteed to be unique across Data Releases; moreover it is not guaranteed that the same astronomical source will always have the same source_id in different Data Releases. Hence the only safe way to compare source records between different Data Releases in general is to check the records of proximal source(s) in the same small part of the sky.

SOURCE_ID : Unique source identifier (unique within a particular Data Release) (long)

A unique numerical identifier of the source, encoding the approximate position of the source (roughly to the nearest arcmin), the provenance (data processing centre where it was created), a running number, and a component number.

The approximate equatorial (ICRS) position is encoded using the nested HEALPix scheme at level 12 (Nside = 4096), which divides the sky into $\simeq 200$ million pixels of about 0.7 arcmin^2.

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 3-bit Data Processing Centre code in bits 33 - 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
  - a 7-bit component number in bits 1 – 7

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

- HEALpix index at level 12 = source_id / 34359738368
- HEALpix index at level 11 = source_id / 137438953472
- HEALpix index level 10 = source_id / 549755813888
- HEALpix index at level n = source_id / $(2^{35} \times 4^{(12-n)})$ = source_id / $2^{(59-2n)}$

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 `https://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 sources in the table.

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 (float, 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 (float, 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 stellar parallax ϖ of the source at the reference epoch `ref_epoch`

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

Standard error σ_ϖ of the stellar parallax at the reference epoch `ref_epoch`

PARALLAX_OVER_ERROR : Parallax divided by its standard error (float)

Parallax divided by its standard error

PM : Total proper motion (float, Angular Velocity[mas/year])

The total proper motion calculated as the magnitude of the resultant vector of the proper motion component vectors `pmra` and `pmdec`, i.e. $\texttt{pm}^2 = \texttt{pmra}^2 + \texttt{pmdec}^2$.

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

Proper motion in right ascension $\mu_{\alpha*} \equiv \mu_\alpha \cos\delta$ of the source in ICRS at the reference epoch `ref_epoch`. This is the local tangent plane projection of the proper motion vector in the direction of increasing right ascension.

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

Standard error $\sigma_{\mu\alpha*}$ of the local tangent plane projection of the proper motion vector in the direction of increasing 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 (float, Angular Velocity[mas/year])

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

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

Correlation coefficient $\rho(\alpha, \delta)$ between right ascension and declination, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\alpha, \varpi)$ between right ascension and parallax, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\alpha, \mu_{\alpha*})$ between right ascension and proper motion in right ascension, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\alpha, \mu_{\delta})$ between right ascension and proper motion in declination, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\delta, \varpi)$ between declination and parallax, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\delta, \mu_{\alpha*})$ between declination and proper motion in right ascension, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\delta, \mu_\delta)$ between declination and proper motion in declination, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\varpi, \mu_{\alpha*})$ between parallax and proper motion in right ascension, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\varpi, \mu_\delta)$ between parallax and proper motion in declination, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\mu_{\alpha*}, \mu_\delta)$ between proper motion in right ascension and proper motion in declination, a dimensionless quantity in the range [-1,+1]

ASTROMETRIC_N_OBS_AL : Total number of observations AL (short)

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 (short)

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). Nearly all sources having G $<$ 13 will have AC observations from 2d windows, while fainter than that limit only $\sim$ 1% of transit observations (the so–called 'calibration faint stars') are assigned 2d windows resulting in AC observations.

ASTROMETRIC_N_GOOD_OBS_AL : Number of good observations AL (short)

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_o 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_BAD_OBS_AL : Number of bad observations AL (short)

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_GOF_AL : Goodness of fit statistic of model wrt along-scan observations (float)

Goodness-of-fit statistic of the astrometric solution for the source in the along-scan direction. This is the 'gaussianized chi-square', which for good fits should approximately follow a normal distribution with zero mean value and unit standard deviation. Values exceeding, say, $+3$ thus indicate a bad fit to the data.

This statistic is computed according to the formula

$$\texttt{astrometric\_gof\_al} = (9\nu/2)^{1/2}[(\chi^2/\nu)^{1/3} + 2/(9\nu) - 1]$$

where $\chi^2(= \texttt{astrometric\_chi2\_al})$ is the AL chi-square statistic and

$$\nu = \texttt{astrometric\_n\_good\_obs\_al} - N$$

is the number of degrees of freedom for a source update. Here $N = 5$ is the number of astrometric parameters. Note that only 'good' (i.e. not strongly downweighted) observations are included in χ^2 and ν.

The above formula is the well-known cube-root transformation of the chi-square variable (Wilson & Hilferty 1931). It is usually quoted to be valid for $\nu > 30$, but is in fact useful for much smaller ν. This transformation of (χ^2, ν) eliminates the inconvenience of having the distribution (and hence the significance levels) depend on the additional variable ν, which is generally not the same for different sources.

An alternative indicator of bad fits is the astrometric_excess_noise. In AGIS the source update deals with bad fits by adding astrometric_excess_noise to the formal observation noise. This reduces the weight of the observations and inflates the covariance of the estimated astrometric parameters correspondingly. However, the chi-square values used to calculate astrometric_gof_al do not take into account the astrometric_excess_noise, and astrometric_gof_al can therefore always be used as a goodness-of-fit indicator of the source solution in AGIS.

ASTROMETRIC_CHI2_AL : AL chi-square value (float)

Astrometric goodness-of-fit (χ^2) in the AL direction.

χ^2 values were computed for the 'good' AL observations of the source, without taking into account the astrometric_excess_noise (if any) of the source. They do however take into account the attitude excess noise (if any) of each observation.

ASTROMETRIC_EXCESS_NOISE : Excess noise of the source (float, 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_noiseSig (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.

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 (float)

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_PARAMS_SOLVED : Which parameters have been solved for? (byte)

This is a binary code indicating which astrometric parameters were estimated for the source. A set bit means the parameter was estimated. The least-significant bit represents α, the next bits δ, ϖ, $\mu_{\alpha*}$, and μ_δ. For example

- `astrometric_params_solved` = 31 (binary 11111): all five astrometric parameters were estimated
- `astrometric_params_solved` = 3 (binary 11): only position (α, δ) was estimated

ASTROMETRIC_PRIMARY_FLAG : Primary or seconday (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.

NU_EFF_USED_IN_ASTROMETRY : Effective wavenumber of the source used in the astrometric solution (float, Misc[μm^{-1}])

Effective wavenumber of the source, $\nu_{\rm eff}$, in μm^{-1}.

This $\nu_{\rm eff}$ is the value used in the image parameter determination and in the astrometric calibration if reliable mean BP and RP photometry were available. It is the inverse of the photon-flux weighted effective wavelength in the G band, as estimated from the BP and RP bands.

Due to cyclic processing of the astrometry and the photometry, this effective wavenumber might be different from the one computed using the latest available photometry. Moreover, if no reliable photometry was available at the time of the astrometric processing, this field is empty and an astrometrically estimated value of the effective wavenumber may instead be given in the `pseudocolour` field.

PSEUDOCOLOUR : Astrometrically estimated pseudocolour of the source (float, Misc[μm^{-1}])

Effective wavenumber of the source estimated in the final astrometric processing.

The `pseudocolour` is the astrometrically estimated effective wavenumber of the photon flux distribution in the astrometric (G) band, measured in μm^{-1}. The value in this field was estimated from the chromatic displacements of image centroids, calibrated by means of the photometrically determined effective wavenumbers ($\nu_{\rm eff}$) of primary sources.

The field is empty when chromaticity was instead taken into account using the photometrically determined $\nu_{\rm eff}$ given in the field `nu_effUsedInAstrometry`.

PSEUDOCOLOUR_ERROR : Standard error of the pseudocolour of the source (float, Misc[μm^{-1}])

Standard error $\sigma_{\tt pseudocolour}$ of the astrometrically determined `pseudocolour` of the source.

RA_PSEUDOCOLOUR_CORR : Correlation between right ascension and pseudocolour (float, Dimensionless[see description])

Correlation coefficient $\rho(\alpha, \tt pseudocolour)$ between right ascension `ra` and `pseudocolour`, a dimensionless quantity in the range [-1,+1]

DEC_PSEUDOCOLOUR_CORR : Correlation between declination and pseudocolour (float, Dimensionless[see description])

Correlation coefficient $\rho(\delta, \texttt{pseudocolour})$ between declination dec and pseudocolour, a dimensionless quantity in the range [-1,+1]

PARALLAX_PSEUDOCOLOUR_CORR : Correlation between parallax and pseudocolour (float, Dimensionless[see description])

Correlation coefficient $\rho(\varpi, \texttt{pseudocolour})$ between parallax and pseudocolour, a dimensionless quantity in the range [-1,+1]

PMRA_PSEUDOCOLOUR_CORR : Correlation between proper motion in right asension and pseudocolour (float, Dimensionless[see description])

Correlation coefficient $\rho(\mu_{\alpha*}, \texttt{pseudocolour})$ between proper motion in right ascension pmra and pseudocolour, a dimensionless quantity in the range [-1,+1]

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

Correlation coefficient $\rho(\mu_{\delta}, \texttt{pseudocolour})$ between proper motion in declination pmdec and pseudocolour, a dimensionless quantity in the range [-1,+1]

ASTROMETRIC_MATCHED_TRANSITS : Matched FOV transits used in the AGIS solution (short)

The number of field–of–view transits matched to this source, counting only the transits containing CCD observations actually used to compute the astrometric solution.

This number will always be equal to or smaller than matched_transits, the difference being the FOV transits that were not used in the astrometric solution because of bad data or excluded time intervals.

VISIBILITY_PERIODS_USED : Number of visibility periods used in Astrometric solution (short)

Number of visibility periods used in the astrometric solution.

A visibility period is a group of observations separated from other groups by a gap of at least 4 days. A source may have from one to tens of field–of–view transits in a visibility period, but with a small spread in time, direction of scanning, and parallax factor. From one visibility period to the next these variables have usually changed significantly. A high number of visibility periods is therefore a better indicator of an astrometrically well–observed source than a large number of field–of–view transits (`matched_transits` or `astrometric_matched_transits`) or CCD observations (`astrometric_n_obs_al`). A small value (e.g. less than 10) indicates that the calculated parallax could be more vulnerable to errors, e.g. from the calibration model, not reflected in the formal uncertainties. See Lindegren et al. (2018) for a discussion of this and other astrometric quality indicators.

ASTROMETRIC_SIGMA5D_MAX : The longest semi-major axis of the 5-d error ellipsoid (float, Angle[mas])

The longest principal axis in the 5-dimensional error ellipsoid.

This is a 5-dimensional equivalent to the semi-major axis of the position error ellipse and is therefore useful for filtering out cases where one of the five parameters, or some linear combination of several parameters, is particularly ill-determined. It is measured in mas and computed as the square root of the largest singular value of the scaled 5×5 covariance matrix of the astrometric parameters. The matrix is scaled so as to put the five parameters on a comparable scale, taking into account the maximum along-scan parallax factor for the parallax and the time coverage of the observations for the proper motion components. If C is the unscaled covariance matrix, the scaled matrix is SCS, where $S = \mathrm{diag}(1, 1, \sin\xi, T/2, T/2)$, $\xi = 45°$ is the solar aspect angle in the nominal scanning law, and T the time coverage of the data used in the solution.

`astrometric_sigma5d_max` is given for both 5-parameter and 2-parameter solutions, as its size is one of the criteria for accepting or rejecting the 5-parameter solution. In case of a 2-parameter solution (`astrometric_params_solved` = 3) it gives the value for the rejected 5-parameter solution, and can then be arbitrarily large.

MATCHED_TRANSITS : The number of transits matched to this source (short)

The total number of field–of–view transits matched to this source.

NEW_MATCHED_TRANSITS : The number of transits newly incorporated into an existing source in the current cycle (short)

Individual field–of–view transits are crossmatched into unique sources at the start of each reprocessing cycle taking the source list from the previous cycle as a starting point. During that process a combination of appending, merging and splitting operations is performed to create a more complete and reliable map of unique sources given the available information. Existing individual sources may accrete further transits, may be merged into fewer unique sources, or may split into two or more new, unique sources as more measurements are accumulated. Field `new_matched_transits` logs the number of transits newly appended to an existing source during the most recent cyclic reprocessing crossmatch.

MATCHED_TRANSITS_REMOVED : The number of transits removed from an existing source in the current cycle (short)

Individual field–of–view transits are crossmatched into unique sources at the start of each reprocessing cycle taking the source list from the previous cycle as a starting point. During that process a combination of appending, merging and splitting operations is performed to create a more complete and reliable map of unique sources given the available information. Existing individual sources may accrete further transits, may be merged into fewer unique sources, or may split into two or more new, unique sources as more measurements are accumulated. Field `matched_transits_removed` logs the number of transits removed during the most recent cyclic reprocessing crossmatch from those allocated to an existing source during all previous cycles.

IPD_GOF_HARMONIC_AMPLITUDE : Amplitude of the IPD GoF versus position angle of scan (float, Dimensionless[see description])

This statistic measures the amplitude of the variation of the IPD GoF (reduced chi-square) as function of the position angle of the scan direction. A large amplitude indicates that the source is double, in which case the phase indicates the position angle of the pair modulo 180 degrees.

Let ψ be the position angle of the scan direction. The following expression is fitted to the IPD GoF for all the AF observations of the source:

$$\ln(\text{GoF}) = c_0 + c_2 \cos(2\psi) + s_2 \sin(2\psi)$$

The amplitude and phase of the variation are calculated as

$$\texttt{ipd\_gof\_harmonic\_amplitude} = \sqrt{c_2^2 + s_2^2}$$

$$\texttt{ipd\_gof\_harmonic\_phase} = \frac{1}{2}\,\text{atan2}(s_2, c_2) \quad (+\,180^\circ)$$

where atan2 returns the angle in degrees, and 180 is added for negative values.

IPD_GOF_HARMONIC_PHASE : Phase of the IPD GoF versus position angle of scan (float, Angle[deg])

This statistic measures the phase of the variation of the IPD GoF (reduced chi-square) as function of the position angle of the scan direction. See the description of parameter `ipd_gof_harmonic_amplitu` for further details.

IPD_FRAC_MULTI_PEAK : Percent of successful-IPD windows with more than one peak (byte)

This field provides information on the raw windows used for the astrometric processing of this source coming from the Image Parameters Determination (IPD) module in the core processing. It provides the fraction of windows (having a successful IPD result), as percentage (from 0 to 100), for which the IPD algorithm has identified a double peak, meaning that the detection may be a visually resolved double star (either just visual double or real binary).

Typically this attribute is expected to have small, non-zero values. Either 0% and 100% values will probably be very rare. There is no clear threshold that can be considered a good indication of an actual double source (there may be some false flagging due to cosmic rays, for example) but sources with values like 20–40% are probably good candidates for being double sources. For 1D windows at least, and due to the different scan angles, the value will probably be limited to something like 60–70%.

IPD_FRAC_ODD_WIN : Percent of transits with truncated windows or multiple gate (byte)

This field is calculated during AGIS and provides information on the raw windows used for the astrometric processing of this source. It provides the fraction (as a percentage, from 0 to 100) of transits having either truncation or multiple gates flagged in one or more windows. Such a situation invariably means that the on-board VPU detected some nearby source (which may be just a spurious detection, but typically could be some real nearby source — having another distinct transit and most probably assigned to a different source). So in general a non–zero fraction indicates that this source may be contaminated by another nearby source.

A value of zero (which may not be very frequent) can indicate a ‘clean’ source in this respect (limited by the angular resolution and detection sensitivity of Gaia). Small non–zero values (e.g. 10% at most) may indicate sources which are still relatively clean and isolated. Please note that a source affected by a multiple gate may be caused by a quite distant (in the across–scan direction) bright source, so astrometrically it may still be clean (but with slightly degraded image parameters).

RUWE : Renormalised unit weight error (float)

The Renormalised Unit Weight Error is computed as

$$\texttt{ruwe} = \frac{\sqrt{\texttt{astrometric\_chi2\_al}/(\texttt{astrometric\_n\_good\_obs\_al} - m)}}{f(G, G_{\rm BP} - G_{\rm RP})}$$

where m is the number of parameters solved (the number of set bits in `paramsSolved`) and f is a renormalising function.

In practice f is determined in an off-line statistical analysis of the secondary solutions — see 'Re-normalising the astrometric chi-square in Gaia DR2' (Lindegren 2018) — and provided as a look-up table. Also note that this value is set to null for sources with only a two-parameter solution, since this value would be difficult to interpret in such cases.

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

The `scan_direction_strength_k1`...4 and `scan_direction_mean_k1`...4 quantify the distribution of AL scan directions across the source. `scan_direction_strength_k1` (and similarly 2,3,4) are the absolute value of the trigonometric moments $m_k = \langle\exp(ik\theta)\rangle$ for $k = 1, 2, 3, 4$ where θ is the position angle of the scan and the mean value is taken over the `astrometric_n_good_obs_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.

N.B. When `astrometric_n_obs_ac` > 0 the scan direction attributes are not provided at Gaia EDR3. Hence for all sources brighter than G ≈ 13, and for a tiny fraction of fainter sources ($\approx 1\%$), these 8 scan direction fields will be NULL.

The `scan_direction_strength_k1`...4 are numbers 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 the corresponding `scan_direction_mean_k1`...4).

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, `scan_direction_strength_k1` is the degree of concentration when the sense of direction is taken into account, while scan_direction_strength_k2 is the degree of concentration without regard to the sense of direction. A large value of scan_direction_stren 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 scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_strength_k1 for further details.

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

The scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_strength_k1 for further details.

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

The scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_strength_k1 for further details.

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

The scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source. scan_direction_mean_k1 (and similarly for $k = 2, 3, 4$) 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 astrometric_n_good_obs_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.

N.B. When astrometric_n_obs_ac > 0 the scan direction attributes are not provided at Gaia EDR3. Hence for all sources brighter than G ≈ 13, and for a tiny fraction of fainter sources ($\approx 1\%$), these 8 scan direction fields will be NULL.

scan_direction_mean_k1 (and similarly for $k = 2, 3, 4$) is an angle between $-180°/k$ and $+180°/k$, giving the mean position angle of the scans at order k.

The different orders k are statistics of the scan directions modulo $360°/k$. For example, at first order ($k = 1$), $\theta = 10°$ and $\theta = 190°$ count as different directions, but at second order ($k = 2$) they are the same. Thus, scan_direction_mean_k1 is the mean direction when the sense of direction is taken into account, while scan_direction_mean_k2 is the mean direction without regard to the sense of the direction. For example, scan_direction_mean_k1 = 0 means that the scans preferentially go towards North, while scan_direction_mean_k2 = 0 means that they preferentially go in the North-South direction, and scan_direction_mean_k4 = 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 scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_mean_k1 for further details.

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

The scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_mean_k1 for further details.

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

The scan_direction_strength_k1...4 and scan_direction_mean_k1...4 attributes quantify the distribution of AL scan directions across the source.

See the description for attribute scan_direction_mean_k1 for further details.

DUPLICATED_SOURCE : Source with multiple source identifiers (boolean)

During data processing, this source happened to be duplicated and only one source identifier has been kept. Observations assigned to the discarded source identifier(s) were not used. This may indicate observational, cross-matching or processing problems, or stellar multiplicity, and probable astrometric or photometric problems in all cases. Up to and including Gaia DR3, for close doubles with separations below some 2 arcsec, truncated windows have not been processed, neither in astrometry nor 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 unpredictable in the sense that it might refer to either (or neither) image, and no consistency is assured.

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

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 (float, Flux[e-/s])

Standard deviation of the G-band fluxes divided by sqrt(`phot_g_n_obs`)

PHOT_G_MEAN_FLUX_OVER_ERROR : G-band mean flux divided by its error (float)

Mean flux in the G-band divided by its error.

PHOT_G_MEAN_MAG : G-band mean magnitude (float, 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.

No error is provided for this quantity as the error distribution is only symmetric in flux space. This converts to an asymmetric error distribution in magnitude space which cannot be represented by a single error value.

PHOT_BP_N_OBS : Number of observations contributing to BP photometry (short)

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

PHOT_BP_MEAN_FLUX : Integrated BP mean flux (double, Flux[e-/s])

Mean flux in the integrated BP band.

PHOT_BP_MEAN_FLUX_ERROR : Error on the integrated BP mean flux (float, Flux[e-/s])

Error on the mean flux in the integrated BP band (errors are computed from the dispersion about the weighted mean of input calibrated photometry). A handful of sources have error equal to zero. More details and the list of the sources affected are in Sect. **??**.

PHOT_BP_MEAN_FLUX_OVER_ERROR : Integrated BP mean flux divided by its error (float)

Integrated BP mean flux divided by its error. A handful of sources have error equal to zero, meaning that the ratio is NULL. More details and the list of the sources affected are in Sect. **??**.

PHOT_BP_MEAN_MAG : Integrated BP mean magnitude (float, Magnitude[mag])

Mean magnitude in the integrated BP band. This is computed from the BP-band mean flux applying the magnitude zero-point in the Vega scale.

No error is provided for this quantity as the error distribution is only symmetric in flux space. This converts to an asymmetric error distribution in magnitude space which cannot be represented by a single error value.

PHOT_RP_N_OBS : Number of observations contributing to RP photometry (short)

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

PHOT_RP_MEAN_FLUX : Integrated RP mean flux (double, Flux[e-/s])

Mean flux in the integrated RP band.

PHOT_RP_MEAN_FLUX_ERROR : Error on the integrated RP mean flux (float, Flux[e-/s])

Error on the mean flux in the integrated RP band (errors are computed from the dispersion about the weighted mean of input calibrated photometry). A handful of sources have error equal to zero. More details and the list of the sources affected are in Sect. **??**.

PHOT_RP_MEAN_FLUX_OVER_ERROR : Integrated RP mean flux divided by its error (float)

Integrated RP mean flux divided by its error. A handful of sources have error equal to zero, meaning that the ratio is NULL. More details and the list of the sources affected are in Sect. **??**.

PHOT_RP_MEAN_MAG : Integrated RP mean magnitude (float, Magnitude[mag])

Mean magnitude in the integrated RP band. This is computed from the RP-band mean flux applying the magnitude zero-point in the Vega scale.

No error is provided for this quantity as the error distribution is only symmetric in flux space. This converts to an asymmetric error distribution in magnitude space which cannot be represented by a single error value.

PHOT_BP_N_CONTAMINATED_TRANSITS : Number of BP contaminated transits (short)

Number of BP transits that contributed to the mean photometry and were considered to be contaminated by one or more nearby sources. The contaminating sources may come from the other field of view.

PHOT_BP_N_BLENDED_TRANSITS : Number of BP blended transits (short)

Number of BP transits that contributed to the mean photometry and were flagged to be blends of more than one source (i.e. more than one source is present in the observing window). The blended sources may come from different fields of view.

PHOT_RP_N_CONTAMINATED_TRANSITS : Number of RP contaminated transits (short)

Number of RP transits that contributed to the mean photometry and were considered to be contaminated by one or more nearby sources. The contaminating sources may come from the other field of view.

PHOT_RP_N_BLENDED_TRANSITS : Number of RP blended transits (short)

Number of RP transits that contributed to the mean photometry and were flagged to be blends of more than one source (i.e. more than one source is present in the observing window). The blended sources may come from different fields of view.

PHOT_PROC_MODE : Photometry processing mode (byte)

This flag indicates the photometric calibration process used for the source. The process is determined by the availability of colour information derived from the internally calibrated mean BP and RP source spectra. The following values are defined for Gaia EDR3:

- 0: this corresponds to the "gold" photometric dataset. Sources in this dataset have complete colour information.
- 1: this corresponds to the "silver" photometric dataset. Sources in this dataset have incomplete colour information and therefore were calibrated using an iterative process that estimated the missing colour information from the source mean G and either BP or RP photometry (depending on which band had full colour information available) using empirical relationships derived from the gold dataset.
- 2: this corresponds to the "bronze" photometric dataset. Sources in this dataset had insufficient colour information and therefore were calibrated using default colour information derived from the gold dataset.

Because the process of generating the mean BP and RP spectra and the process of producing mean BP and RP integrated photometry are very different and have different requirements it is possible for gold sources to be missing any of the bands, i.e. "gold" does not imply anything about the availability of mean G, BP and RP photometry. Similarly for silver and bronze sources it is possible to have photometry available in any bands (and possible combinations).

More details about the different calibration procedures are available in Chapter **??** of the Gaia EDR3 on-line documentation and in Riello (2020)

PHOT_BP_RP_EXCESS_FACTOR : BP/RP excess factor (float)

BP/RP excess factor estimated from the comparison of the sum of integrated BP and RP fluxes with respect to the flux in the G band. This measures the excess of flux in the BP and RP integrated photometry with respect to the G band. A deviation from the norm means that there is a consistency issue between the fluxes. This could generally imply a problem with the G, BP or RP measurements. More details on how to best interpret this metric can be found in Riello (2020).

BP_RP : BP - RP colour (float, Magnitude[mag])

BP−RP colour (`phot_bp_mean_mag` – `phot_rp_mean_mag`).

BP_G : BP - G colour (float, Magnitude[mag])

BP−G colour (`phot_bp_mean_mag` – `phot_g_mean_mag`).

G_RP : G - RP colour (float, Magnitude[mag])

G−RP colour (`phot_g_mean_mag` – `phot_rp_mean_mag`).

DR2_RADIAL_VELOCITY : Radial velocity from Gaia DR2 (float, Velocity[km/s])

Spectroscopic radial velocity in the solar barycentric reference frame. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

The radial velocity provided is the median value of the radial velocity measurements at all epochs.

DR2_RADIAL_VELOCITY_ERROR : Radial velocity error from Gaia DR2 (float, Velocity[km/s])

The `dr2_radial_velocity_error` is the error on the median to which a constant noise floor of 0.11 km/s has been added in quadrature to take into account the calibration contribution. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

In detail, `dr2_radial_velocity_error` = $\sqrt{\sigma^2_{V_{\rm rad}} + 0.11^2}$ where $\sigma_{V_{\rm rad}}$ is the error on the median:

$$\sigma_{V_{\rm rad}} = \sqrt{\frac{\pi}{2}} \cdot \frac{\sigma(V^{\rm t}_{\rm rad})}{\sqrt{\texttt{dr2\_rv\_nb\_transits}}}$$

where $\sigma(V^{\rm t}_{\rm rad})$ is the standard deviation of the epoch radial velocities and dr2_rv_nb_transits the number of transits for which a $V^{\rm t}_{\rm rad}$ has been obtained.

DR2_RV_NB_TRANSITS : Number of transits used to compute radial velocity in Gaia DR2 (short)

The number of transits (epochs) used to compute dr2_radial_velocity. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

DR2_RV_TEMPLATE_TEFF : Teff of the template used to compute radial velocity in Gaia DR2 (float, Temperature[K])

Effective temperature of the synthetic spectrum template used to determine dr2_radial_velocity. N.B. the purpose of this parameter is to provide information on the synthetic template spectrum used to determine dr2_radial_velocity, and not to provide an estimate of the stellar effective temperature of this source. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

DR2_RV_TEMPLATE_LOGG : logg of the template used to compute radial velocity in Gaia DR2 (float, GravitySurface[log cgs])

$\log g$ of the synthetic spectrum template used to determine dr2_radial_velocity. N.B. the purpose of this parameter is to provide information on the synthetic template spectrum used to determine dr2_radial_velocity, and not to provide an estimate of the $\log g$ of this source. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

DR2_RV_TEMPLATE_FE_H : Fe/H of the template used to compute radial velocity in Gaia DR2 (float, Abundances[dex])

Fe/H of the synthetic spectrum template used to determine dr2_radial_velocity. N.B. the purpose of this parameter is to provide information on the synthetic template spectrum used to determine dr2_radial_velocity, and not to provide an estimate of the stellar atmospheric Fe/H of this source. At Gaia EDR3 this value is simply that copied in from Gaia DR2.

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

Galactic Longitude of the object at reference epoch `ref_epoch`, see Section **??** of the release documentation for conversion details.

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

Galactic Latitude of the object at reference epoch `ref_epoch`, see Section **??** of the release documentation for conversion details.

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

Ecliptic Longitude of the object at reference epoch `ref_epoch`, obtained from the equatorial coordinates using the transformation defined in Volume 1, Section 1.5.3 of ESA (1997).

Note that in the transformation applied here the ICRS origin is shifted in the equatorial plane from Γ by $\phi = 0.05542$ arcsec, positive from Γ to the ICRS origin (Chapront et al. 2002). The ICRS has an unambiguous definition with an origin in the ICRF equator defined by the realisation of the ICRF. The ecliptic system is less well-defined, potentially depending on additional conventions in dynamical theories. The transformation employed here corresponds to the inertial mean ecliptic with obliquity and Γ defined by reference to the ICRS equator. Both the obliquity and the position of Γ on the ICRS equator with respect to the ICRS origin have been obtained from Lunar Laser Ranging measurements. This has no time dependence – there is no secular variation of the obliquity and no precession – and it simply defines the relative situation of the various planes at J2000.

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

Ecliptic Latitude of the object at reference epoch `ref_epoch`. For further details see the description for attribute `ecl_lon`.

2 External catalogues

2.1 TYCHO2TDSC_MERGE

Tycho-2 merged with the TDSC catalog and TDSC supplement.

The Tycho Double Star Catalogue, (TDSC, Fabricius et al. 2002) contains 98482 components of double and multiple systems processed in the Tycho-2 context. It includes either original Tycho-2 data or results from a dedicated re-processing aimed at binaries. As pointed out by P. Marrese (personal communication), the TDSC star with identifier 29583 is redundant and it was therefore skipped. The TDSC supplement contains data from an additional 4777 components from either Hipparcos or Tycho-1.

The Tycho-2 main catalogue (Høg et al. 2000) contains 2 539 913 sources, including many binaries, but a minimum separation of 0.8 arcsec was imposed during the catalogue construction. The Tycho-2 supplement-1 contains data for 17588 Hipparcos and Tycho-1 stars, which do not appear in the main catalogue, but only the 4777 stars relevant for TDSC are included here. The Tycho-2 supplement-2 contains an additional 1146 Tycho-1 stars of poor quality.

We have merged Tycho-2 (main) with the TDSC main and supplement, keeping the Tycho-2 data model and extending it to include TDSC–specific fields. This is only possible to a certain degree as specified in detail below. In particular, Tycho-2 includes fields for mean position, proper motion etc. for a combination of Tycho-2 and several ground based catalogues. These fields are inherited for TDSC main stars, but were not derived for the TDSC supplement, where we only provide HIP proper motions. For Tycho-2 stars not in TDSC, blank TDSC fields were appended.

For Tycho-2 stars in TDSC, the following fields were replaced by the corresponding TDSC fields:

- tyc1, tyc2, tyc3;
- hip;
- ccdm.

In addition, if the TDSC contains a new solution:

- bt_mag, e_bt_mag, vt_mag, e_vt_mag, ra_deg, de_deg, ep_ra1990, ep_de1990, e_ra_deg, eDeDec;
- The mean position flag, pflag, is set to 'P' ("photocentre") if resolved and there are Tycho-2 mean positions. Mean position etc. are then repeated for both new components;

- The proximity indicator, prox, is set to blank if the Tycho-2 star was resolved in TDSC;
- The type-of-solution flag, posflg, set to 'N';
- For resolved Tycho-2 stars, two records are given.

For the few TDSC stars with new solutions, but not in Tycho-2, and for the TDSC supplement stars (Hipparcos or Tycho-1), the Tycho-2 part of the merged record was populated in the following way:

- TYC1..3 from TDSC;
- pflag set to TDSC pmflg ('H' or 'X'), 'H' indicating Hip proper motions;
- no mean position and related fields;
- proper motions only for Hipparcos stars;
- B_T, V_T photometry from TDSC;
- Tycho-1 flag, tyc, is set to posflg, i.e. 'T' or 'H' although Hipparcos stars may well be in Tycho-1;
- Hipparcos, hip, and CCDM, ccdm, identifiers from TDSC;
- astrometry from TDSC, but the (ra, dec)-correlation, corr, is set to blank.

New TDSC specific fields added after the Tycho-2 part of the record:

- sys_no, cmp, n_main, n_sup, magflg, wds, note, hd;
- rcmp, pa, sep, e_pa, e_paSep, e_sep.

Columns description:

ID : Tycho-2 identifier (string)

The Tycho-2 identifier id string TYC ... 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 component identifier (tyc3) for TDSC entries is copied from TDSC. The recommended star designation contains a hyphen between the TYC numbers, e.g. TYC 1-13-1.

HIP : Hipparcos number (int)

Hipparcos number identifier.

TYC1 : TYC1 component from TYC or GSC (string)

The TYC identifier string component `tyc1`) is constructed from the Guide Star Catalogue region number.

TYC2 : TYC2 component from TYC or GSC (string)

The TYC identifier string component `tyc2` is constructed from the running number within the `tyc1` region.

TYC3 : TYC3 component from TYC or TDSC (string)

The TYC identifier string component `tyc3` is normally 1. Some non-GSC running numbers were constructed for the first Tycho Catalogue and for Tycho-2. The component identifier for Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) entries is copied from TDSC.

ID_TYCHO : Numeric Tycho-2 identifier (long)

These are the IDs as published in Tycho-2. In Tycho-2 objects were identified by 3 numbers (`tyc1`, `tyc2` and `tyc3`) and we have combined these into a single unique number given by (`tyc1`*1000000)+(`tyc2`*10)+(`tyc3`).

TYC : Tycho-1 star (string)

This field is specific to Tycho-2 and not found in the Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002).

- ‘ ’ indicates no Tycho-1 star was found within 0.8 arcsec (quality 1-8) or 2.4 arcsec (quality 9);
- ‘T’ indicates 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.
- ‘H’ TDSC star not in Tycho-2 but in Hipparcos. It may also be in Tycho-1.

RA : Observed Tycho-2 Right Ascension, ICRS (double, Angle[deg])

Observed Tycho-2 Right Ascension, ICRS. This field is a convenience copy of ra_deg.

DEC : Observed Tycho-2 Declination, ICRS (double, Angle[deg])

Observed Tycho-2 Declination, ICRS. This field is a convenience copy of the field de_deg.

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 Ascension, ICRS, epoch=J2000 (double, Angle[deg])

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. Tycho-2 is one of the several catalogues used to determine the mean position and proper motion. The Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) was not used when forming these mean positions. The observed Tycho-2 position is given in the fields RAdeg and DEdeg.

DE_MDEG : Mean Declination, ICRS, at epoch=J2000 (double, Angle[deg])

Mean Declination, 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 Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) was not used when forming these mean positions. 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])

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])

Some Hipparcos stars (having a positive number in the HIP column) have no proper motions; these are virtually all in multiple systems.

EP_RA1990 : Epoch–1990 of ra_deg (float, Time[year])

Epoch–1990 of `ra_deg`.

EP_DE1990 : Epoch–1990 of de_deg (float, Time[year])

Epoch–1990 of `de_deg`.

EP_RA_M : Mean epoch of RA. (float, Time[year])

Mean epoch of RA. The mean epochs are given in Julian years.

EP_DE_M : Mean epoch of Dec. (float, Time[year])

Mean epoch of Dec. The mean epochs are given in Julian years.

NUM : Number of positions used for forming mean data (short)

Number of positions used in constructing the mean positions and proper motions, one of these contributing positions coming from Tycho-2.

E_RA_DEG : Uncertainty RA*cos(dec), of observed Tycho-2 RA. (double, Angle[mas])

Uncertainty, $\sigma_{\alpha \cos \delta}$, of the observed Tycho-2 RA. The errors are based on error models.

E_DE_DEG : Uncertainty of observed Tycho-2 Dec. (double, Angle[mas])

Uncertainty of the observed Tycho-2 declination. The errors are based on error models.

CORR : Correlation (RAdeg,DEdeg) (double)

Correlation (`ra_deg, de_deg`). For Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) stars not in Tycho-2, the field is blank.

E_RA_MDEG : Uncertainty RA*cos(dec),at mean epoch. (double, Angle[mas])

Uncertainty, $\sigma_\alpha \cos\delta$, for the right ascension direction at mean epoch. The errors are based on error models.

E_DE_MDEG : Uncertainty of Dec at mean epoch. (double, Angle[mas])

Uncertainty, σ_δ, for the declination at mean epoch. The errors are based on error models.

E_PM_RA : Uncertainty proper motion in RA*cos(dec). (float, Angular Velocity[mas/year])

Uncertainty, $\sigma_{\mu_\alpha \cos\delta}$, for the proper motion in right ascension direction. The errors are based on error models.

E_PM_DE : Uncertainty of proper motion in Dec. (float, Angular Velocity[mas/year])

Uncertainty, σ_{μ_δ}, for the proper motion in declination. The errors are based on error models.

Q_RA_MDEG : Goodness of fit for mean RA (float)

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when $\mathtt{num} > 2$. Values exceeding 9.9 are truncated to 9.9.

Q_DE_MDEG : Goodness of fit for mean Dec (float)

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when $\mathtt{num} > 2$. Values exceeding 9.9 are truncated to 9.9.

Q_PM_DE : Goodness of fit for pm_de (float)

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when num > 2. Values exceeding 9.9 are truncated to 9.9.

Q_PM_RA : Goodness of fit for pm_ra (float)

This goodness of fit is the ratio of the scatter-based and the model-based error. It is only defined when num > 2. Values exceeding 9.9 are truncated to 9.9.

PFLAG : Mean position flag (string)

The mean position flag takes one of:

- ‘ ’: normal mean position and proper motion;
- ‘P’: the mean position, proper motion, etc., refer to the photocentre of two Tycho-2 entries, where the B_T magnitudes were used in weighting the positions. It is also used for Tycho-2 stars resolved in the Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) and the mean positions and proper motions are then repeated;
- ‘X’: no mean position, no proper motion;
- ‘H’: no mean position, but proper motions from Hipparcos. This option is only used for TDSC stars not in Tycho-2.

POSFLG : Type of Tycho-2 solution (string)

The type of Tycho-2 solution takes one of:

- ‘ ’: 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.

Specific values for entries from the Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002):

- ‘N’: New double star treatment for TDSC;

'T': Tycho-1 position from the Tycho-2 Supplement_1;

H': Hipparcos position from the Tycho-2 Supplement_1.

The values [TH] are only used in the TDSC supplement. In the TDSC main catalogue only flags [' 'N] are used.

CCDM : CCDM component identifier for HIP stars (string)

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.

For Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) entries, the HIP and CCDM fields are from TDSC. There, the separation limit of 0.8 arcsec does not applied.

PROX : Proximity indicator (short, Angle[100mas])

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.

This is a Tycho-2 specific field. For Tycho-2 stars resolved in the Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002), the field is blank.

BT_MAG : Tycho-2 BT magnitude (float, Magnitude[mag])

Blank when no magnitude is available. Either `bt_mag` or `vt_mag` is always given. Approximate Johnson photometry may be obtained as: $V = V_{\mathrm{T}} - 0.090(B_{\mathrm{T}} - V_{\mathrm{T}})$ and $B - V = 0.850(B_{\mathrm{T}} - V_{\mathrm{T}})$. Consult Section 1.3 of Volume 1 of ESA (1997) for details.

Details for the Tycho Double Star Catalogue (TDSC, Fabricius et al. 2002) photometry are specified in 'magflg'.

VT_MAG : Tycho-2 VT magnitude (float, Magnitude[mag])

Blank when no magnitude is available. See the description above for bt_mag for further details.

E_BT_MAG : Uncertainty of BT (float, Magnitude[mag])

Uncertainty of bt_mag. Blank when no magnitude is available. See the description above for bt_mag for details of the photometric system.

E_VT_MAG : Uncertainty of VT (float, Magnitude[mag])

Uncertainty of vt_mag. Blank when no magnitude is available. See the description above for bt_mag for details of the photometric system.

SYS_NO : TDSC identifier for the system (int)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

TDSC identifier for systems appearing in TDSC or its supplement.

CMP : Component designation (string)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002) of one or two characters. The TDSC system identifier (sys_no) plus the component designation give an unambiguous identification of the TDSC component. When possible, the component designation is from the Washington Double Star Catalog (WDS, Mason et al. 2001). In cases where a component designation is added to a WDS system, or to a system not in WDS, this was normally done using letters A,B,... according to the V_{T} magnitude. Cases where the designations deviate from the WDS designations in a non-trivial way are explained in the TDSC notes.

N_MAIN : Number of components in TDSC main catalogue (byte)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Number of components for this system listed in the TDSC main catalogue. The TDSC main catalogue contains components detected in the Tycho-2 (Høg et al. 2000) processing or in the TDSC processing, while the supplement contains components copied across from the Tycho-2 Supplement. A system in TDSC may have components in both the main catalogue and in the supplement. A system known in the Washington Double Star Catalogue (WDS, Mason et al. 2001) may have just one component listed in the TDSC.

N_SUP : Number of components in the TDSC supplement (byte)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002). Number of components for this system listed in the TDSC supplement (which is included in this merged version). The TDSC main catalogue contains components detected in the Tycho-2 (Høg et al. 2000) processing or in the TDSC processing, while the supplement contains components copied across from the Tycho-2 Supplement. A system in TDSC may have components in both the main catalogue and in the supplement. A system known in the Washington Double Star Catalog (WDS, Mason et al. 2001) may have just one component listed in the TDSC.

MAGFLG : TDSC photometry flag (char)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002) giving details for the TDSC photometry.

Except for *Hp*, the photometry is always on the same system as in Tycho-2 (Høg et al. 2000). We expect the Tycho photometry of Hipparcos stars from Fabricius & Makarov (2000) to be more accurate than the normal Tycho-2 photometry.

- ‘ ’: normal photometry, either from Tycho-2 or the TDSC processing;
- ‘A’: normal photometry given here, but alternative photometry is given in Fabricius & Makarov (2000);
- ‘F’: Tycho photometry from Fabricius & Makarov (2000);
- ‘T’: Tycho photometry from Tycho-1 (ESA 1997);
- ‘B’: B_{T} from Tycho-1, *Hp* is given instead of V_{T};
- ‘V’: V_{T} from Tycho-1, no B_{T};
- ‘H’: *Hp* is given instead of V_{T}, no B_{T}.

In the main TDSC catalogue only flags [‘ ’A] are used; in the TDSC supplement only flags [FTBVH].

WDS : WDS identifier for the system (string)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

The Washington Double Star Catalogue (WDS, Mason et al. 2001) contains a 10 character field with approximate ICRS coordinates for the primary component in the form hhmmm+ddmm. This field together with the component designation identifies the relevant entries of the WDS. Exceptions and ambiguities are explained in the notes to the TDSC catalogue.

NOTE : TDSC notes (char)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Flag for a note, normally to the identification in the Washington Double Star Catalog (WDS, Mason et al. 2001). Some WDS identifications need clarification, e.g. because the WDS entry gives no designation or because the star has more than one WDS designation. In other cases the identification is somewhat uncertain or a new component was added to a known system.

- ' ': no note;
- 'A': alternative WDS designation exists;
- 'D': dubious/uncertain WDS identification;
- 'N': a non-specific note;
- 'O': good quality orbit exists, cf. Fabricius et al. (2002), Table 2;
- 'R': this WDS component is probably resolved;
- 'S': a close companion to a WDS component (probably);
- 'T': a Tycho single star, added to a WDS system;
- 'U': undesignated in WDS (non-trivial) or unclear designation.

Notes [ANTU] are explained in detail in the file of notes accompanying the original TDSC.

HD : HD identifier for TDSC entries (int)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Identifier from the Henry Draper catalogue as listed in the original TDSC catalogue.

RCMP : Reference component for position angle and separation (string)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Reference component (cmp) for position angle and separation as detailed in the fields pa and sep.

PA : Position angle (float, Angle[deg])

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Position angle (degrees) of the present component (cmp) with respect to the reference component (rcmp).

Position angle and separation are computed at the mean observational epoch for the two stars by applying proper motion to the right ascensions and declinations at the individual epochs of observation. The position angle is given relative to the ICRS pole.

SEP : Separation (float, Angle[arcsec])

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Separation (arcseconds) of the present component (cmp) with respect to the reference component (rcmp). See the detailed description for pa for further details.

E_PA : Uncertainty of the position angle (float, Angle[deg])

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Uncertainty (degrees) of the position angle of the present component (cmp) with respect to the reference component (rcmp).

E_PA_SEP : Uncertainty of the position angle * separation (short)

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Uncertainty (mas) of the position angle, of the present component (cmp) with respect to the reference component (rcmp), multiplied by the separation.

E_SEP : Uncertainty of the separation (short, Angle[mas])

Tycho Double Star Catalogue specific field (TDSC, Fabricius et al. 2002).

Uncertainty (mas) of the separation of the present component (`cmp`) with respect to the reference component (`rcmp`).

3 Crossmatches

3.1 ALLWISE_BEST_NEIGHBOUR

allWISE BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in allWISE.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

ALLWISE_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

3.2 ALLWISE_NEIGHBOURHOOD

allWISE Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in allWISE. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

ALLWISE_OID : External Catalogue source identifier (int)

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

3.3 APASSDR9_BEST_NEIGHBOUR

APASS DR9 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in APASS DR9. The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_APASSDR9_OID : External Catalogue source identifier (long)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue. The identifier is the Vizier

RECNO.

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

Angular distance between a Gaia source and its best 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.

XM_FLAG : Cross-match algorithm flag (int)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.

- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of ipd_gof_harmonic_amplitude or ruwe.

For detailed documentation about xm_flag and the cross-match algorithm, see Chapter **??**. For a detailed description of gaia_source columns ipd_gof_harmonic_amplitude and ruwe, see Chapter **??**.

3.4 APASSDR9_NEIGHBOURHOOD

APASS DR9 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in APASS DR9. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_APASSDR9_OID : External Catalogue source identifier (long)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue. The identifier is the Vizier RECNO.

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

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (int)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.5 APASSDR9_JOIN

Convenience table to be used to join APASS DR9 catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (clean_apassdr9_oid).
Both original_ext_source_id and clean_apassdr9_oid are present in the cross-match output tables (apassdr9BestNeighbour and apassdr9Neighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same clean_apassdr9_oid.
In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the clean_apassdr9_oid in the join with the cross-match result tables.
See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

CLEAN_APASSDR9_OID : External Catalogue source identifier (int)

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

3.6 GSC23_BEST_NEIGHBOUR

GSC2.3 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in GSC2.3.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter ??. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter ??.

CLEAN_GSC23_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

3.7 GSC23_JOIN

Convenience table to be used to join GSC 2.3 catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (clean_gsc23_oid).
Both original_ext_source_id and clean_gsc23_oid are present in the cross-match output tables (gsc23BestNeighbour and gsc23Neighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same clean_gsc23_oid.
In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the clean_gsc23_oid in the join with the cross-match result tables.
See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

CLEAN_GSC23_OID : External Catalogue source identifier (int)

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

3.8 GSC23_NEIGHBOURHOOD

GSC2.3 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in GSC2.3. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

CLEAN_GSC23_OID : External Catalogue source identifier (int)

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

3.9 HIPPARCOS2_BEST_NEIGHBOUR

Hipparcos2 BestNeighbour table lists each matched external catalogue object with its best neighbour in Gaia. The cross-match algorithm is not symmetric and searches Hipparcos2 sources counterparts in Gaia.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in Gaia whose position is compatible within position errors with the external catalogue target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

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 (int)

The unique source identifier in the original External catalogue.

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

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in Gaia Catalogue (byte)

Number of sources in the Gaia Catalogue which match the External Catalogue source within position errors.
The identifiers of all the neighbours can be found in the Neighbourhood table.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.10 HIPPARCOS2_NEIGHBOURHOOD

Hipparcos2 Neighbourhood table includes all good neighbours for each matched Hipparcos2 object. A good neighbour for a given Hipparcos2 source is a nearby Gaia object whose position is compatible (within position errors) with the Hipparcos2 target.
The cross-match algorithm is not symmetric and searches Hipparcos2 sources counterparts in Gaia. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

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 (int)

The unique source identifier in the original External catalogue.

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

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.11 PANSTARRS1_BEST_NEIGHBOUR

Pan-STARRS1 DR1 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in Pan-STARRS1 DR1.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_PANSTARRS1_OID : External Catalogue source identifier (long)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

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

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.

- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of ipd_gof_harmonic_amplitude or ruwe.

For detailed documentation about xm_flag and the cross-match algorithm, see Chapter ??. For a detailed description of gaia_source columns ipd_gof_harmonic_amplitude and ruwe, see Chapter ??.

3.12 PANSTARRS1_JOIN

Convenience table to be used to join Pan-STARRS1 DR1.1 catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (clean_panstarrs1_oid). Both original_ext_source_id and clean_panstarrs1_oid are present in the cross-match output tables (panstarrs1BestNeighbour and panstarrs1Neighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same clean_panstarrs1_oid. In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed. In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the clean_panstarrs1_oid in the join with the cross-match result tables. See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

CLEAN_PANSTARRS1_OID : External Catalogue source identifier (long)

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

3.13 PANSTARRS1_NEIGHBOURHOOD

Pan-STARRS1 DR1 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in Pan-STARRS1 DR1. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_PANSTARRS1_OID : External Catalogue source identifier (long)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

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

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.14 RAVEDR5_BEST_NEIGHBOUR

RAVE DR5 BestNeighbour table lists each matched external catalogue object with its best neighbour in Gaia. The cross-match algorithm is not symmetric and searches RAVE DR5 sources counterparts in Gaia.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in Gaia whose position is compatible within position errors with the external catalogue target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

CLEAN_RAVEDR5_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in Gaia Catalogue (byte)

Number of sources in the Gaia Catalogue which match the External Catalogue source within position errors.
The identifiers of all the neighbours can be found in the Neighbourhood table.

3.15 RAVEDR5_JOIN

Convenience table to be used to join RAVE DR5 catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (clean_ravedr5_oid).
Both original_ext_source_id and clean_ravedr5_oid are present in the cross-match output tables (ravedr5BestNeighbour and ravedr5Neighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same clean_ravedr5_oid.
In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the clean_ravedr5_oid in the join with the cross-match result tables.
See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

CLEAN_RAVEDR5_OID : External Catalogue source identifier (int)

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

3.16 RAVEDR5_NEIGHBOURHOOD

RAVE DR5 Neighbourhood table includes all good neighbours for each matched RAVE DR5 object. A good neighbour for a given RAVE DR5 source is a nearby Gaia object whose position is compatible (within position errors) with the RAVE DR5 target.
The cross-match algorithm is not symmetric and searches RAVE DR5 sources counterparts in Gaia. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

CLEAN_RAVEDR5_OID : External Catalogue source identifier (int)

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

3.17 SDSSDR13_BEST_NEIGHBOUR

SDSS DR13 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in SDSS DR13.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_SDSSDR13_OID : External Catalogue source identifier (int)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

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

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.

- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of ipd_gof_harmonic_amplitude or ruwe.

For detailed documentation about xm_flag and the cross-match algorithm, see Chapter **??**. For a detailed description of gaia_source columns ipd_gof_harmonic_amplitude and ruwe, see Chapter **??**.

3.18 SDSSDR13_JOIN

Convenience table to be used to join SDSS DR13 catalogue with the cross-match results. The table links the external catalogue original source_id (`original_ext_source_id`) to the corresponding the additional numerical identifier (`sdssdr13Oid`).
Both `original_ext_source_id` and `sdssdr13Oid` are present in the cross-match output tables (`sdssdr13BestNeighbour` and `sdssdr13Neighbourhoo`
However, in case there are suspected duplicates in the external catalogue, different `original_ext_source_id` will correspond to the same `sdssdr13Oid`.
In the cross-match output table only the `original_ext_source_id` of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the `original_ext_source_id` in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the `sdssdr13Oid` in the join with the cross-match result tables.
See Documentation **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

CLEAN_SDSSDR13_OID : External Catalogue source identifier (int)

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

3.19 SDSSDR13_NEIGHBOURHOOD

SDSS DR13 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in SDSS DR13. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

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

CLEAN_SDSSDR13_OID : External Catalogue source identifier (int)

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

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

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

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.20 SKYMAPPERDR2_BEST_NEIGHBOUR

SkyMapper DR2 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in SkyMapper DR2.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

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 (long)

The unique source identifier in the original External catalogue.

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

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.21 SKYMAPPERDR2_JOIN

Convenience table to be used to join SkyMapper DR2 catalogue with the cross-match results. It lists all the SkyMapper DR2 sources which were used in the cross-match. See Documentation, **??**, for more details on the catalogue.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (long)

The unique source identifier in the original External catalogue.

3.22 SKYMAPPERDR2_NEIGHBOURHOOD

SkyMapper DR2 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in SkyMapper DR2. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

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 (long)

The unique source identifier in the original External catalogue.

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

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

3.23 TMASS_PSC_XSC_BEST_NEIGHBOUR

2MASS BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in 2MASS.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

CLEAN_TMASS_PSC_XSC_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

3.24 TMASS_PSC_XSC_JOIN

Convenience table to be used to join 2MASS PSC+XSC catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (clean_tmass_psc_xsc_oid). Both original_ext_source_id and clean_tmass_psc_xsc_oid are present in the cross-match output tables (tmassPscXscBestNeighbour and tmassPscXscNeighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same clean_tmass_psc_xsc_oid.
In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the clean_tmass_psc_xsc_oid in the join with the cross-match result tables.
See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_PSC_SOURCE_ID : Original 2MASS PSC source identifier (string)

The unique source identifier in 2MASS PSC.

ORIGINAL_XSC_SOURCE_ID : Original 2MASS XSC source identifier (string)

The unique source identifier in 2MASS XSC.

CLEAN_TMASS_PSC_XSC_OID : External Catalogue source identifier (int)

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

3.25 TMASS_PSC_XSC_NEIGHBOURHOOD

2MASS Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in 2MASS. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

CLEAN_TMASS_PSC_XSC_OID : External Catalogue source identifier (int)

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

3.26 TYCHO2TDSC_MERGE_BEST_NEIGHBOUR

Tycho2TDSCmerge BestNeighbour table lists each matched external catalogue object with its best neighbour in Gaia. The cross-match algorithm is not symmetric and searches Tycho2TDSCmerge sources counterparts in Gaia.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in Gaia whose position is compatible within position errors with the external catalogue target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

TYCHO2TDSC_MERGE_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in Gaia Catalogue (byte)

Number of sources in the Gaia Catalogue which match the External Catalogue source within position errors.
The identifiers of all the neighbours can be found in the Neighbourhood table.

3.27 TYCHO2TDSC_MERGE_JOIN

Convenience table to be used to join Tycho2-TDSC Merge catalogue with the cross-match results. The table links the external catalogue original source_id (original_ext_source_id) to the corresponding the additional numerical identifier (tycho2tdsc_merge_oid).
Both original_ext_source_id and tycho2tdsc_merge_oid are present in the cross-match output tables (tycho2tdscMergeBestNeighbour and tycho2tdscMergeNeighbourhood). However, in case there are suspected duplicates in the external catalogue, different original_ext_source_id will correspond to the same tycho2tdsc_merge_oid.
In the cross-match output table only the original_ext_source_id of the source with the best astrometry among the suspected duplicates will be listed.
In practice, users may use the original_ext_source_id in the original catalogue to find the matching source with the best astrometry. Users interested to find all matching suspected duplicates should instead use the tycho2tdsc_merge_oid in the join with the cross-match result tables.
See Documentation, **??**, for more details on the duplicates in the external catalogues and their treatment in the cross-match computations.

Columns description:

ORIGINAL_EXT_SOURCE_ID : Original External Catalogue source identifier (string)

The unique source identifier in the original External catalogue.

TYCHO2TDSC_MERGE_OID : External Catalogue source identifier (int)

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

3.28 TYCHO2TDSC_MERGE_NEIGHBOURHOOD

Tycho2TDSCmerge Neighbourhood table includes all good neighbours for each matched Tycho2TDSCmerge object. A good neighbour for a given Tycho2TDSCmerge source is a nearby Gaia object whose position is compatible (within position errors) with the Tycho2TDSCmerge target.
The cross-match algorithm is not symmetric and searches Tycho2TDSCmerge sources counterparts in Gaia. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the Gaia environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

TYCHO2TDSC_MERGE_OID : External Catalogue source identifier (int)

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

3.29 URAT1_BEST_NEIGHBOUR

URAT-1 BestNeighbour table lists each matched Gaia object with its best neighbour in the external catalogue. The cross-match algorithm is not symmetric and searches Gaia sources counterparts in URAT-1.
The best neighbour is chosen among good neighbours as the one with the highest value of the figure of merit, which evaluates the ratio between two opposite models/hypotheses: the counterpart candidate is a match or it is found by chance. Good neighbours are nearby objects in the external catalogue whose position is compatible within position errors with the Gaia target.
The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

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

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

URAT1_OID : External Catalogue source identifier (int)

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

NUMBER_OF_NEIGHBOURS : Number of neighbours in External Catalogue (byte)

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 (byte)

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.

3.30 URAT1_NEIGHBOURHOOD

URAT-1 Neighbourhood table includes all good neighbours for each matched Gaia object. A good neighbour for a given Gaia source is a nearby object in the external catalogue whose position is compatible (within position errors) with the Gaia target.
The cross-match algorithm is not symmetric and searches Gaia sources counterparts in URAT-1. The cross-match algorithm is positional and exploits the full 5 parameters covariance matrix of Gaia astrometric solution when available and the external catalogue positions and position errors. In addition it takes into account the external catalogue environment using the local density.

Please note that the cross-match algorithm is a trade-off between multiple requirements, in particular between completeness and correctness. It is thus not limited to a simple cone search.

Reference papers:
Marrese et al. (2017)
Marrese et al. (2019)

Columns description:

SOURCE_ID : Unique Gaia source identifier (long)

A unique single numerical identifier of the source obtained from gaia_source (for a detailed description see `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 (float, Angle[arcsec])

Angular distance between a Gaia source and its good neighbours in the External Catalogue

SCORE : Score of neighbours (double)

Score of a given neighbour.
The score is a figure of merit based on geometric distance and local density of the external catalogue: the higher the score, the more probable the match is.

XM_FLAG : Cross-match algorithm flag (short)

This flag is a bitmask indicating the details of the cross-match algorithm used for the source.

xm_flag values and descriptions:

- 0 = Initial value; resets all bits.
- 1 = The external catalogue object has one or more multiples. This means that there is at least another object with exactly the same astrometry.
- 2 = The external catalogue object has one or more suspected duplicates. This means that there is at least another object much closer than the catalogue angular resolution.
- 4 = The external catalogue object is resolved in Gaia.
- 8 = The Gaia object has a five parameters astrometric solution.
- 16 = The Gaia object has a two parameters astrometric solution.
- 32 = The external catalogue object is matched only after the special treatment for sources with under-estimated position errors.
- 64 = The external catalogue object is matched only after the special treatment for Gaia sources with large values of `ipd_gof_harmonic_amplitude` or `ruwe`.

For detailed documentation about `xm_flag` and the cross-match algorithm, see Chapter **??**. For a detailed description of `gaia_source` columns `ipd_gof_harmonic_amplitude` and `ruwe`, see Chapter **??**.

URAT1_OID : External Catalogue source identifier (int)

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

4 Auxiliary tables

4.1 COMMANDED_SCAN_LAW

This table provides a representation of the Gaia scanning law over the 34 month time period covered by the Gaia Data Release 3 (from 2014-07-25 10:31:26 to 2017-05-28 08:46:29), including the Ecliptic Pole Scanning at the begin of the mission. Note that this is the commanded attitude of the spacecraft, the actual attitude could deviate from it by up to about 30 arcsec. Also, it does not contain any of the data interruptions that occurred during the real mission, of which the main ones are listed in Chapter **??**, Section **??**.

The scanning law has been sampled at a 10 second interval, in which the satellite rotates about 10 arcminutes (the target spin rate is actually 59.9641857803 arcsec/sec). Note that this is several times shorter than a typical field-of-view transit and the scan position angle will be practically constant during this interval.

Notes:

- The times in columns 1, 2 and 3 are in Julian days in TCB with time origin 2010-01-01T00:00 (JD 2455197.5), following the time coordinate convention used in the Gaia archive. TCB stands for Barycentric Coordinate Time and is the time standard used in Gaia processing, equivalent to the proper time experienced by a clock at rest in a coordinate frame co-moving with the barycentre of the Solar system but outside its gravity well, therefore not influenced by the gravitational time dilation caused by the Sun and the rest of the solar system.
- Column 1 is the reference time for the spacecraft attitude, while columns 2 and 3 give the times with the (relativistic) corrections applied for the light-travel time to the solar system barycentre, corresponding to an infinitely distant source at the RA, DEC at the centres of FOV 1 and 2, respectively.
- FOV1 and FOV2 correspond to the preceding (PFOV) and following (FFOV) fields-of-view, respectively.
- The centres of the field of views are separated by the basic angle of 106.5 deg, see Fig. 2 of Lindegren et al. (2012). Their origin in the focal plane is illustrated in Fig. 3 of the same paper: both originate in the astrometric field (AF) 7, with FOV1 in row 3 and FOV2 in row 5.

- The scan angle, theta, is the position angle of the direction in which the FOV is moving (also called 'along-scan' direction), and is defined in the usual astronomical sense: theta = 0 when the FoV is moving towards local North, and theta = 90 degrees towards local East.
- All values have been formatted to the default double numerical precision and so this precision should not be interpreted as the accuracy of the data.

Columns description:

JD_TIME : Time [Julian Date in TCB at Gaia - 2455197.5] (double, Time[Julian Date (day)])

Time at Gaia in units of JD (in TCB) in days −2 455 197.5. The time at which the scan angles and FoV angles are evaluated in TCB (Temps Coordonnée Barycentrique) with an offset of 2 455 197.5 days is applied (corresponding to a reference time T_0 at 2010-01-01T00:00:00) to have a conveniently small numerical value.

BJD_FOV1 : Time [Julian Date in TCB at barycentre for FOV1 - 2455197.5] (double, Time[Barycentric JD in TCB - 2455197.5 (day)])

Observation time in units of Barycentric JD (in TCB) in days −2 455 197.5, 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 corresponding to an infinitely distant source at (`ra_fov1`, `dec_fov1`), resulting in Barycentric Julian Date (BJD). Finally, an offset of 2 455 197.5 days is applied (corresponding to a reference time T_0 at 2010-01-01T00:00:00) to have a conveniently small numerical value.

BJD_FOV2 : Time [Julian Date in TCB at barycentre for FOV2 - 2455197.5] (double, Time[Barycentric JD in TCB - 2455197.5 (day)])

Observation time in units of Barycentric JD (in TCB) in days −2 455 197.5, 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 corresponding to an infinitely distant source at (`ra_fov2`, `dec_fov2`), resulting in Barycentric Julian Date (BJD). Finally, an offset of 2 455 197.5 days is applied (corresponding to a reference time T_0 at 2010-01-01T00:00:00) to have a conveniently small numerical value.

OBMT_TIME : Time at Gaia (OBMT) (long, Time[OBMT])

Observation time at Gaia converted to OBMT using the HATT (High Accuracy Time Transformation).

RA_FOV1 : Right Ascension of FOV1 centre (float, Angle[deg])

Barycentric Right Ascension α of Field of View 1 (preceding) in ICRS at given time.

DEC_FOV1 : Declination of FOV1 centre (float, Angle[deg])

Barycentric Declination δ of Field of View 1 (preceding) in ICRS at given time.

HEAL_PIX_FOV1 : FOV1 HEALPix level 12 (int)

Level 12 nested scheme HEALPix containing the Field of View 1 (preceding) right ascension and declination.

This field can be used in conjunction with `source_id`, whose most significant bits contain HEALPix information.

SCAN_ANGLE_FOV1 : Scan position angle of FOV1 (float, Angle[deg])

Field of View 1 (preceding) scan angle.

RA_FOV2 : Right ascension of FOV2 centre (float, Angle[deg])

Barycentric Right Ascension α of Field of View 2 (following) in ICRS at given time.

DEC_FOV2 : Declination of FOV2 centre (float, Angle[deg])

Barycentric Declination δ of Field of View 2 (preceding) in ICRS at given time.

HEAL_PIX_FOV2 : FOV2 HEALPix level 12 (int)

Level 12 nested scheme HEALPix containing the Field of View 2 (following) right ascension and declination.

This field can be used in conjunction with source_id, whose most significant bits contain HEALPix information.

SCAN_ANGLE_FOV2 : Scan position angle of FOV2 (float, Angle[deg])

Field of View 2 (following) scan angle.

SOLUTION_ID : Solution Identifier (long)

All Gaia data processed by the Data Processing and Analysis Consortium comes tagged with a solution identifier. This is a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that where used in the generation of the data as well as the input data used. It is mainly for internal DPAC use but is included in the published data releases to enable end users to examine the provenance of processed data products. To decode a given solution ID visit https://gaia.esac.esa.int/decoder/solnDecoder.jsp

4.2 AGN_CROSS_ID

Table agn_cross_id lists sources whose positions and proper motions define the celestial reference frame of Gaia catalogue.

agn_cross_id lists the sources in Gaia (E)DR3 cross-matched to sources in a number of external AGN catalogues. The first column is the sources identifier in the external catalogue specified in the third column, the second column is the source identifier in Gaia (E)DR3.

The selection of sources and the quality of the Gaia-CRF3 are discussed in Klioner (2020).

Columns description:

SOURCE_NAME_IN_CATALOGUE : Identifier in the external catalogue (string)

Source name in the external catalogue (see description in agn_cross_id.catalogue_name).

SOURCE_ID : Gaia source identifier (long)

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

CATALOGUE_NAME : Name of the external catalogue (string)

A unique name for each considered external catalogue used to cross match QSOs. Only one identification is given here even if the same source occurs in more than one catalogue. Further details are given in Chapter **??** of the full documentation.

4.3 FRAME_ROTATOR_SOURCE

Sources used to compute the Gaia reference frame.

The AGIS frame rotator algorithm has two different parts: the reference frame orientation; and the reference frame spin. The reference frame orientation is fixed using the International Earth Rotation and Reference System Service (=IERS) position of a subset of IERS sources defining the third realization of the International Coordinate Reference Frame (Charlot et al., 2020, submitted to A&A), `http://hpiers.obspm.fr/icrs-pc/newwww/icrf/index.php`. The reference frame spin is defined using the Gaia proper motion of a list of QSOs. The reference frame algorithms have an outliers scheme. Hence for each aspect we provide the considered sources and the used sources actually used, and the number of used sources might be lower than the number of considered sources.

Columns description:

SOURCE_ID : Gaia source identifier (long)

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

CONSIDERED_FOR_REFERENCE_FRAME_ORIENTATION : Considered for the reference frame orientation (boolean)

True if the source was a considered source for the reference frame orientation, false otherwise.

USED_FOR_REFERENCE_FRAME_ORIENTATION : Used for the reference frame orientation (boolean)

True if the source was effectively used for the reference frame orientation, false otherwise.

CONSIDERED_FOR_REFERENCE_FRAME_SPIN : Considered for the reference frame spin (boolean)

True if the source was a considered source for the reference frame spin determination, false otherwise.

USED_FOR_REFERENCE_FRAME_SPIN : Used for the reference frame spin (boolean)

True if the source was effectively used for the reference frame spin determination, false otherwise.

4.4 DR2_NEIGHBOURHOOD

Users wishing to look up the E/DR3 record for an astrophysical source identified in DR2 must **NOT** simply extract the record from E/DR3 having the same source identifier.

As described in the detailed description of attribute `designation` in gaia_source it is not guaranteed that the same astronomical source will always have the same source identifier in different Data Releases. Hence the only safe way to compare source records between different Data Releases in general is to check the records of proximal source(s) in the same small part of the sky. This table provides the means to do this via a precomputed crossmatch of such sources, taking into account the proper motions available at E/DR3.

Within the neighbourhood of a given E/DR3 source there may be none, one or (rarely) several possible counterparts in DR2 indicated by rows in this table. This occasional source confusion is an inevitable consequence of the merging, splitting and deletion of identifiers introduced in previous releases during the DR3 processing and results in no guaranteed one–to–one correspondence in source identifiers between the releases.

For more details of the procedure used to create this crossmatch, see Chapter **??** in the online documentation.

Columns description:

DR2_SOURCE_ID : Source identifier in Gaia DR2 (long)

Source identifier assigned during DR2 processing for an astrophysical object in close proximity to (possibly) the same object in DR3.

DR3_SOURCE_ID : Source identifier in Gaia E/DR3 (long)

Source identifier assigned during DR3 processing for an astrophysical object in close proximity to one or more (including possibly the same) objects in DR2.

ANGULAR_DISTANCE : Angular distance between the two sources (float, Angle[mas])

Angular (great–circle) distance on sky between the source pairing between DR2 and DR3.

MAGNITUDE_DIFFERENCE : G band magnitude difference between the sources (float, Magnitude[mag])

G band magnitude difference between the sources based on the individual magnitudes materialised in gaia_source at the time of the respective data releases. The sense of the difference is DR3 minus DR2.

PROPER_MOTION_PROPAGATION : Flag indicating whether E/DR3 coordinates were proper motion corrected (boolean)

This flag indicates whether the DR3 source has proper motion estimates. If yes, they have been used to propagate DR3 coordinates to the DR2 epoch (J2015.5). A simple linear correction has been applied, due to the epoch proximity between both catalogues (0.5 yr).

5 Simulation tables

5.1 GAIA_SOURCE_SIMULATION

Table of sources realised according to the Gaia Object Generator (GOG) simulation. Observed attributes are given with simulated observational uncertainties.

This table contains the output of GOG. The values are obtained after adding the corresponding uncertainty (based on the error models) to the true values in table `gaia_universe_model`. Both the values and the uncertainties are provided.

Columns description:

SOLUTION_ID : Solution Identifier (long)

All Gaia data processed by the Data Processing and Analysis Consortium comes tagged with a solution identifier. This is a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that where used in the generation of the data as well as the input data used. It is mainly for internal DPAC use but is included in the published data releases to enable end users to examine the provenance of processed data products. To decode a given solution ID visit `https://gaia.esac.esa.int/decoder/solnDecoder.jsp`

SOURCE_ID : Long Identifier (long)

A unique source identifier composed by the type of source, the sky region where the source is located and a sequential number inside this region (see the `source_extended_id` in `gaia_universe_model` table).

In the `source_id` information is coded within the 64 bit long integer. The celestial position is encoded via a level 12 Hierarchical Triangular Mesh, covering roughly one square arc minute size on the average:

- The 4 most significant bits contain the object type: (0: Unknown; 1: Stellar; 2: Galaxy; 3: QSO; 4: Supernova; 5: Exoplanet; 6: Noise or PPE; 7: Cluster; 8: Planetary Nebulae; 9: HII Region; 10: GRB; 11: Asteroid; 12: Comet; 13: Planet; 14: Satellite; 15: User Source; -1: Not identified)
- The 28 following bits contain the HTM index at level 12 (note the use of HTM as opposed to HEALPix in `source_id` in `gaia_source`)

- One bit indicates the variability,
- One bit indicates whether this is a multiple system (i.e. not a component).
- The 4 next groups of 3 bits are the 4 hierarchical levels for a multiple system. It is based on the fact that the maximum multiplicity of a hierarchical multiple system currently known is 7 (i.e. 3 bits are needed) with a 4 levels depth. The components in a level are sequential (i.e. non-hierarchical).
- The 18 least significant bits concern the object number in the region.

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

GOG simulation of the right ascension of the barycentre at J2010 reference epoch in ICRS frame

RA_ERROR : Right Ascension error (float, Angle[mas])

GOG simulation of the standard error of right ascension

DEC : Declination (double, Angle[deg])

GOG simulation of the declination of the barycentre at J2010 reference epoch in ICRS frame

DEC_ERROR : Declination error (float, Angle[mas])

GOG simulation of the standard error of declination

PARALLAX : Parallax (float, Angle[mas])

GOG simulation of the parallax of the source. The inverse of the parallax is the distance from the barycenter of the Solar System to the barycenter of the source at J2010 reference epoch

PARALLAX_ERROR : Parallax error (float, Angle[mas])

GOG simulation of the standard error of parallax

PMRA : Proper motion in RA (float, Angular Velocity[mas/year])

GOG simulation of the proper motion along right ascension at J2010 reference epoch: $\mu_{\alpha*} \equiv \mu_{\alpha} \cos \delta$. This is the local tangent plane projection of the proper motion vector in the direction of increasing right ascension.

PMRA_ERROR : Error in RA proper motion (float, Angular Velocity[mas/year])

GOG simulation of the standard error of proper motion in right ascension direction

PMDEC : Proper motion in dec (float, Angular Velocity[mas/year])

GOG simulation of the proper motion along declination at J2010 reference epoch. This is the projection of the proper motion vector in the direction of increasing declination.

PMDEC_ERROR : Error in dec. proper motion (float, Angular Velocity[mas/year])

GOG simulation of the standard error of proper motion in declination direction

N_OBS_AL : Number of AL observations (int)

AL number of accepted observations

N_OUTLIERS_AL : Number of outliers AL observations (int)

AL number of outliers observations

PHOT_G_MEAN_FLUX : Mean G flux (float, Flux[e-/s])

GOG simulation of the mean flux in the G band.

PHOT_G_MEAN_FLUX_ERROR : Mean G flux error (float, Flux[e-/s])

GOG simulation of the mean G-band flux error

PHOT_G_MEAN_MAG : Mean G magnitude (float, Magnitude[mag])

GOG simulation of the apparent mean magnitude in the G band in the Vega scale.

PHOT_BP_MEAN_FLUX : Mean BP flux (float, Flux[e-/s])

GOG simulation of the mean flux in the BP band

PHOT_BP_MEAN_FLUX_ERROR : Mean BP flux error (float, Flux[e-/s])

GOG simulation of the mean BP flux error

PHOT_BP_MEAN_MAG : Mean BP magnitude (float, Magnitude[mag])

GOG simulation of the mean apparent magnitude in the integrated BP band in the Vega scale.

PHOT_RP_MEAN_FLUX : Mean RP flux (float, Flux[e-/s])

GOG simulation of the mean flux in the RP band.

PHOT_RP_MEAN_FLUX_ERROR : Mean RP flux error (float, Flux[e-/s])

GOG simulation of the mean RP flux error

PHOT_RP_MEAN_MAG : Mean RP magnitude (float, Magnitude[mag])

GOG simulation of the mean apparent magnitude in the integrated RP band in the Vega scale.

PHOT_RVS_MEAN_FLUX : Mean RVS flux (float, Flux[e-/s])

GOG simulation of the mean flux in the RVS band.

PHOT_RVS_MEAN_FLUX_ERROR : Mean RVS flux error (float, Flux[e-/s])

GOG simulation of the mean RVS flux error

PHOT_RVS_MEAN_MAG : Mean RVS magnitude (float, Magnitude[mag])

GOG simulation of the mean apparent magnitude in the integrated RVS band in the Vega scale.

RADIAL_VELOCITY : Radial velocity (float, Velocity[km/s])

GOG simulation of the spectroscopic radial velocity in the solar barycentric reference frame at J2010 reference epoch.

RADIAL_VELOCITY_ERROR : Radial velocity error (float, Velocity[km/s])

GOG simulation of the radial velocity error

TEFF : Effective temperature (float, Temperature[K])

GOG simulation of the star effective temperature

TEFF_ERROR : Effective temperature error (float, Temperature[K])

GOG simulation of the star effective temperature error

VSINI : v sin i (float, Velocity[km/s])

GOG simulation of the rotational velocity

VSINI_ERROR : v sin i error (float, Velocity[km/s])

GOG simulation of the rotational velocity error

A0 : Extinction at 550 nm (float, Magnitude[mag])

GOG simulation of the extinction at 550 nm

A0_ERROR : Extinction at 550 nm error (float, Magnitude[mag])

GOG simulation of the extinction at 550 nm error

FEH : Iron abundance (float, Abundances[dex])

GOG simulation of the iron abundance

FEH_ERROR : Iron abundance error (float, Abundances[dex])

GOG simulation of the iron abundance error

LOGG : Surface gravity (float, GravitySurface[log cgs])

GOG simulation of the log10 of the surface gravity (log cgs)

LOGG_ERROR : Surface gravity Error (float, GravitySurface[log cgs])

GOG simulation of the log10 of the surface gravity error

5.2 GAIA_UNIVERSE_MODEL

Table of simulated galactic stars according to the Gaia Universal Model Simulation (GUMS). True values of the intrinsic simulated quantities (astrometry, photometry and physical parameters) for the sources generated by GOG using the Universe Model are given. No errors are added.

Columns description:

SOURCE_EXTENDED_ID : Extended source identifier (string)

Unique object String identifier describing:

- the object type. Here only stars or stellar systems are present, code ="*"
- the HTM region of the object (0-268435455)
- the object number in this region (0-262143)
- the multiplicity (Washington Double Stars Catalogue -WDS- type, 7 components, 4 hierarchical levels max)
- a variability flag ("V")

Example: *000000455-000035Ab2V is a variable star and component Ab2 in a 3-level system. This system is the 35th of the HTM region 455. Such a system as at least 7 sources present in the GUMS table: *000000455-000035+ (the system), *000000455-000035A+, *000000455-000035B, *000000455-000035Aa, *000000455-000035Ab+, *000000455-000035Ab1, *000000455-000035Ab2V

SOURCE_ID : Long Identifier (long)

A unique source identifier composed by the type of source, the sky region where the source is located and a sequential number inside this region (as the `source_extended_id`).

In the `source_id` information is coded within the 64 bit long integer. The celestial position is encoded via a level 12 Hierarchical Triangular Mesh, covering roughly one square arc minute size on the average:

- The 4 most significant bits contain the object type: (0: Unknown; 1: Stellar; 2: Galaxy; 3: QSO; 4: Supernova; 5: Exoplanet; 6: Noise or PPE; 7: Cluster; 8:

Planetary Nebulae; 9: HII Region; 10: GRB; 11: Asteroid; 12: Comet; 13: Planet; 14: Satellite; 15: User Source; -1: Not identified)

- The 28 following bits contain the HTM index at level 12 (note the use of HTM as opposed to HEALPix in `source_id` in `gaia_source`)
- One bit indicates the variability,
- One bit indicates whether this is a multiple system (i.e. not a component).
- The 4 next groups of 3 bits are the 4 hierarchical levels for a multiple system. It is based on the fact that the maximum multiplicity of a hierarchical multiple system currently known is 7 (i.e. 3 bits are needed) with a 4 levels depth. The components in a level are sequential (i.e. non-hierarchical).
- The 18 least significant bits concern the object number in the region.

SOLUTION_ID : Solution Identifier (long)

All Gaia data processed by the Data Processing and Analysis Consortium comes tagged with a solution identifier. This is a numeric field attached to each table row that can be used to unequivocally identify the version of all the subsystems that where used in the generation of the data as well as the input data used. It is mainly for internal DPAC use but is included in the published data releases to enable end users to examine the provenance of processed data products. To decode a given solution ID visit `https://gaia.esac.esa.int/decoder/solnDecoder.jsp`

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

Right ascension of the barycentre at J2010 reference epoch in ICRS frame

DEC : Declination (double, Angle[deg])

Declination of the barycentre at J2010 reference epoch in ICRS frame

DISTANCE : Distance (float, Length & Distance[pc])

Distance from the barycenter of the Solar System to the barycenter of the source at J2010 reference epoch

PMRA : Proper motion along right ascension (float, Angular Velocity[mas/year])

Proper motion along right ascension at J2010 reference epoch: $\mu_{\alpha*} \equiv \mu_\alpha \cos\delta$. This is the local tangent plane projection of the proper motion vector in the direction of increasing right ascension.

PMDEC : Proper motion along declination (float, Angular Velocity[mas/year])

Proper motion along declination at J2010 reference epoch. This is the projection of the proper motion vector in the direction of increasing declination.

RADIAL_VELOCITY : Radial Velocity (float, Velocity[km/s])

Spectroscopic radial velocity in the solar barycentric reference frame at J2010 reference epoch.

MAG_G : Mean Apparent G magnitude (float, Magnitude[mag])

Mean apparent magnitude in the G band in the Vega scale.

MAG_BP : Mean Apparent BP magnitude (float, Magnitude[mag])

Mean Apparent magnitude in the integrated BP band in the Vega scale.

MAG_RP : Mean Apparent RP magnitude (float, Magnitude[mag])

Mean Apparent magnitude in the integrated RP band in the Vega scale.

MAG_RVS : Mean Apparent RVS magnitude (float, Magnitude[mag])

Mean Apparent magnitude in the integrated RVS band in the Vega scale.

V_I : (V-I) color (float, Magnitude[mag])

Intrinsic V-I color (Johnson-Cousins)

MEAN_ABSOLUTE_V : Mean Absolute V magnitude (float, Magnitude[mag])

Mean Absolute V (Johnson) magnitude

AG : Absorption in G (float, Magnitude[mag])

line-of-sight interstellar absorption in the G band

AV : Absorption in V (float, Magnitude[mag])

line-of-sight interstellar absorption in the V band

TEFF : Effective temperature (float, Temperature[K])

Stellar effective temperature.

SPECTRAL_TYPE : spectral class + luminosity class (string)

Stellar MK classification

LOGG : Surface gravity (float, GravitySurface[log cgs])

Stellar surface gravity log g

FEH : Metallicity (float, Abundances[dex])

Stellar metallicity [Fe/H]

ALPHAFE : Alpha elements (float, Abundances[dex])

Abundance of alpha-elements with respect to iron [α/Fe]

MBOL : Absolute bolometric magnitude (float, Magnitude[mag])

Mean absolute bolometric magnitude

AGE : Age (float, Time[Gyear])

Age of the stellar source (Gyr)

MASS : Mass (float, Mass[Solar Mass])

Stellar mass

RADIUS : Radius (float, Length & Distance[Solar Radius])

Stellar radius (mean value for variable pulsating stars)

VSINI : Rotational velocity (float, Velocity[km/s])

Projected rotational velocity

POPULATION : Population (int)

Galactic stellar population: 1=thin disc, 2=thick disc, 3=spheroid, 4=bulge

HAS_PHOTOCENTER_MOTION : Boolean describing if the photocenter has or not motion (boolean)

Field to describe if the photocenter has or not stellar hotspot induced motion

NC : Number of components (int)

nb of components (a component can be either one star or a system)

NT : Total number of object (int)

total number of objects (stars, brown dwarfs or exoplanets) in the system

SEMIMAJOR_AXIS : Semi major axis (float, Length & Distance[AU])

semi-major axis of the orbit of the component (for multiple systems)

ECCENTRICITY : Eccentricity (float)

Eccentricity of the orbit of the component (for multiple systems)

INCLINATION : Inclination (float, Angle[deg])

Inclination of the orbit of the component (for multiple systems)

LONGITUDE_ASCENDING_NODE : Longitude of ascending node (float, Angle[deg])

Longitude of the ascending node of the orbit of the component (for multiple systems)

ORBIT_PERIOD : Period of the orbit (float, Time[day])

Period of the orbit of the component (for multiple systems)

PERIASTRON_DATE : Date of periastron (float, Time[day])

Periastron date of the orbit of the component (for multiple systems)

PERIASTRON_ARGUMENT : Periastron argument (float, Angle[deg])

Periastron argument of the orbit of the component (for multiple systems)

VARIABILITY_TYPE : Variability type (string)

Stellar variability type : ACV, be, cepheid, classicalnovae, deltascuti, dwarfnovae, DYPer, emission, Flaring, gammador, microlens, mira, RCrBs, RRab, RRc, roAp, semiregular, ZZceti

VARIABILITY_AMPLITUDE : Amplitude of variability (float, Magnitude[mag])

Photometric variability amplitude in V magnitude

VARIABILITY_PERIOD : Period of variability (float, Time[day])

Photometric variability period.

VARIABILITY_PHASE : Phase of variability (float)

Photometric variability phase at J2010 reference epoch

R_ENV_R_STAR : Envelope characterisic for Be stars (float)

Envelope characteristic parameter for Be stars

6 Differences between the Gaia EDR3 and DR2 data models

Here we summarise the differences between the new (Gaia EDR3) data model and that presented in the previous (DR2) release. Users of the archive systems (Chapter **??**) will be aware that ADQL provides the primary interface to the data, and that all table names are prefixed with a release identifier in ADQL scripts – for example, `gaiaedr3.gaia_source` for the main catalogue table in the current release. At a minimum it will be necessary to update table prefixes in older scripts from `gaiadr2` to `gaiaedr3` to enable them to work with the new data. Furthermore it is important to note that the set of tables presented in the new release is not identical to those released previously. Even when the same table name is present there are a small number of columns that have name changes or that are not included in the new release.

6.1 Table changes in Gaia EDR3

The following differences with respect to Gaia DR2 should be noted:

6.1.1 Main catalogue tables

The following Gaia DR2 table is not present in Gaia EDR3:

- `ruwe`.

The single parameter contained therein, namely the renormalised unit–weight error, is included in `gaia_source` No further tables have been added in this part of the data model.

6.1.2 Solar system object tables

The following Gaia DR2 tables are not present in Gaia EDR3:

- `sso_observation`;
- `sso_source`.

Solar system tables will reappear in the full Gaia DR3. No further tables have been added in this part of the data model.

6.1.3 Variability tables

The following Gaia DR2 tables are not present in Gaia EDR3:

- vari_cepheid;
- vari_classifier_class_definition;
- vari_classifier_definition;
- vari_classifier_result;
- vari_long_period_variable;
- vari_rotation_modulation;
- vari_rrlyrae;
- vari_short_timescale;
- vari_time_series_statistics.

An expanded set of variability tables will reappear in the full Gaia DR3. No further tables have been added in this part of the data model.

6.1.4 External catalogues

External catalogue tables added at Gaia EDR3 are:

- tycho2_tdsc_merge: a merge of the Tycho2 (Høg et al. 2000) and Tycho Double Star (TDSC; Fabricius et al. 2002) catalogues

At Gaia DR2 the data model descriptions for external catalogues served through the Gaia archive included those released and documented with Gaia DR1. For Gaia EDR3 we have not duplicated these descriptions, but users should note that the external catalogue tables themselves remain available in the archive for use in conjunction with the crossmatch tables (see below). Moreover the associated online data model documentation remains available (Hambly et al. 2018).

6.1.5 Crossmatches

The following Gaia DR2 tables are not present in Gaia EDR3:

- sdssdr9_best_neighbour (superseded by SDSS DR13 – see below);
- sdssdr9_neighbourhood (superseded by SDSS DR13 – see below);

- tmass_best_neighbour (superseded by 2MASS PSC/XSC combined – see below);
- tmass_neighbourhood (superseded by 2MASS PSC/XSC combined – see below);
- tycho2_best_neighbour (superseded by Tycho2/TDSC combined – see below);
- tycho2_neighbourhood (superseded by Tycho2/TDSC combined – see below);

The following tables have been added at Gaia EDR3:

- apassdr9_join;
- gsc23_join;
- panstarrs1_join;
- ravedr5_join;
- sdssdr13_best_neighbour;
- sdssdr13_neighbourhood;
- sdssdr13_join;
- skymapperdr2_best_neighbour;
- skymapperdr2_neighbourhood;
- skymapperdr2_join;
- tmass_psc_xsc_best_neighbour;
- tmass_psc_xsc_neighbourhood;
- tmass_psc_xsc_join;
- tycho2_tdsc_merge_best_neighbour;
- tycho2_tdsc_merge_neighbourhood;
- tycho2_tdsc_merge_join.

Details concerning the contents and use of the join tables in conjunction with the usual neighbour and neighbourhood tables can be found in Chapter **??**.

6.1.6 Auxiliary tables

The following Gaia DR2 tables are not present in Gaia EDR3:

- aux_allwise_agn_gdr2_cross_id (superseded – see below);
- aux_iers_gdr2_cross_id (superseded – see below);
- aux_ss0_orbit_residuals;
- aux_sso_orbits;
- dr1_neighbourhood (superseded – see below).

The following Gaia EDR3 tables have been added:

- agn_cross_id;
- commanded_scan_law;
- dr2_neighbourhood;
- frame_rotator_source;
- gaia_source_simulation (see Sect. **??**);
- gaia_universe_model (see Sect. **??**).

6.1.7 Datalink tables

The following Gaia DR2 tables are not present in Gaia EDR3:

- light_curve;
- epoch_photometry.

Datalink resources (enormously expanded over those available at Gaia DR2) will reappear in the full Gaia DR3.

6.2 Column changes in Gaia EDR3

Where tables are common between Gaia EDR3 and DR2, the following deletions and renamings should be noted (we do not include columns that are new in Gaia EDR3 in this digest):

6.2.1 Main catalogue tables

The following columns have been deleted from table gaia_source:

- astrometric_weight_al;
- mean_varpi_factor_al;
- frame_rotator_object_type;
- phot_variable_flag;
- priam_flags;
- teff_val;
- teff_percentile_lower;
- teff_percentile_upper;
- a_g_val;
- a_g_percentile_lower;
- a_g_percentile_upper;
- e_bp_min_rp_val;
- e_bp_min_rp_percentile_upper;
- e_bp_min_rp_percentile_lower;
- flame_flags
- radius_val;
- radius_percentile_upper;
- radius_percentile_lower;
- lum_val;
- lum_percentile_upper;
- lum_percentile_lower.

Note that variability information (including phot_variable_flag) and all the subsequent astrophysical parameters itemised above will reappear, much expanded, in Gaia DR3.

The following columns have been renamed in table gaia_source (old Gaia DR2 names in parentheses):

- pseudocolour (was astrometric_pseudo_colour);
- pseudocolour_error (was astrometric_pseudo_colour_error);
- astrometric_matched_transits (was astrometric_matched_observations);
- matched_transits (was matched_observations);
- dr2_radial_velocity (was radial_velocity – see Sect. ??);
- dr2_radial_velocity_error (was radial_velocity_error – see Sect. ??);
- dr2_rv_nb_transits (was rv_nb_transits – see Sect. ??);
- dr2_rv_template_teff (was rv_template_teff – see Sect. ??);
- dr2_rv_template_logg (was rv_template_logg – see Sect. ??);
- dr2_rv_template_fe_h (was rv_template_fe_h – see Sect. ??);

6.2.2 Crossmatches

The following columns have been deleted in _best_neighbour tables:

- gaia_astrometric_params;
- best_neighbour_multiplicity.

The following column has been deleted in _neighbourhood tables:

- gaia_astrometric_params.

For a full description of the changes in crossmatching between Gaia EDR3 and Gaia DR2 please see Chapter ??.

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