



# A circumbinary companion from Hipparcos-Gaia astrometry

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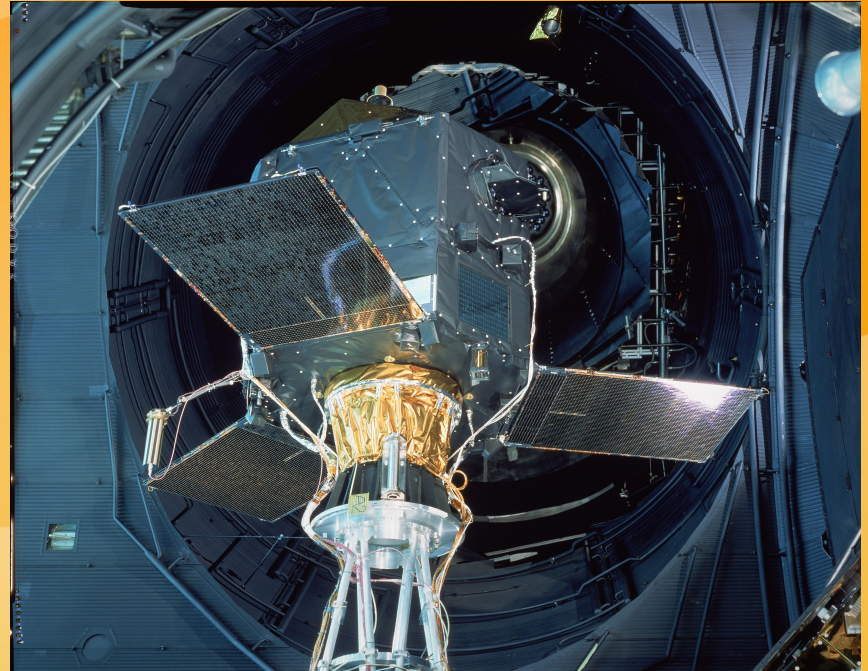
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- Hipparcos and Gaia astrometry
- Astrometric signatures
- 2D confidence map of the companion mass and sma

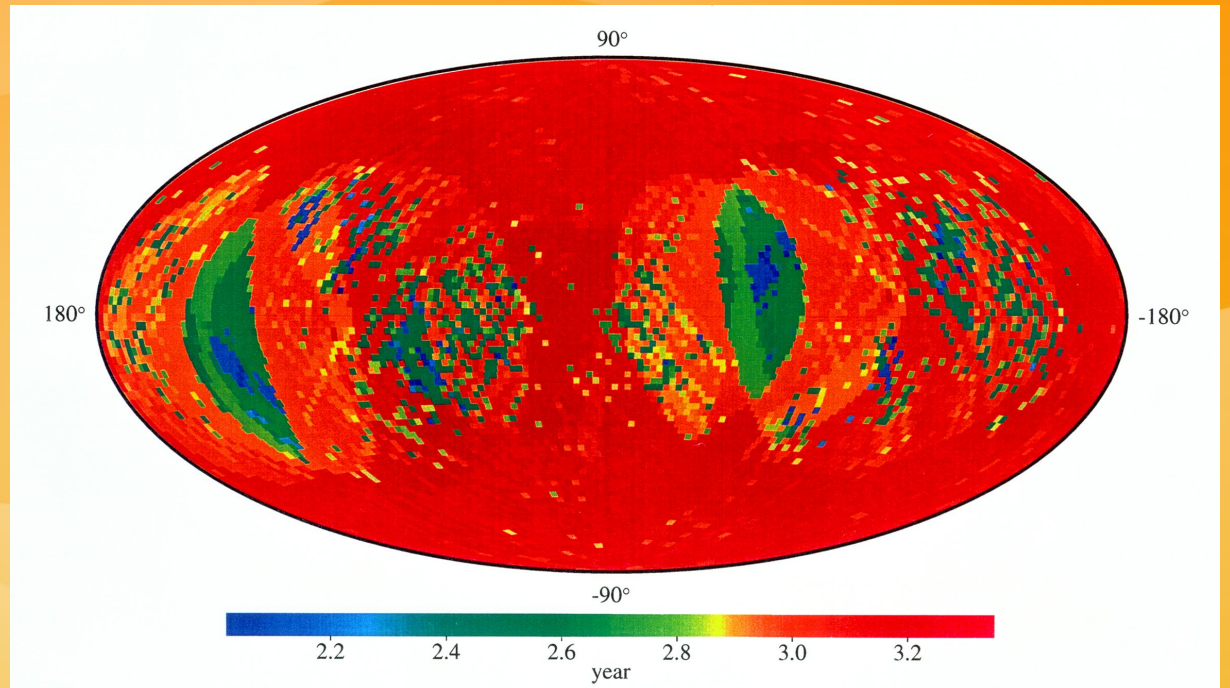
# Hipparcos

- ESA High Precision Parallax Collecting Satellite
- 1989 – 1993
- highly elliptical geostationary transfer orbit



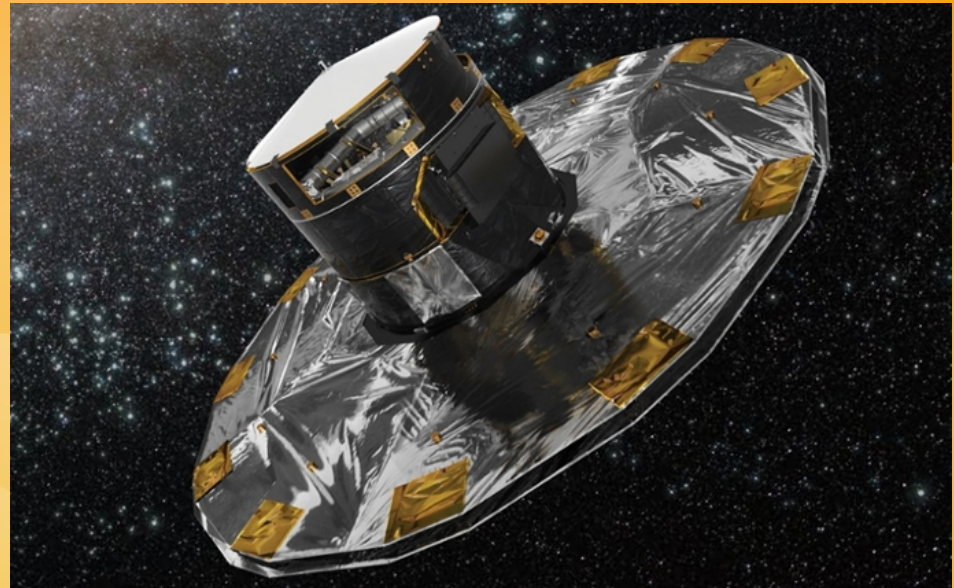
# Hipparcos

- 100/\*
- H. catalogue
- 118 218 \*



# Gaia

- Hipparcos's follow-up mission
- ~~Global Astrometric Interferometer for Astrophysics~~
- 2014-2025
- L2 Lagrange point



# Gaia data releases

- DR1: 14 September 2016
- DR2: 25 April 2018
- Early DR3: 3 December 2020
- DR3: 13 June 2022
- Focused Product Release: 10 October 2023
- DR4 (based on 66 months of data): expected December 2026
- DR5 (based on all mission data): not before 2030

# Astrometric signatures

- The astrometric excess noise

is the excess of scatter in the residuals of along scan angle measurements compared to the astrometric displacement of the source modeled as a single-star, that includes position, linear proper motion and parallactic motion

# Astrometric signatures

- The renormalized unit weight error

An alternative to the AEN. **A large value (>1.4)** for a source is often accepted as **indicating binarity**. Well-behaved sources (single or not), for which the five-parameter fit gives a reasonably good fit, should have  $ruwe < 1.4$ .

# Astrometric signatures

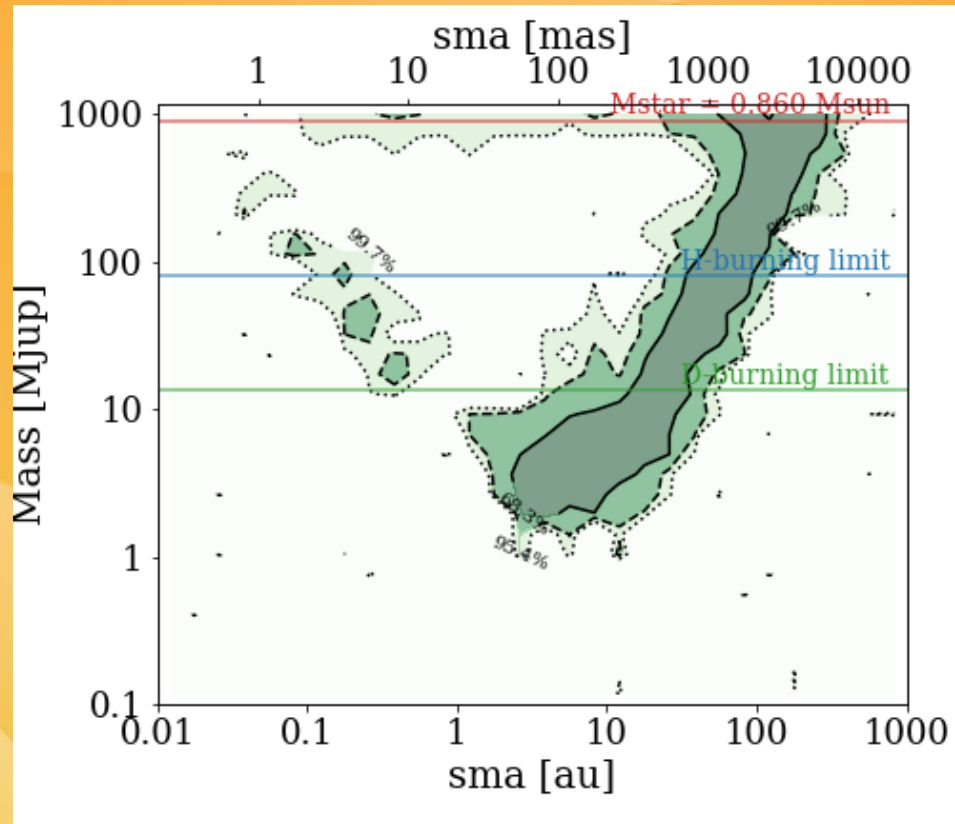
- The proper motion anomaly

The PMA is the proper motion offset between the Hipparcos-Gaia average proper motion (with a baseline  $\sim 24.5$  years), and the GDR3 fitted linear proper motion (with a baseline of 36 months). It thus measures an acceleration of the primary star due to the presence of a long-period secondary companion.

# Astrometric signatures

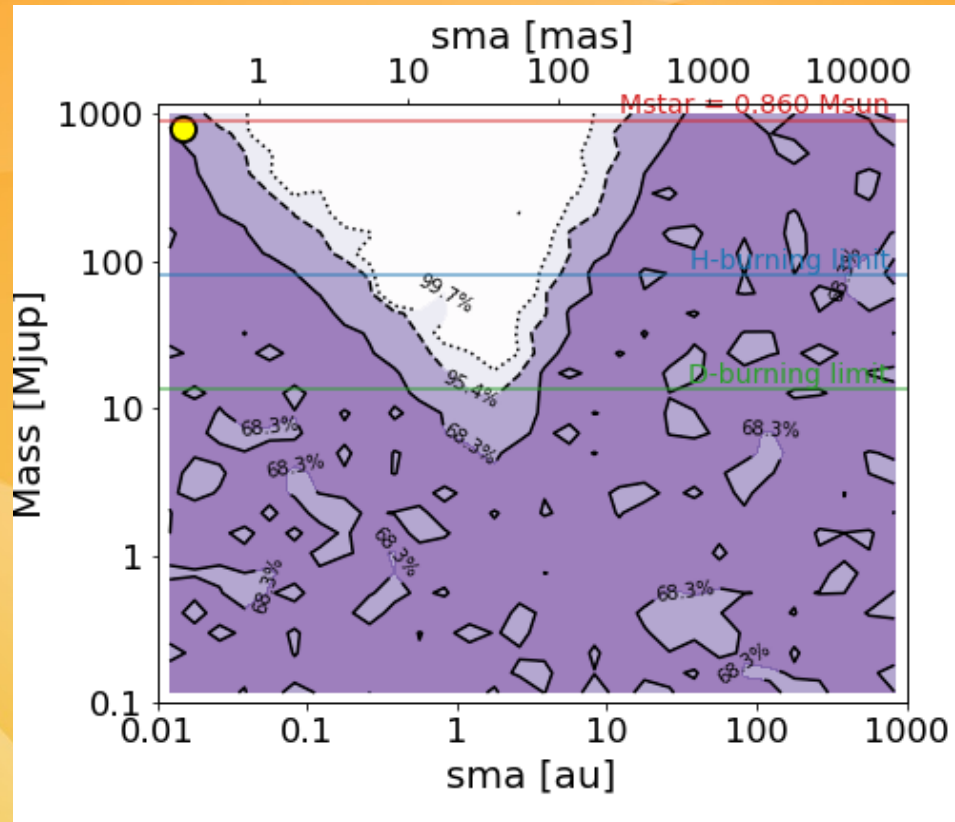
- The aim is to model the key data, namely PMa, AEN, and ruwe, which allow us to characterize the presence of companions and determine their main parameters, such as mass and sma
- To assess the non-singleness of stars from AEN, ruwe, and PMa, Kiefer et al. (2025) defined the “astrometric signatures”. They properly quantify the deviation of AEN, ruwe and PMa beyond the level that they must have had if the sources were single.

# Gaia DR3 43789772861265792



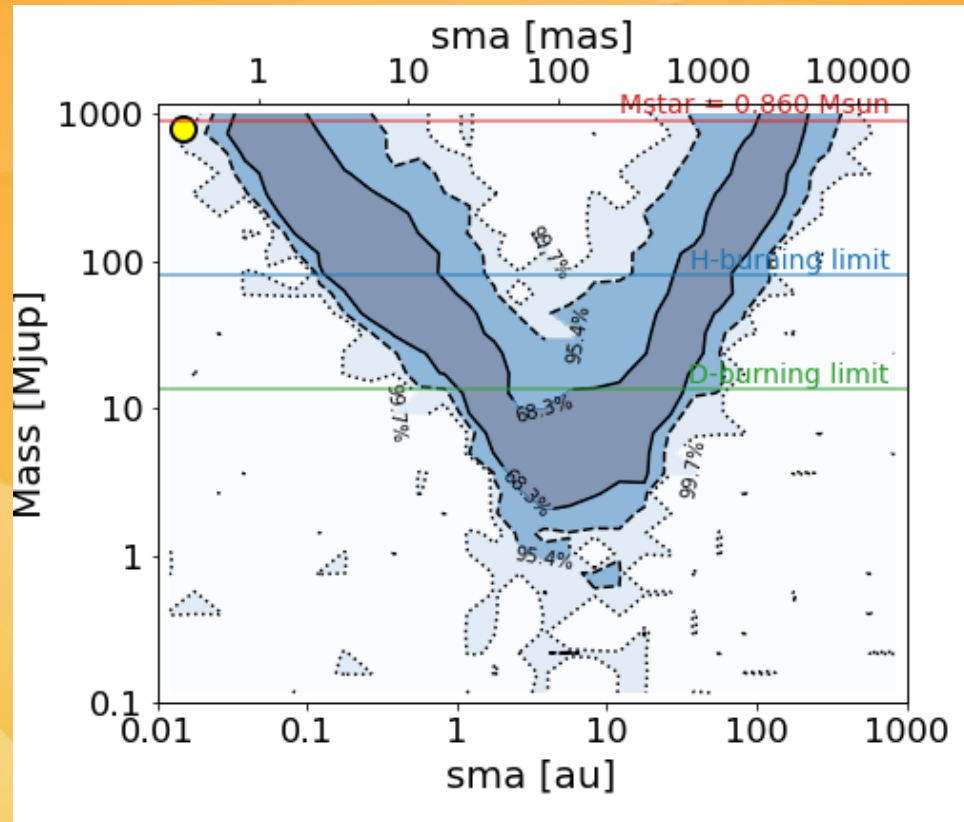
First consideration normal stars at age 5 Gyr.

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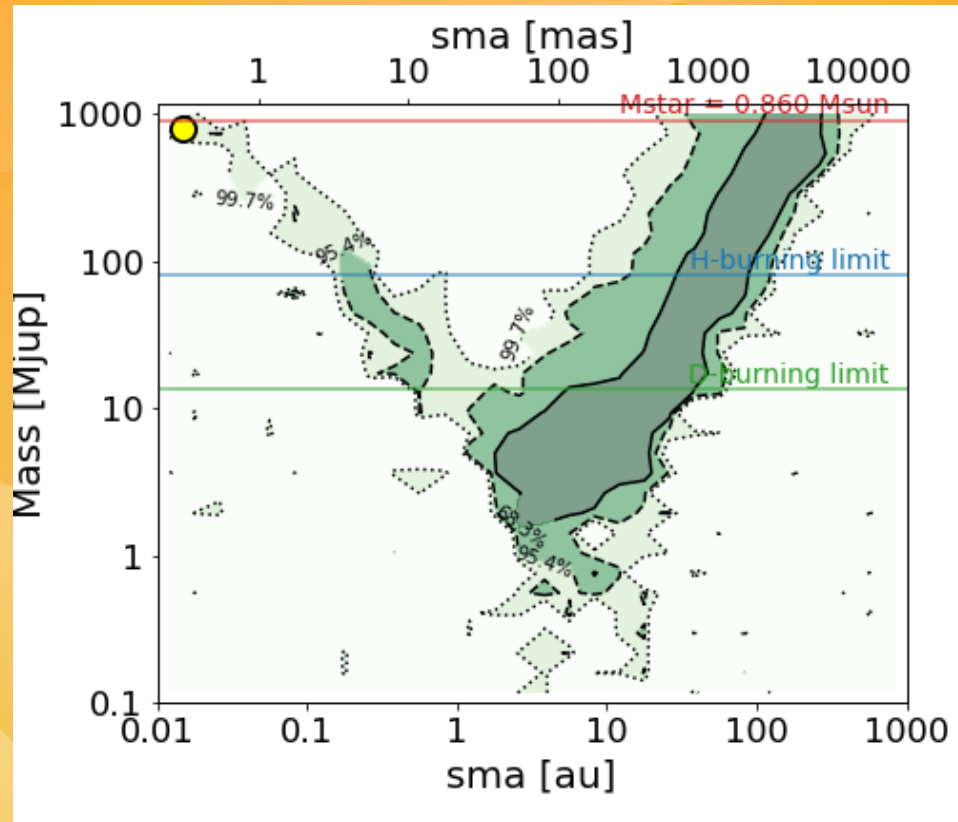
The RUWE-based map.

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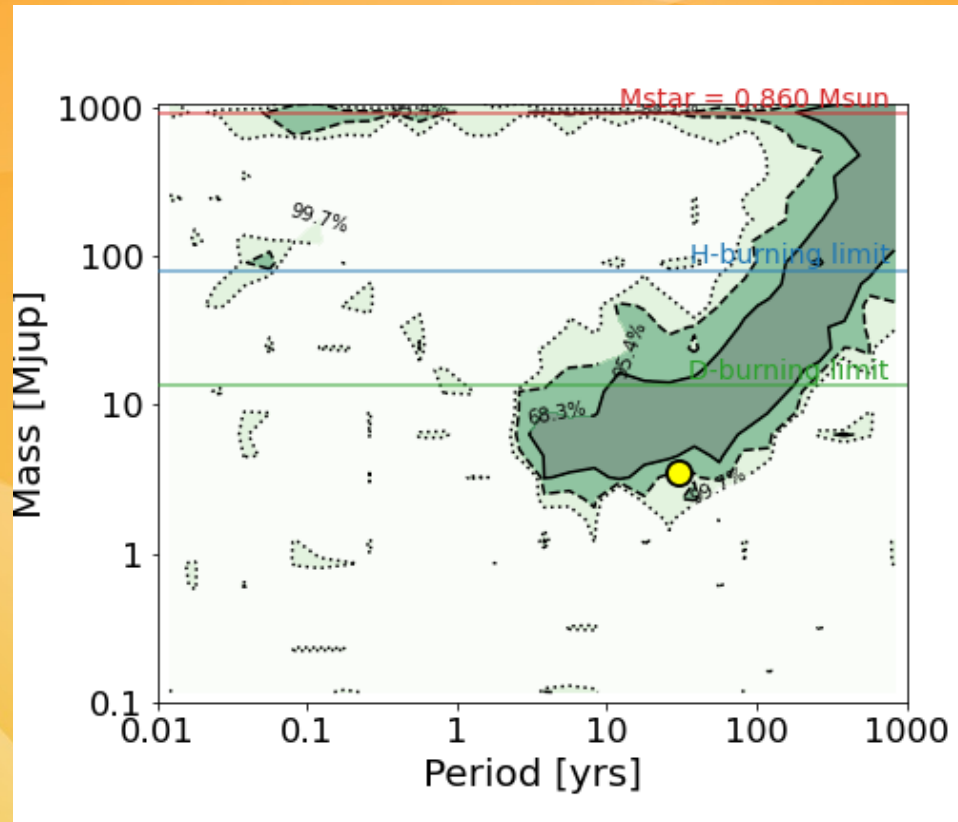
The PMa-based map.

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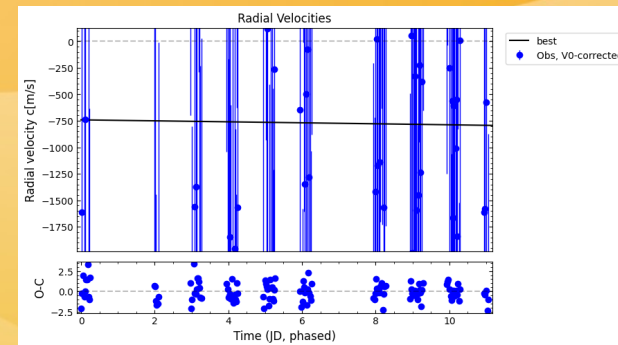
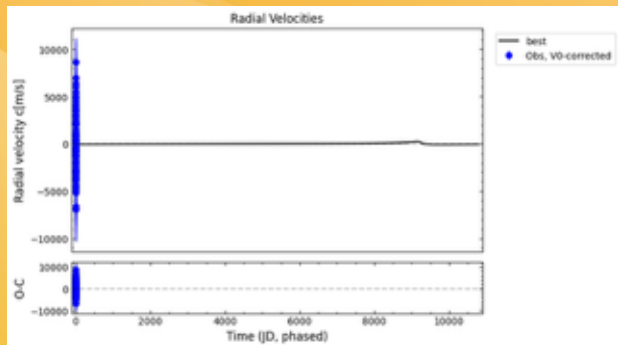
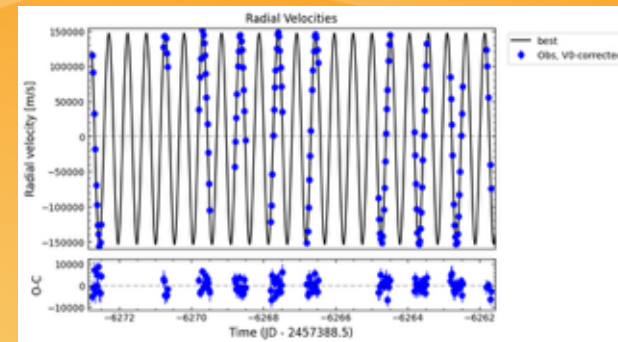
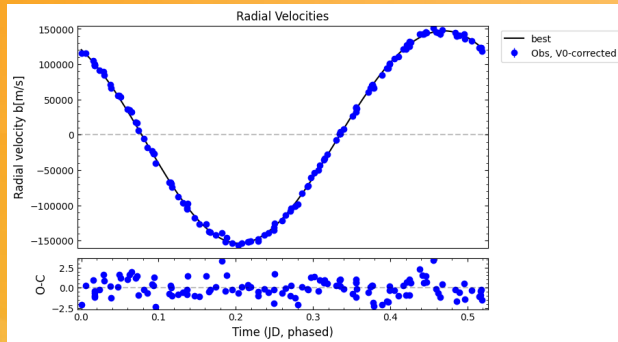
Combination of RUWE-based and the PMA-based map.

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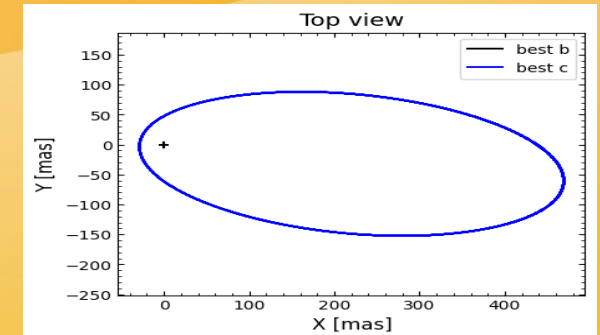
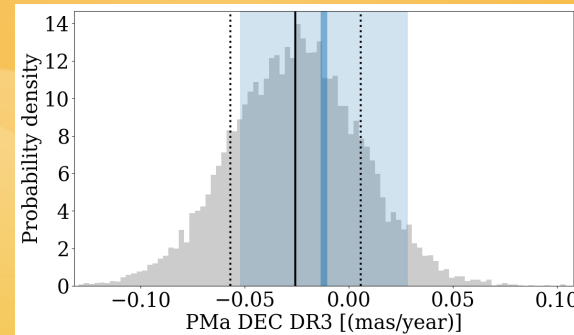
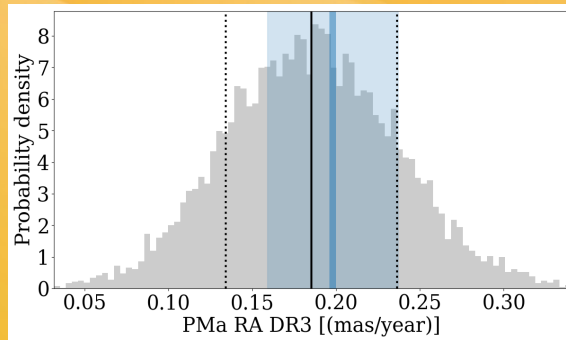
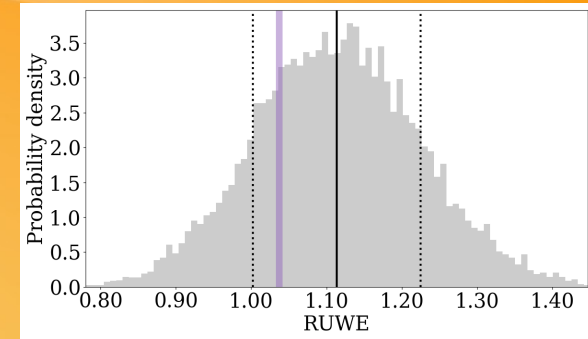
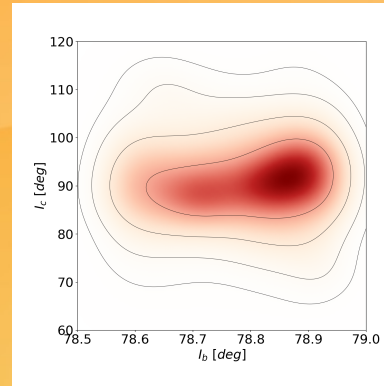
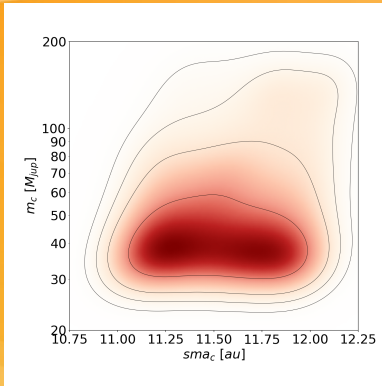
PMEX map, accounting for the WD-K binary "removed".

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The RV fit is perfect, however no additional signal at all.

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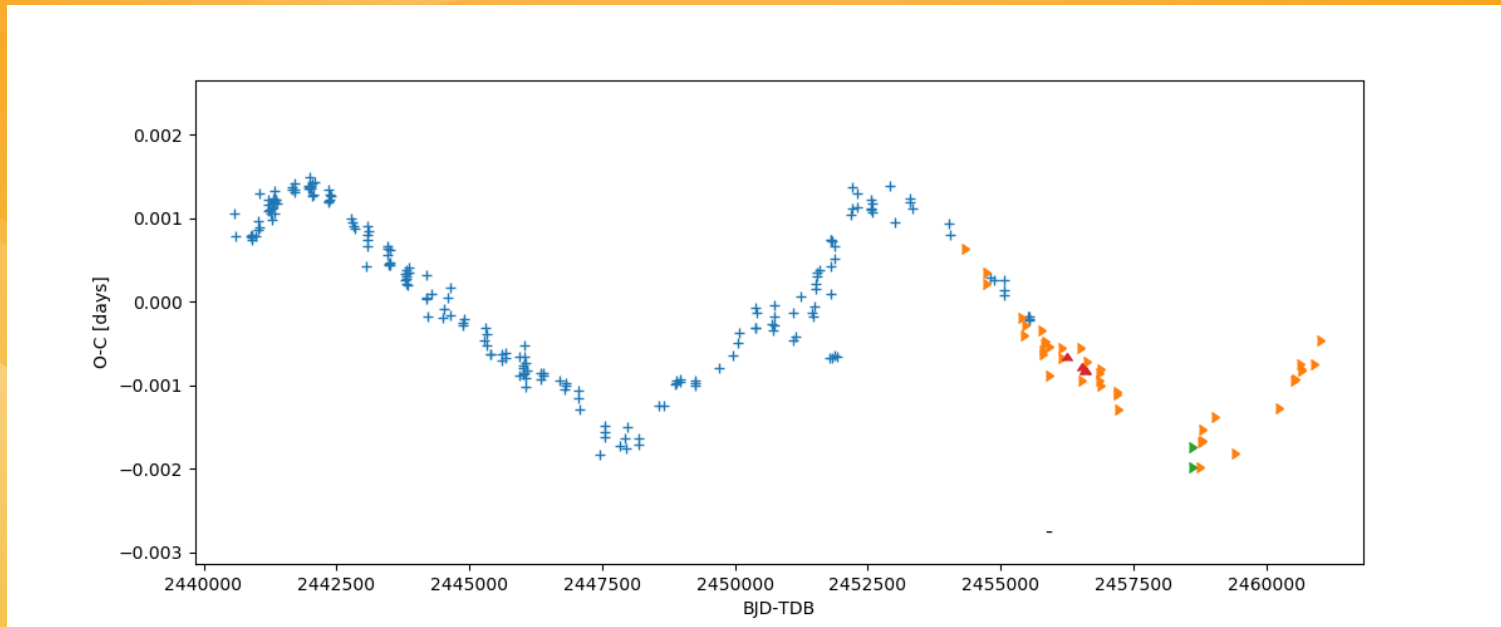


MCMC with RV and PMEX astrometry

The companion inferred from light-time variations is totally compatible with the Gaia-Hipparcos astrometry.

# Gaia DR3 43789772861265792

## Eclipse timing variations



Thank you for your time and attention today.