Gaia Treatment of Astrometric Binaries with a Variable Component: VIM, VIMA, VIMO

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1. ABOUT GAIA

- An ESA all-sky survey planned from 2012 to 2017
- 100 astrometric+photometric measurements / star
- Accuracy of each measurement, up to mag 15:
  - astrometric abscissa : 50 10^{-6} arcsec
  - magnitude: 0.001 mag

2. OUR PURPOSE

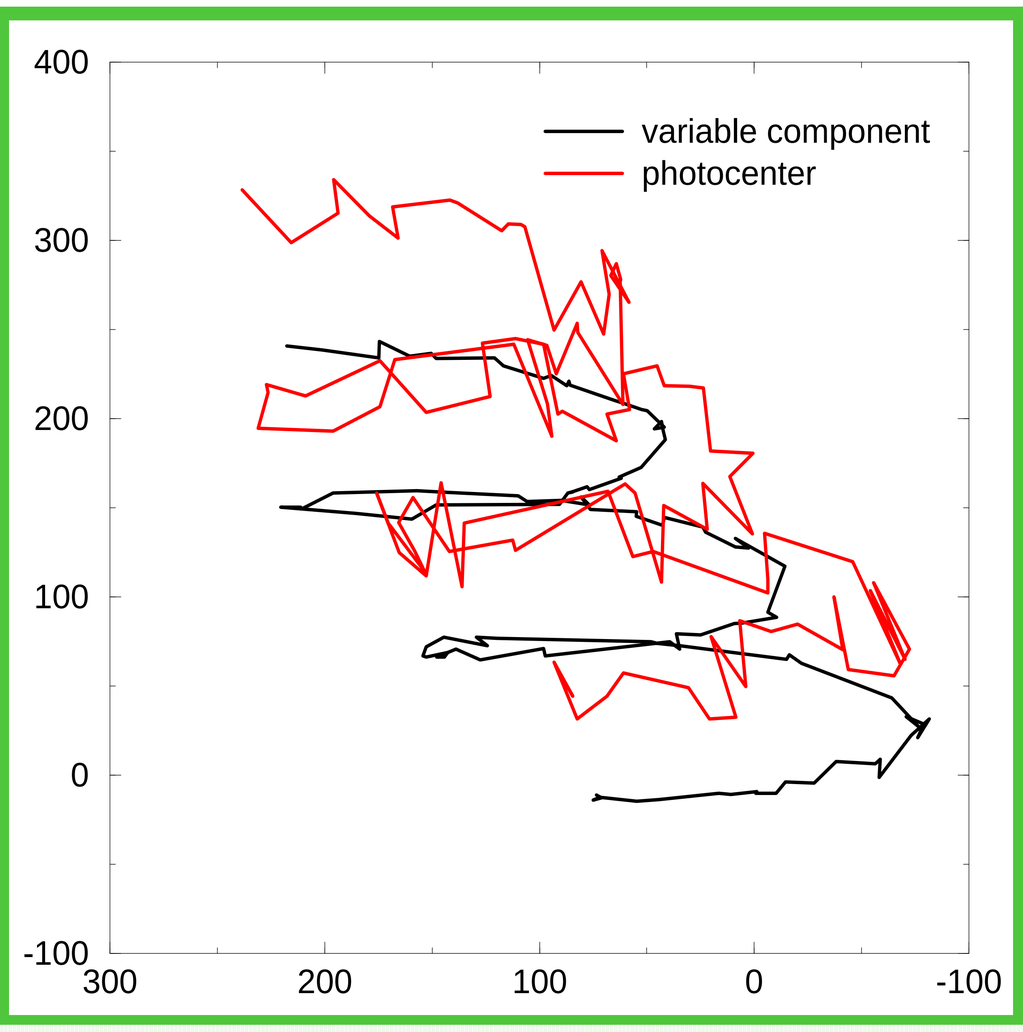
We want to derive astrometric solution and physical parameters for unresolved binaries with 1 component variable in luminosity.

We consider 3 cases :

1. VIM: orbital motion is non-existent or linear
2. VIMA: a small arc of the orbit is observed
3. VIMO: the orbit may be entirely reconstructed

3. Variability Induced Movers (VIM)

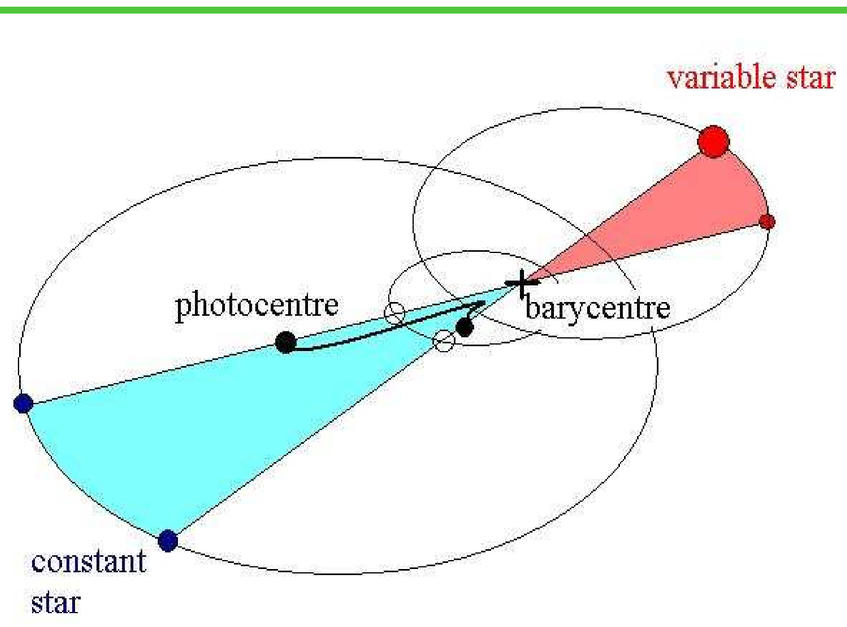
- Components with relative fixed relative positions or linear motion
- Linear model with 2 or 4 more parameters than the single-star model.
- Results: average position of the photocentre + position of the variable component D_α, D_δ + D_α', D_δ' (optional).



Simulation of the motions of a VIM: annual parallax, proper motion and shift of the photocentre (in red) related to the total magnitude of the system. The motion of the variable component (in black) is derived with the astrometric solution. The coordinate unit is microarcsecond.

4. VIM + Acceleration (VIMA)

At constant magnitude, the photocentre moves along an arc of orbit.



Model : VIM + Acceleration terms: g_α, g_δ and g'_α, g'_δ (optional) +

$$h = (1 + q) \times 10^{-0.4\, m_{const}} / q$$

with $q = \mathcal{M}_{const}/\mathcal{M}_{var}$ and m_{const} = magnitude of the constant component.

Linear only when h is fixed !

5. VIM + Orbit (VIMO)

Concerns orbital period up to about 10 yr (twice the duration of the mission)

Model: parameters of the barycentre + orbit of the variable star around the barycentre + h

Linear only when h, P, e and T_0 are fixed !

Computation method

In order to save computing time, a method based on χ^2 minimization is applied:

1. Restrict the range of h assuming an arbitrary P and e = 0
2. Search P and h assuming e = 0
3. Assuming e=0.1, search T_0
4. Search a complete solution with the Levenberg-Marquard method
5. If χ^2 is too large, try other starting values for e (0.7 and 0.9 in step 2, 0.5 in step 3 …)

Test with simulation of large orbits

The true parameters are found for 93 % of the stars.

6. CONCLUSION

The unresolved binaries with a variable component will receive accurate astrometric parameters in the final Gaia catalogue, and some constraints to the physical properties (the "h" parameter) of the systems will even be derived thanks to variability.