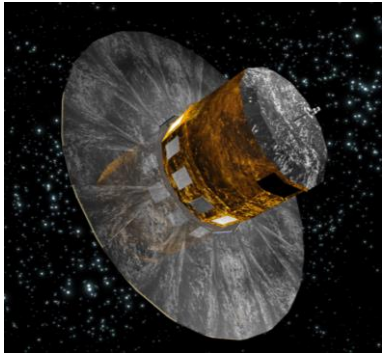


A selection of astrometric binaries from Gaia-DR3 that could also be double-lined spectroscopic binaries and eclipsing binaries

J.-L. Halbwachs, F. Kiefer , Y. Lebreton,
O. Creevey, B. Famaey, P. Guillout, O. Marchal, T. Mazeh, T. Merle, J.B. Salomon

Context. The masses and radii of stars are two fundamental parameters for the study of stellar interiors.

Rarely directly measurable.

To obtain masses : Double-lined spectroscopic binaries (SB2) $\Rightarrow \mathcal{M}_1 \sin^3 i$ and $\mathcal{M}_2 \sin^3 i$ ($\mathcal{M}_1$ and $\mathcal{M}_2$ = masses of the components, i = orbital inclination)

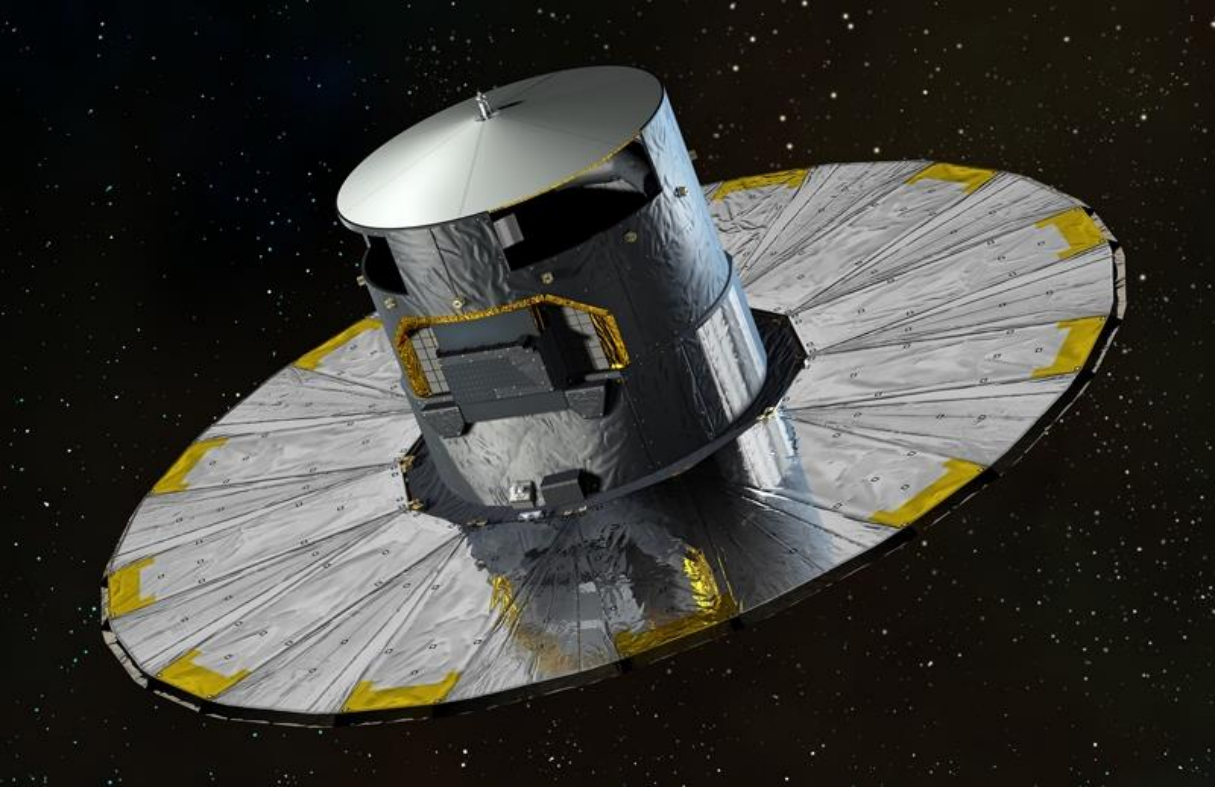
Astrometric or apparent orbit $\Rightarrow i \Rightarrow \mathcal{M}_1$ and $\mathcal{M}_2$

To obtain radii : Eclipsing binaries (EB)

Rare, as they require a particular spatial orientation (Earth's direction in the orbit plane).

Generally, short–period binaries with components altered by mass transfer.

A situation that will change thanks to Gaia !



Gaia. ESA satellite launched end of 2013

DR3 (2022): from August 2014 to 28 May 2017

1.5 billion stars (position, proper motion, parallax)

165,500 unresolved astrometric binaries with an orbital solution ($\Rightarrow$ period, eccentricity, semi-major axis of the photocentric orbit, orbital inclination – Halbwachs et al. 2023)

Selection of the most promising targets

- $\sin^3 i$ more accurate than 1 % to have a chance of getting 1% accurate masses with the DR4 (not before the end of 2025).
- Minimum apparent separation < radius of the primary component, to see eclipses.
- $m_V < 10.40$ mag to be observable from the OHP at T193/Sophie in less than 1 hour.
- $\delta > 0^\circ$ to be observable from the OHP.
- Spectral type F0 or later, so that the radial velocities can be measured with Sophie
- For stars with astrometric+SB1 solution: $a_0/a_1 < 0.9$ or > 1.1, since the binaries with $a_0 = a_1$ will appear as SB1, but not SB2.

$\Rightarrow$ A list of 41 stars

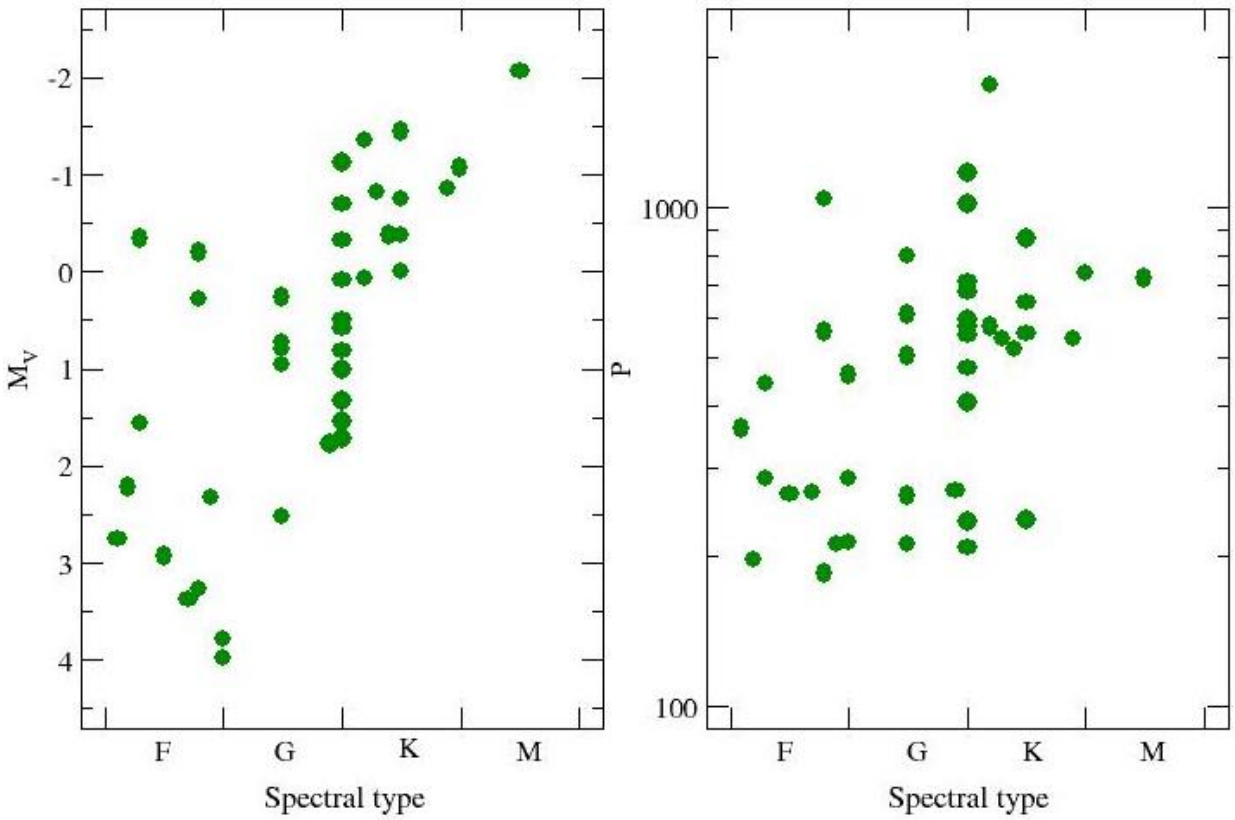
Properties of the selection

HR diagram

- A few F-G dwarfs.
- Many clump giants.

Tsp vs P diagram

- P between 200 and 1000 days.
- P > 500 days for most of the clump giants.



Only some of these binaries could be altered by mass transfer.

Roadmap

1. From next autumn (if proposal accepted), make one or two spectroscopic observations at T193/Sophie (Haute-Provence Observatory) to check that the star is SB2. SB1s will be removed from the program.

2. Look for eclipses $\Rightarrow$ radii of the components. This step is within the reach of experienced amateur astronomers who know how to take images and deduce the magnitudes of the stars.

3. At the same time, continue the spectroscopic observations to calculate the SB2 orbit $\Rightarrow$ a preliminary estimate of masses and magnitudes with the DR3.

4. Derive the masses from the radial velocity measurements and from the astrometric transits of DR4 (not before end of 2025).

5. $\Rightarrow$ A catalogue of accurate stellar masses and radii.

Would you be interested in observing the eclipses of our stars?

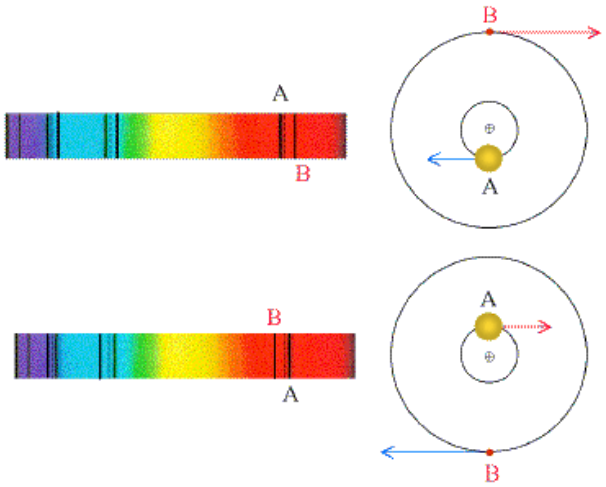
Reference

Halbwachs J.L., Pourbaix D., Arenou F. et al. 2023, A&A 674, A9

A quick reminder about the unresolved double stars
(binaries that appear visually as single stars.)

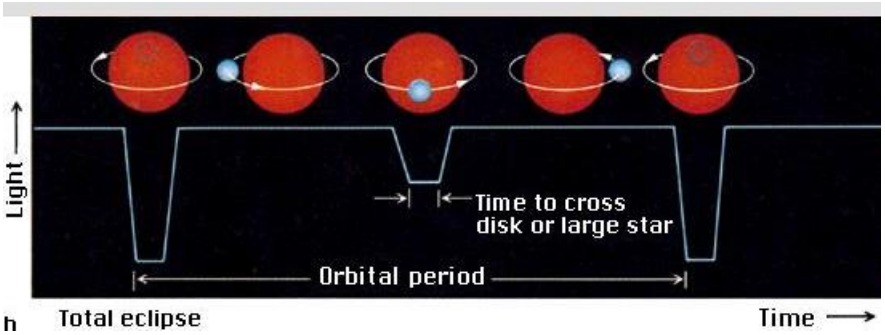
Double-lined Spectroscopic binaries (SB2).

The spectra of 2 stars are superposed, giving two radial velocities that vary in opposite directions.



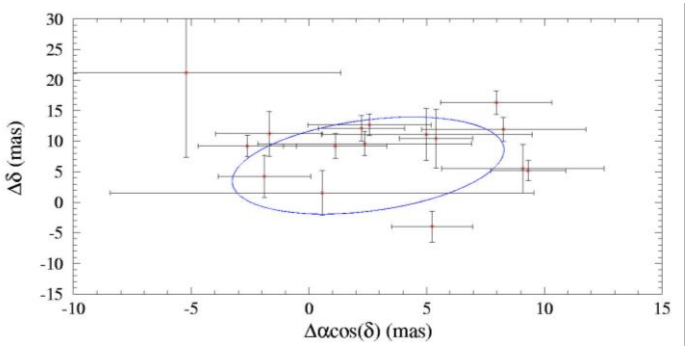
Eclipsing binaries.

The luminosity of the binary decreases when the two stars and the Earth are roughly aligned.



Astrometric binaries.

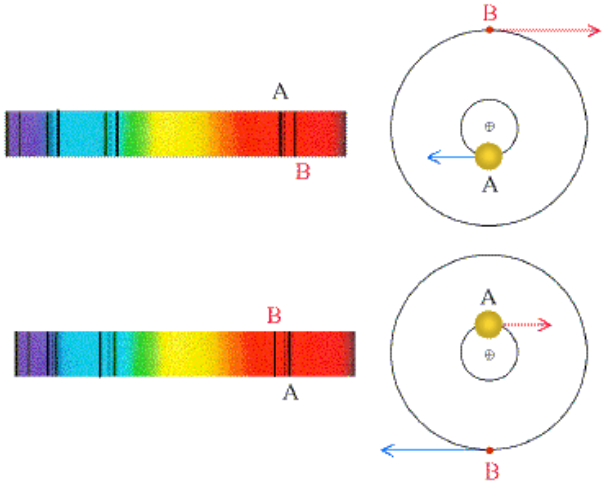
the two quasi-overlapping stars are seen as a large point of light whose center describes a tiny orbit around the binary's barycenter.



Bref rappel sur les étoiles doubles non résolues (binaires dont l'image est celle d'une étoile isolée)

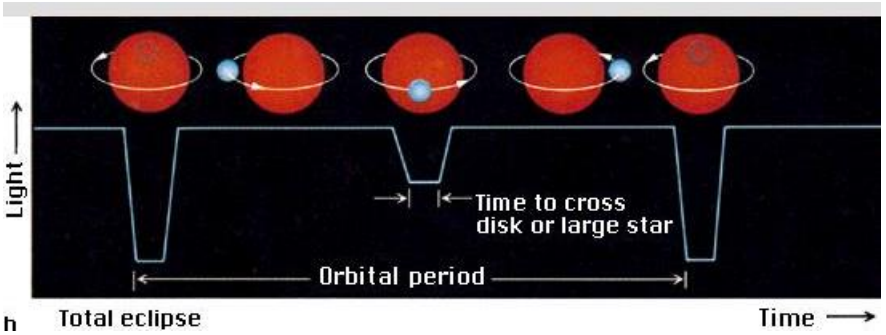
Binaires spectroscopiques à 2 spectres (SB2).

Les spectres des 2 étoiles sont superposés et donnent deux vitesses radiales qui varient en sens opposé.



Binaires à éclipses.

La luminosité de la binaires diminue quand la Terre et les deux étoiles sont quasiment alignées.



Binaires astrométriques.

Les deux étoiles quasi-superposées sont vues comme un gros point lumineux dont le centre décrit une minuscule orbite autour du barycentre de la binaire.