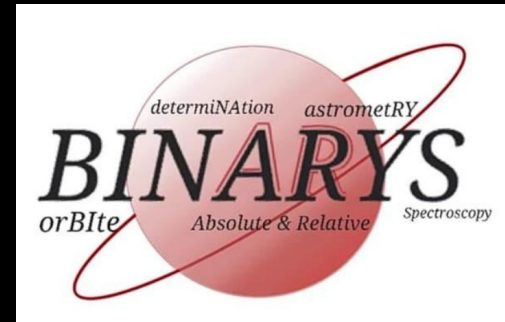
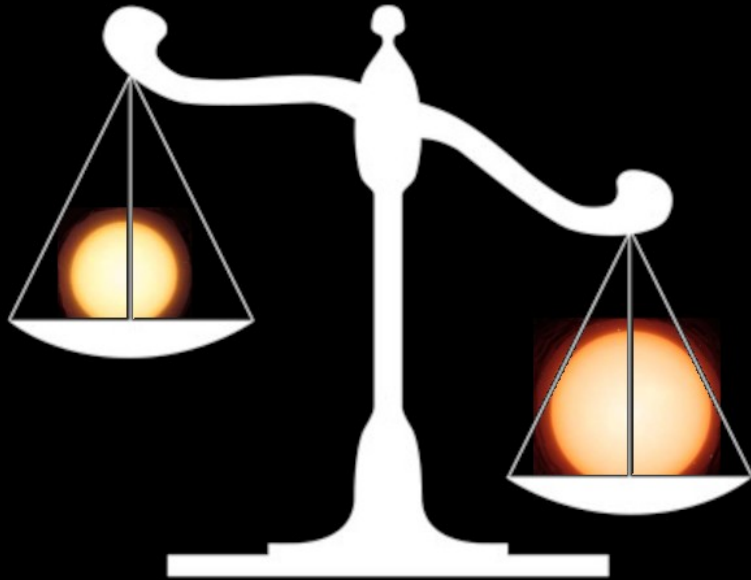


Binary masses with BINARYS



Hipparcos and Gaia



hipparcos

25 years

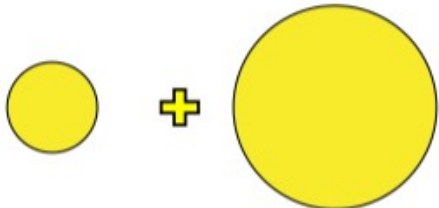
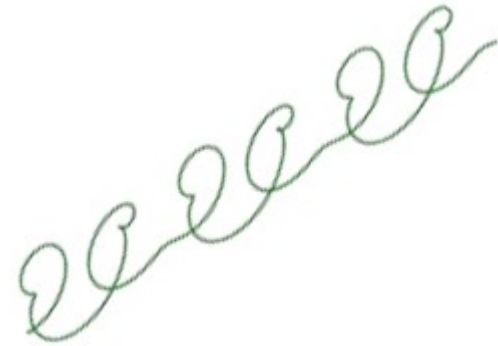


gaia

→ Long period systems

→ Gaia may resolve Hipparcos components

Both observe the photocenter of the system

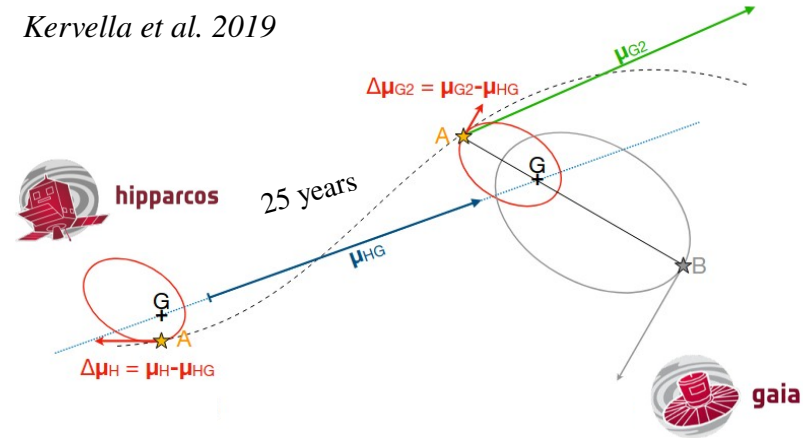


$$a_0 = a_1 \times (1 - \beta/B) \quad \text{with} \quad B = \frac{M_2}{M_1 + M_2} \quad \beta = \frac{L_2}{L_1 + L_2}$$

Combining Hipparcos and Gaia 5p

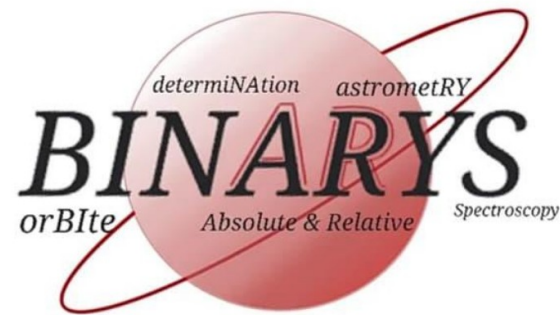
- Proper motion anomaly

Kervella et al. 2019



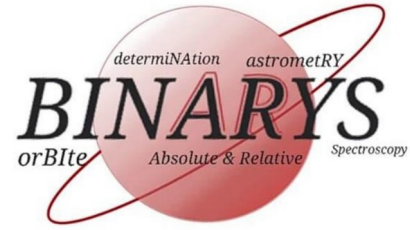
- Hipparcos **Intermediate Astrometric Data** or **Transit Data** (needed for unresolved stars)

+ Gaia single star solution **simulation**

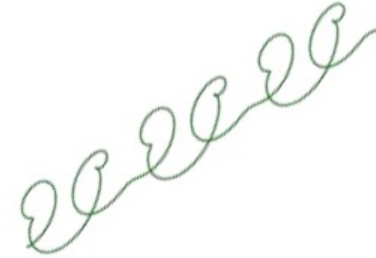


Leclerc et al. 2023

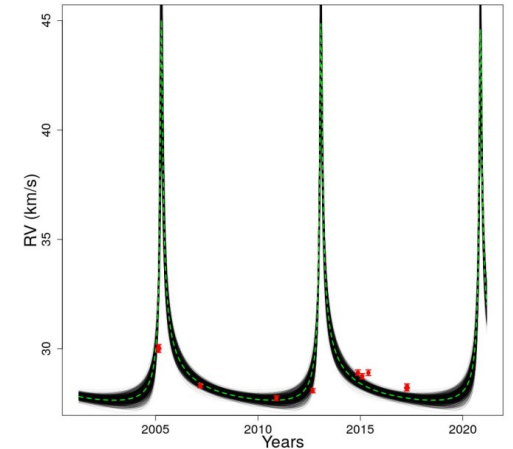
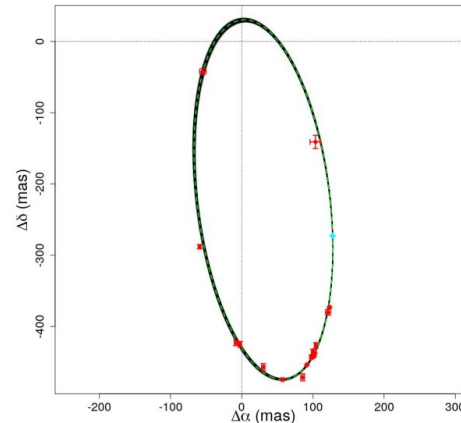
BINARYS



- Absolute Astrometry
- Relative Astrometry
- Radial velocities



→ fast TMB convergence
(automatic differentiation)
→ MCMC posteriors

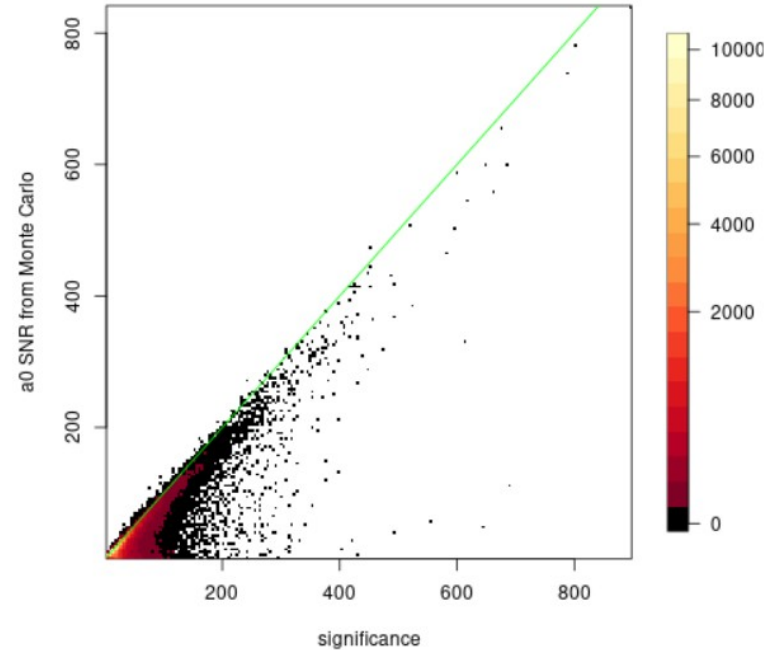


Leclerc et al. 2023

Using Gaia DR3 NSS solutions

Gaia DR3 astrometric NSS solutions :

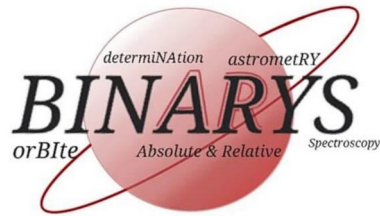
- high non-linear correlations between Thiele Innes coefficients
- Monte Carlo methods not adapted
- Automatic Differentiation method of BINARYS ok



Babusiaux et al. 2023

Mass – luminosity relation

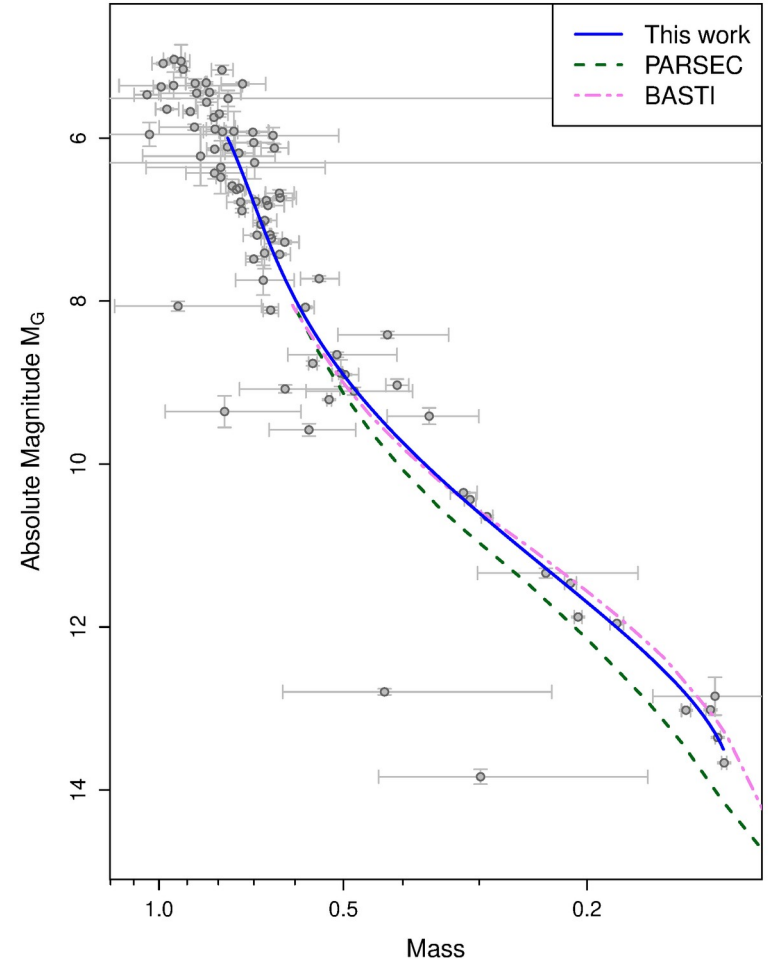
Gaia DR3 astrometric NSS solutions combined with
43 SB9 and 13 APOGEE double-lined spectroscopic binaries
+ 6 Gaia low-mass binaires resolved with Gaia



→ 124 dynamical masses

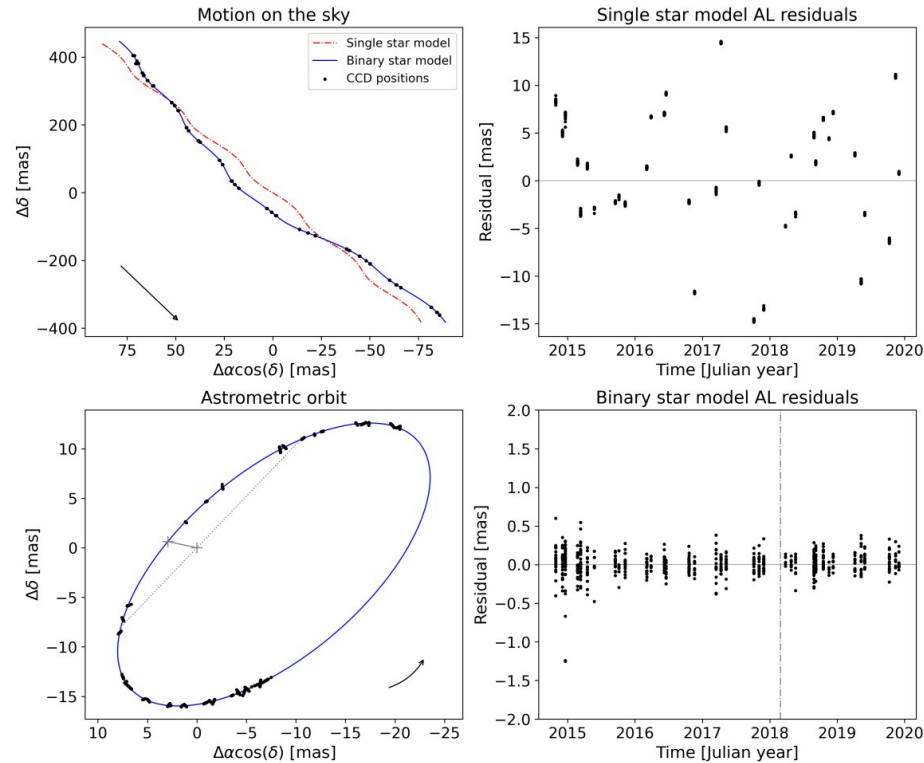
→ Mass – Absolute G magnitude relation

Chevalier et al. 2023



Using Gaia DR4 epoch astrometry

Gaia BH3

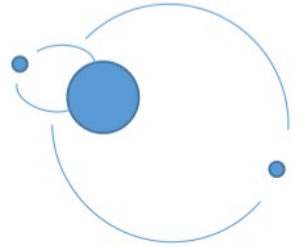


Gaia Collaboration, Panuzzo et al. 2024

<https://gricad-gitlab.univ-grenoble-alpes.fr/ipag-public/gaia/binarys/-/blob/main/BH3/BH3example.R>

BINARYS updates to come

- Hierarchical triple version available (but not yet public)
- Python interface (June)
- Full Gaia DR4 version working with the pre-release astrometric timeseries (June)
- Versions used for the Gaia DR4 validation and the stellar mass-luminosity relation DR4 paper (December ++)



Searching for low mass companions...



Small mass function

← low mass companion

← equal mass companion

Gaia NSS alone (binary_masses)

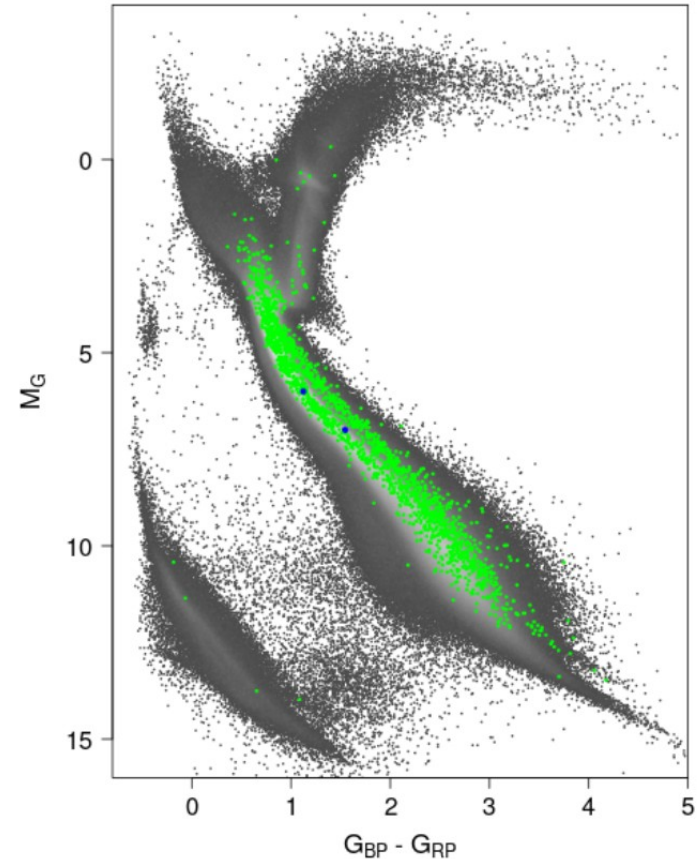
need to fix M_1 and **assume** no flux ratio to get M_2

→ exoplanet or BD **candidate**

Gaia NSS + **one** relative astrometry observation:

flux ratio measured, **both** M_1 and M_2 derived

(e.g. *Pourré et al. 2024*, *Winterhalder et al. 2024*)



Gaia Collaboration, Arenou et al. 2023