Gaia DR3 and its foreseen binary star content

by

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Gaia non-single stars (NSS) data processing

- Exploring a 1.8 billion sources catalogue is not like analysing one's favourite binary star
- Searching (automatically) for binaries has been done only on sources that do not appear single, seen from their large Goodness-of-Fit (GoF) either astrometric, photometric or spectroscopic.
- This allowed to select and process:
  - Astrometric binaries (AB), G < 19
  - Spectroscopic binaries (SB1/2)
  - Eclipsing binaries (EB)
  - And combinations of the above
  - not for DR3: Resolved doubles/binaries
  - not for DR3: Multiple star orbits
- Our choice for Gaia data release DR3 : this is the first publication of Gaia NSS, a conservative approach has been adopted, filtering out many solutions, keeping the most significant only.

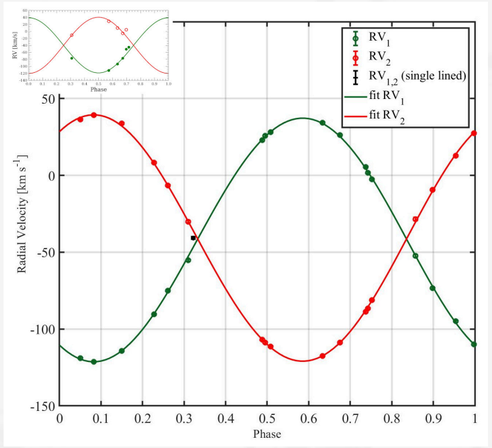
Managing the binary zoo

- Main outcome of the catalogue: orbital or trend parameters
  - Also an improvement on system parameters (parallax, velocity…)

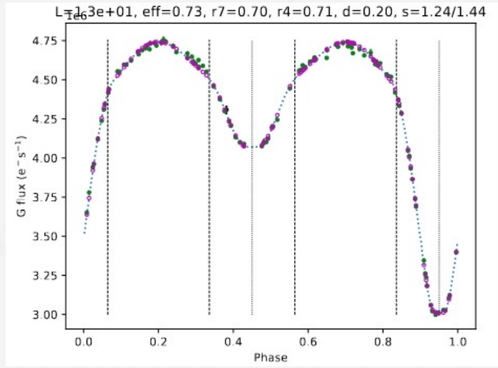
- Astrometric binaries (ordered by decreasing periods)
  - VIMF (fixed variable binary), acceleration 7p (5 astrometric parameters+2 derivatives), acceleration 9p, orbital solutions
  - Processing cascade: the simplest NSS model which fitted the data with an acceptable GoF has been accepted

- Spectroscopic binaries (by decreasing periods)
  - Trend solution (polynomial from 1st to 4th degree), SB1 / SB1C (e~0), SB2 / SB2C

- Eclipsing binaries
  - For DR3: orbital parameters + temperature ratio + sum of radii



ESA/Gaia/DPAC/CU4/NSS, Y. Damerdji, E. Gosset, R. Blomme, T. Morel, P. Panuzzo



ESA/Gaia/DPAC/CU4/NSS, C. Siopis, G. Sadowski

Caveats

- Unfortunately, with 1.8 billion sources, what can go wrong does go wrong…
- Most bad GoF actually originate from resolved double stars or calibration issues
  - E.g, over the 40-millions sources with a bad single star fit (RUWE > 1.4 & G < 19), a very small fraction only may actually be processed as unresolved astrometric binaries.
- When looking for periodicity, one always finds significant periods related to some non-astrophysical signals, e.g. the scanning law (2h/6h spin, 63d precession, one year…)
  - To avoid spurious frequencies, a strong filtering has been applied on all kind of binaries
  - Drawback of producing a weird selection function, while possibly some contamination still

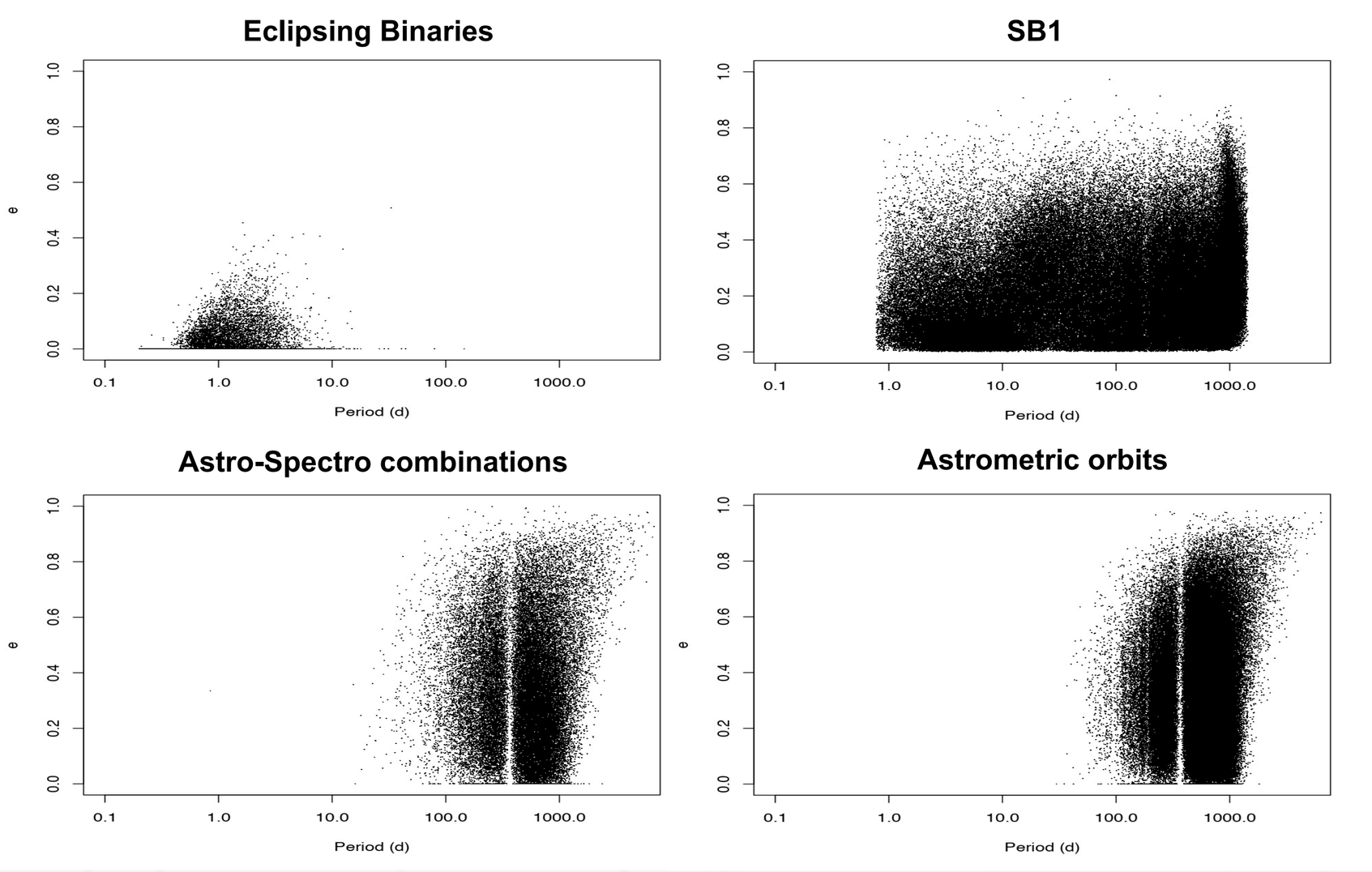
Rough upper limits of the number of solutions

- Astrometric binaries
  - Acceleration ~ 3.10^5
  - Orbital ~ 10^5
  - Including ~ 7.10^2 known substellar hosts
- Spectroscopic binaries
  - SB1+SB1C ~ $1.5\ 10^5$
  - SB2+SB2C ~ 5.10^3
  - Trends ~ 5.10^4
- Eclipsing binaries
  - ~ 4.10^4 (> 10^6 from the variability analysis)
- Astrometric + Spectroscopic ~ 3.10^4
- Spectroscopic + Eclipsing ~ 10^2

NB: astrometry gives the orbit (or acceleration) of the photocentre, not the primary : a low astrometric signal may originate either from a low mass companion or from twins

These preliminary numbers may strongly decrease after validation. They will remain anyway larger than existing catalogues

Period-eccentricity diagrams



NB: Astrometric orbits have an expected dip around one-year periods

Median precision for orbital parameters

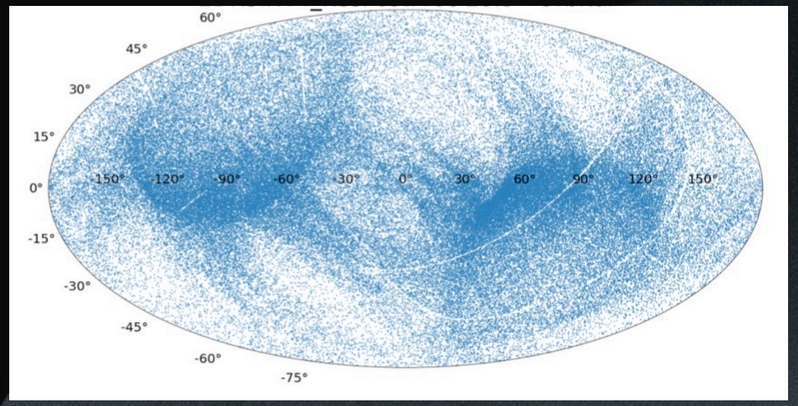
- A good overlap between periods of the various orbital types (+ trends)

- Astrometric orbits
  - Period range (1%-99%) ~ 100-1500d, median relative uncertainty of period ~ 2%
  - Median relative uncertainty of angular semi-major axis ~ 5% (better than 20%)

- Spectroscopic binaries
  - Period range ~ 1-1000d, median relative uncertainty of period ~ 1%
  - Median relative uncertainty of semi-amplitude ~ 6% (better than 20%)

- Combined astrometric + spectroscopic solutions
  - Period range ~ 80-2000d, median relative uncertainty of period ~ 1%
  - Median relative uncertainty of angular semi-major axis ~ 3%

- Eclipsing binaries
  - Period range ~ 0.3-5d, excellent relative uncertainty of period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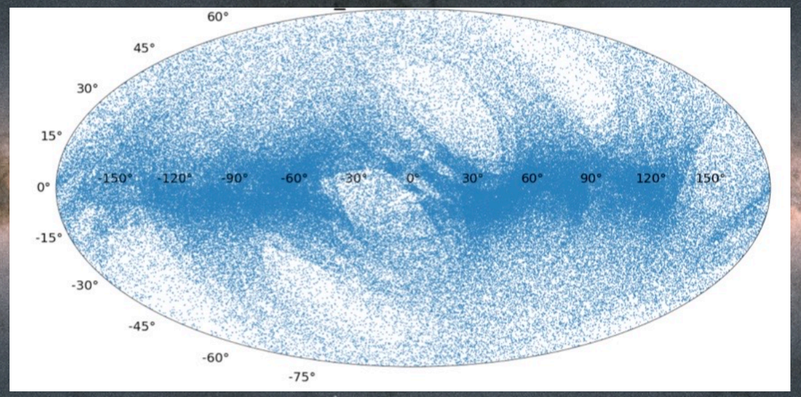
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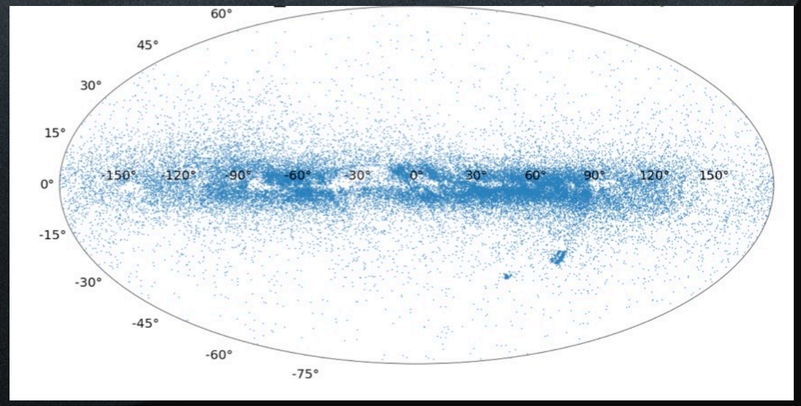
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