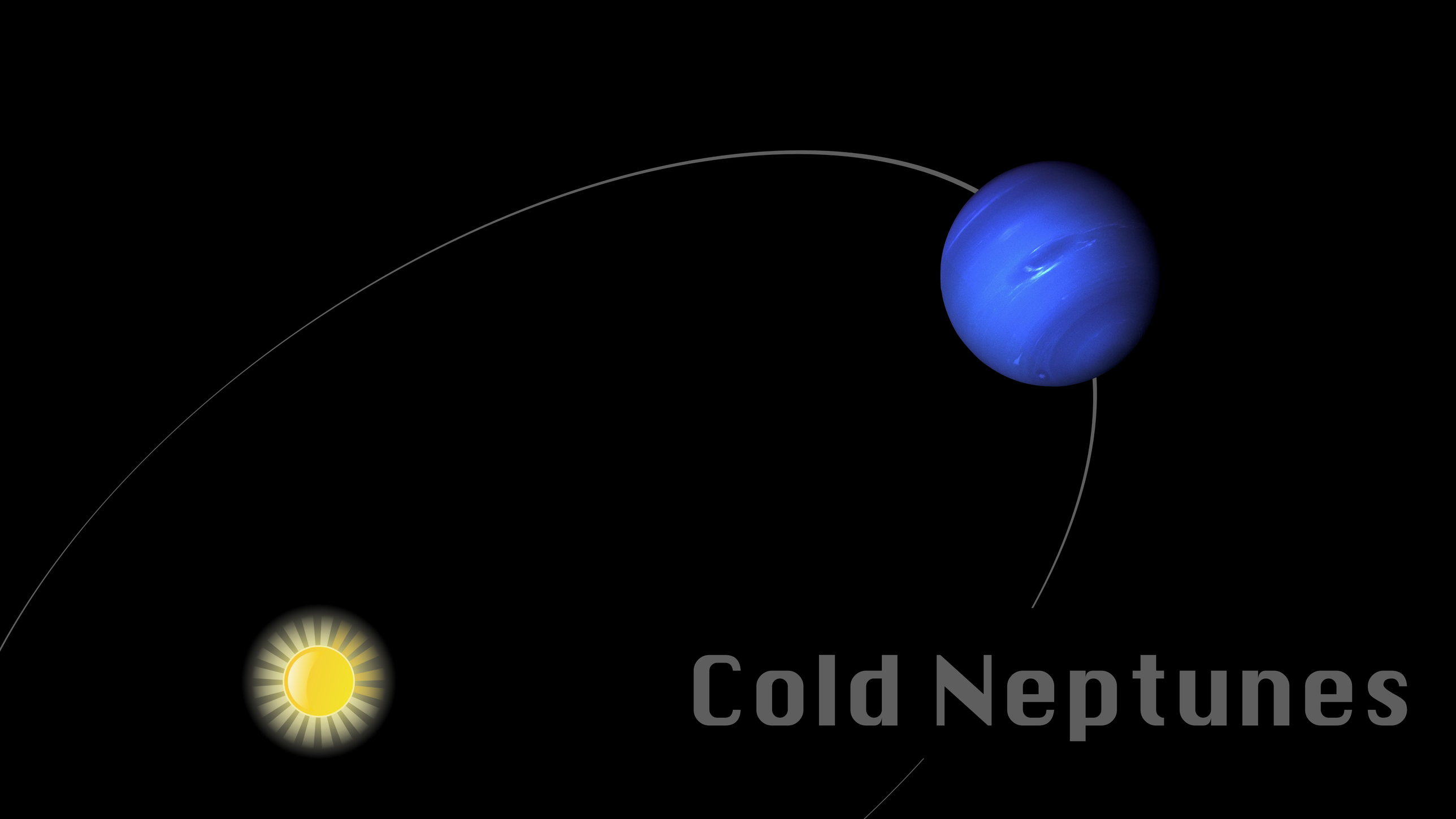
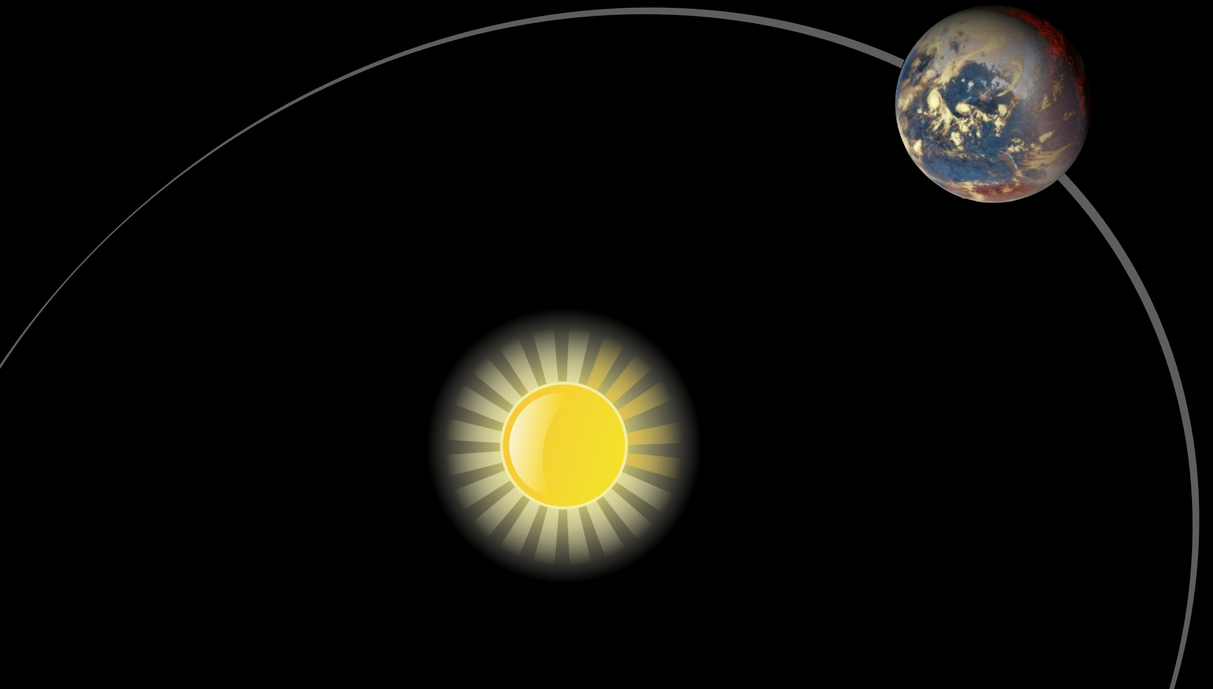
Astrometric Microlensing with Roman Space Telescope and Gaia

Krzysztof A. Rybicki
Astronomical Observatory, University of Warsaw, Poland
with
Yossi Shvartzvald, Sebastiano Calchi-Novati, Łukasz Wyrzykowski, Kasia Kruszyńska

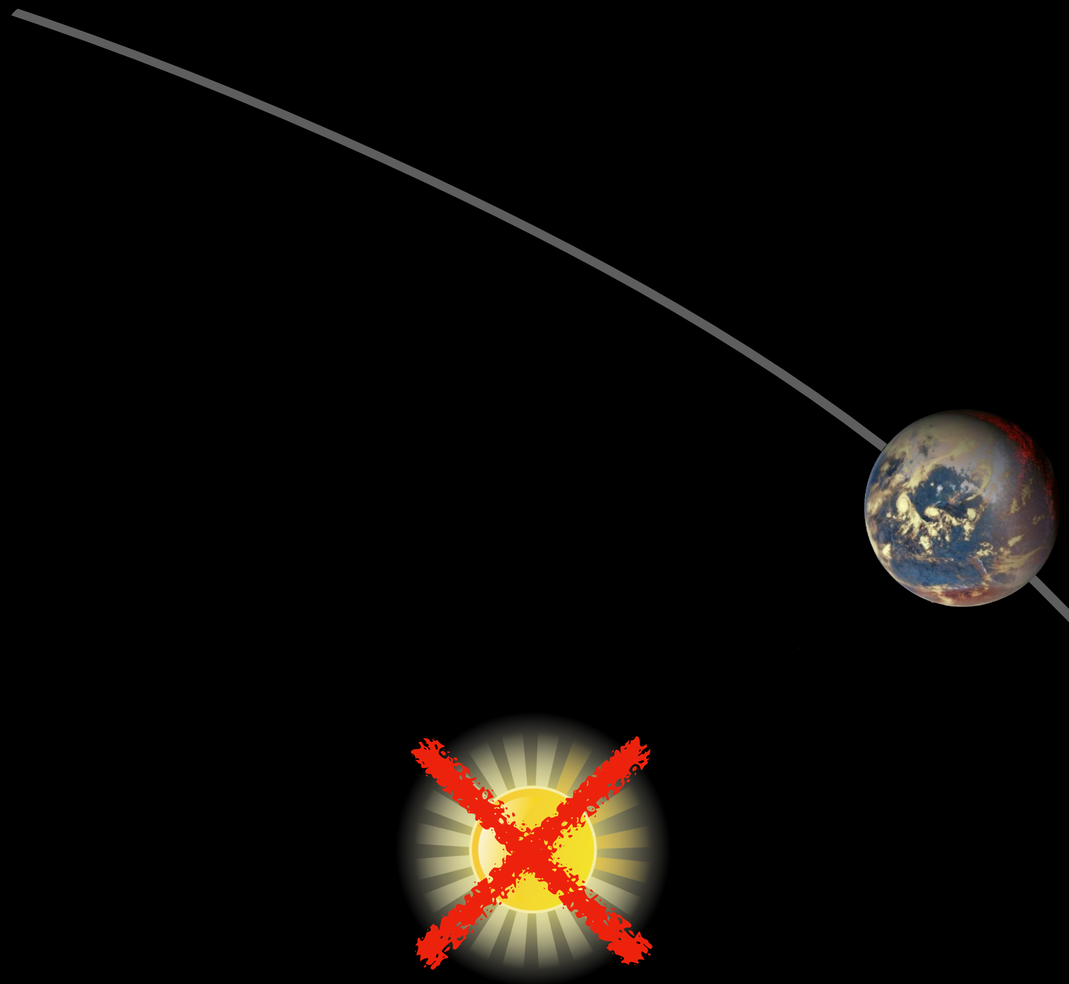
Exploring the Transient Universe with the Nancy Grace Roman Space Telescope, Feb 9th 2022

Why study microlensing?


Cold Neptunes



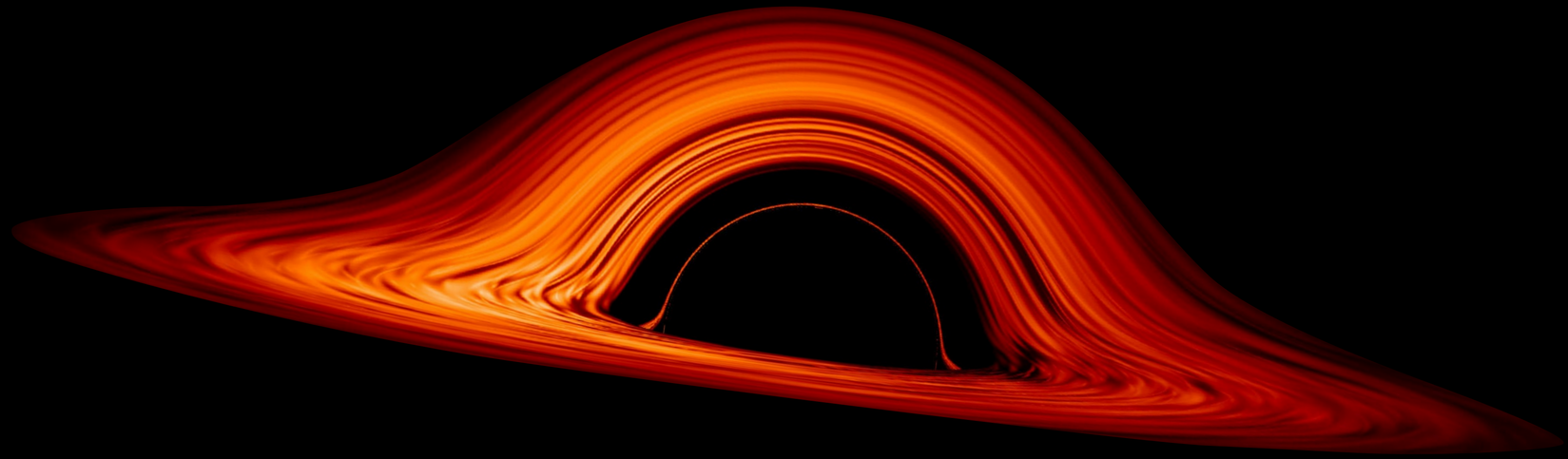
Earth analogs



Free floating planets


MHP
DARK MATTER
The Ultimate Post Workout Muscle Growth Accelerator
Absorbs Faster Than Whey Isolate
600% Increase in Protein Synthesis-Equal to 40 Grams of Protein
Dramatically Spikes Insulin with WaxMAX-C36
Multi-Phase HydroSIZE Creative Transport
Replenishes Glycogen and Increases Cell Volume
Blue Raspberry
Dietary Supplement

Dark matter



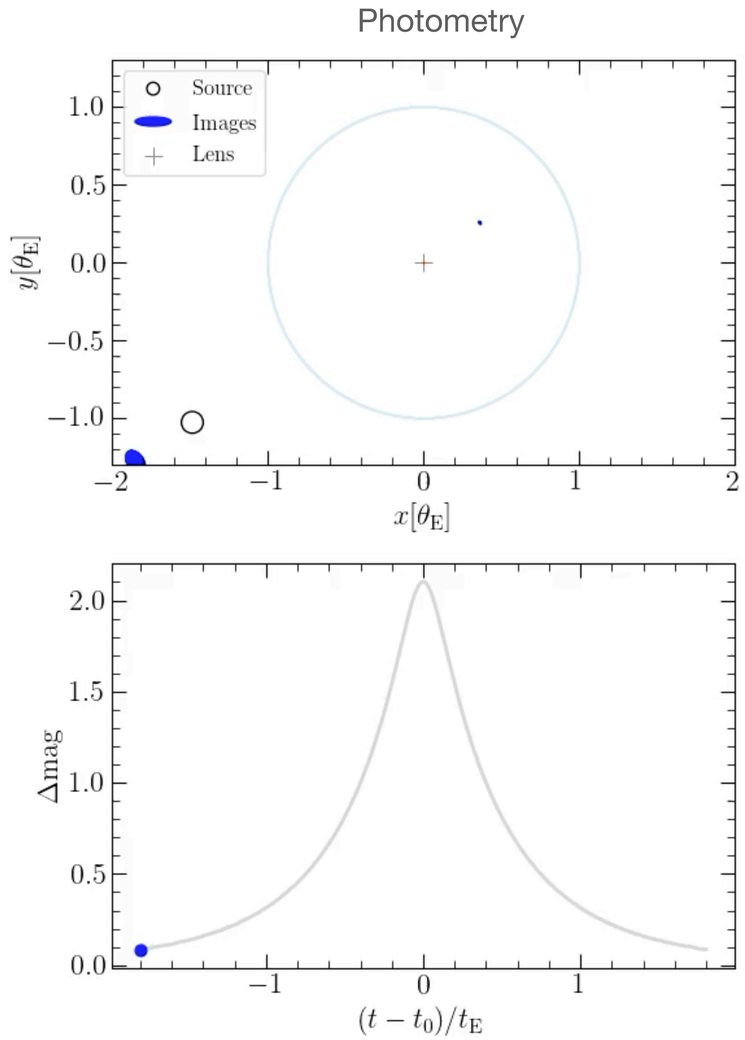
Black Holes

Microlensing flavours: photometry and astrometry

Single lens

Microlensing flavours: photometry and astrometry

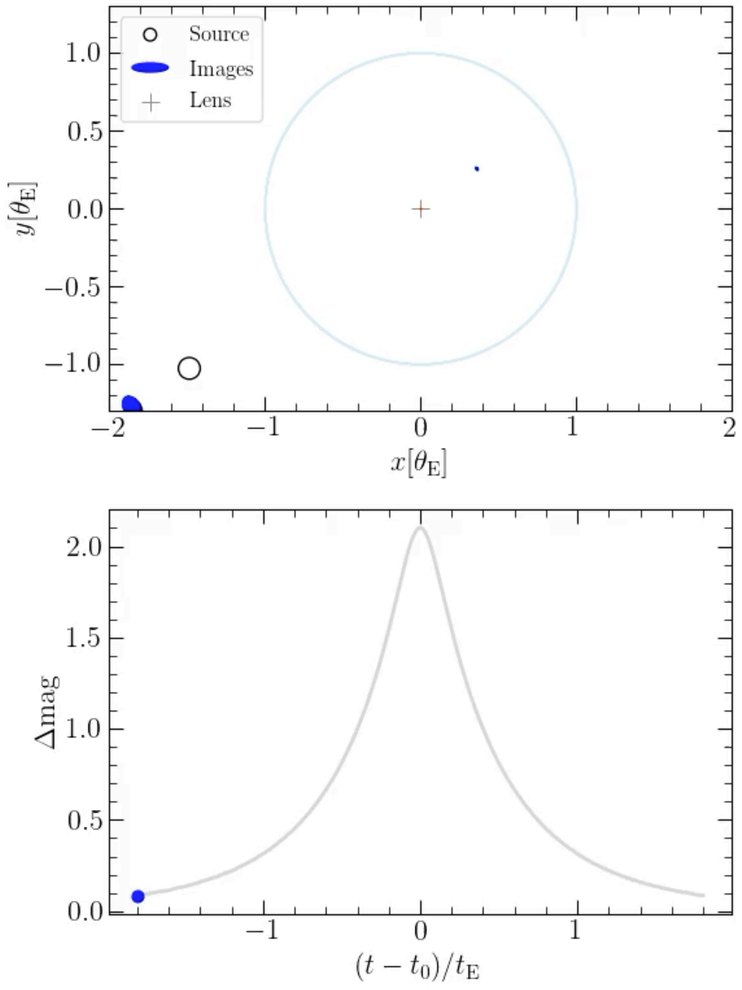
Single lens



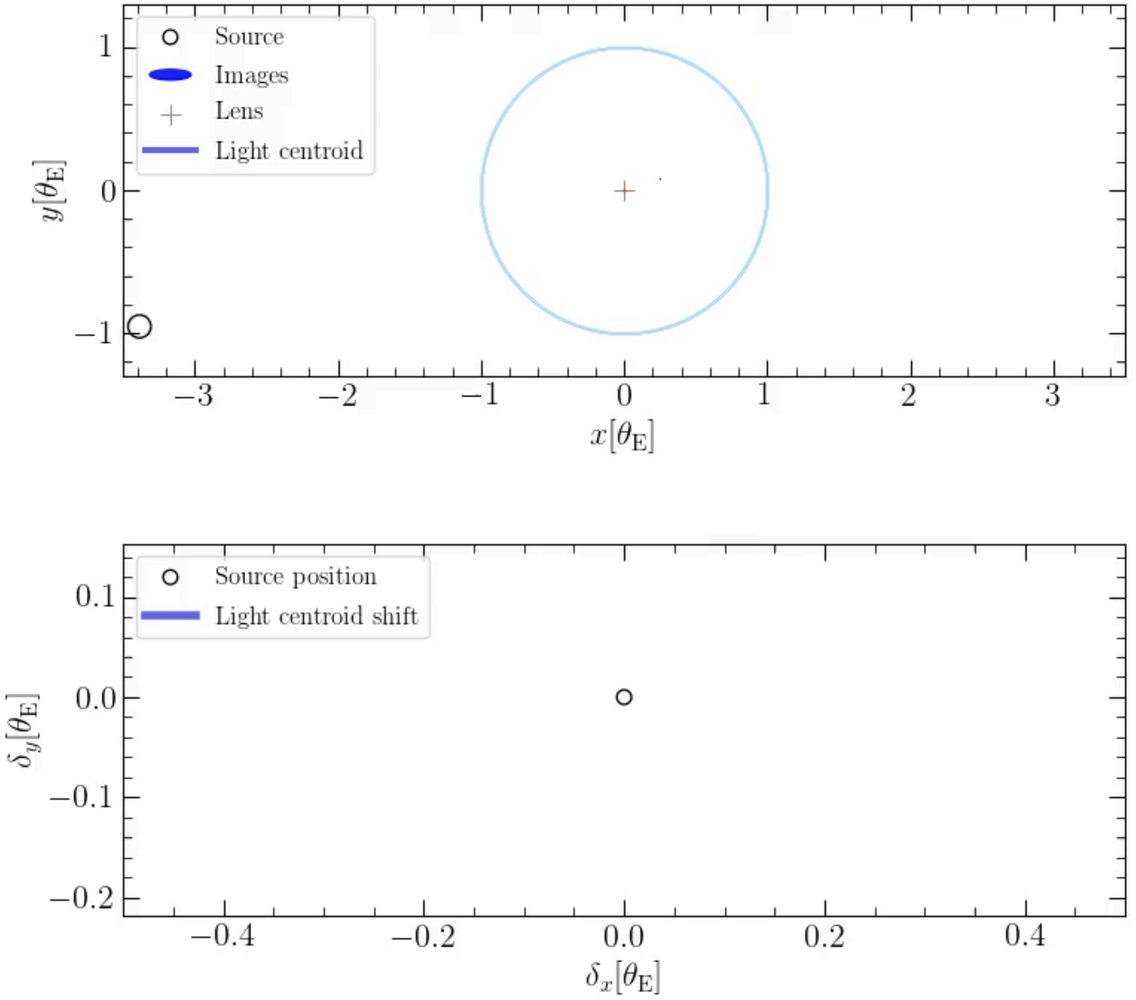
Microlensing flavours: photometry and astrometry

Single lens

Photometry



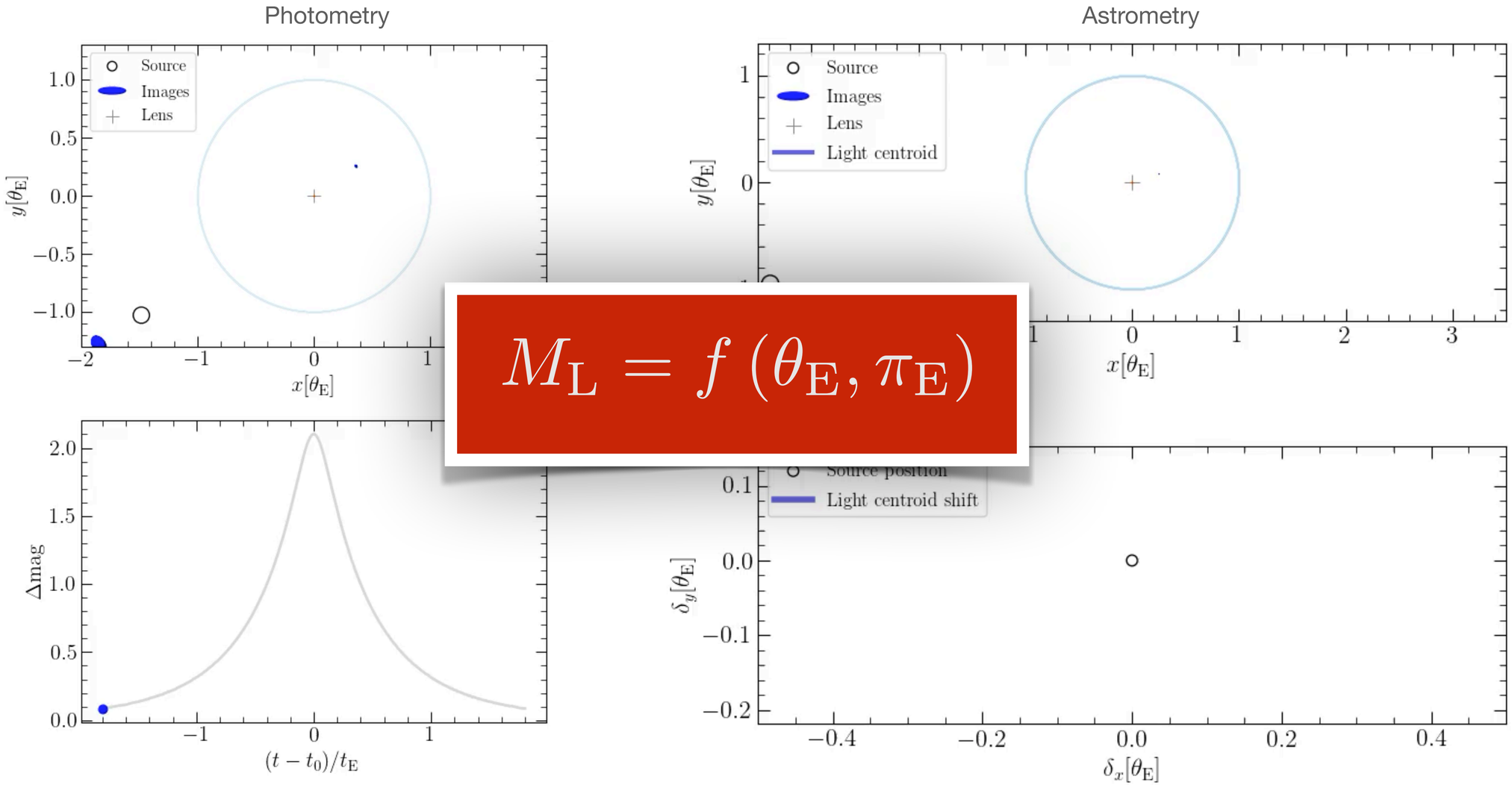
Astrometry



https://www.astrouw.edu.pl/~krybicki/animations.php

Microlensing flavours: photometry and astrometry

Single lens



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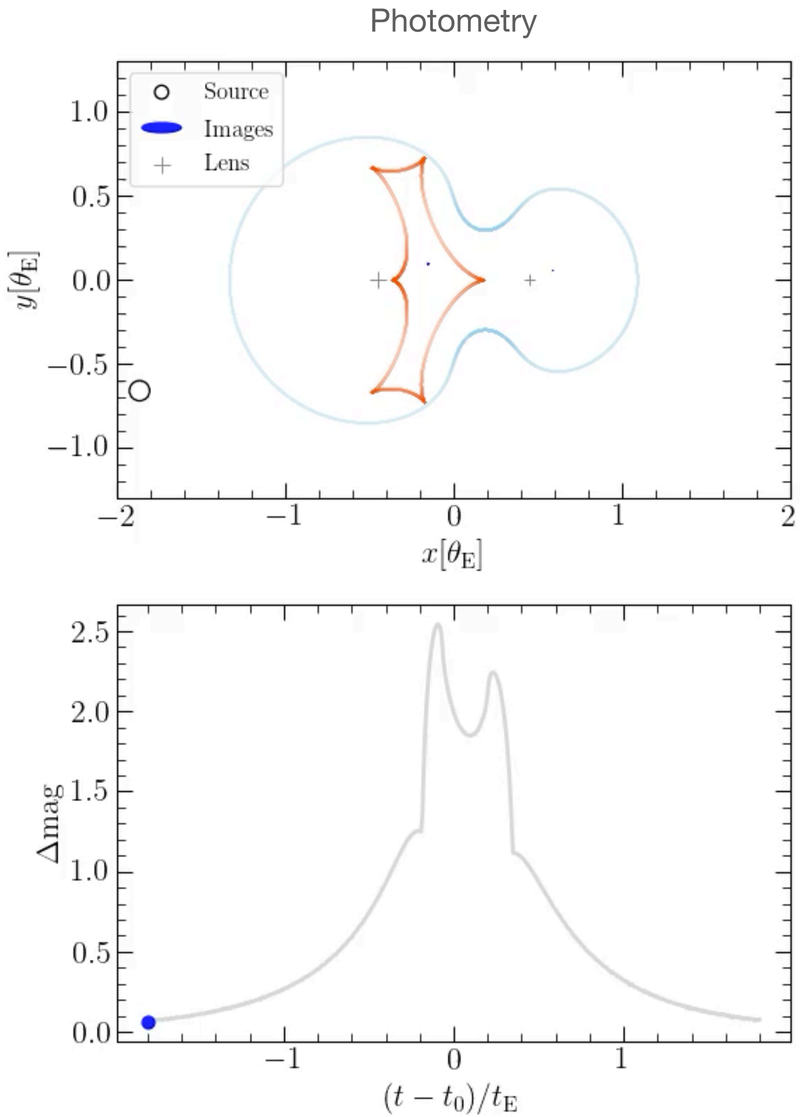

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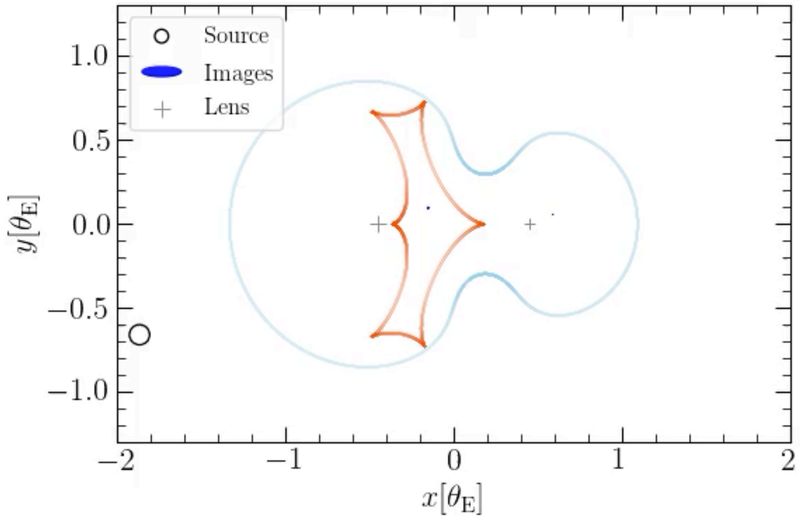
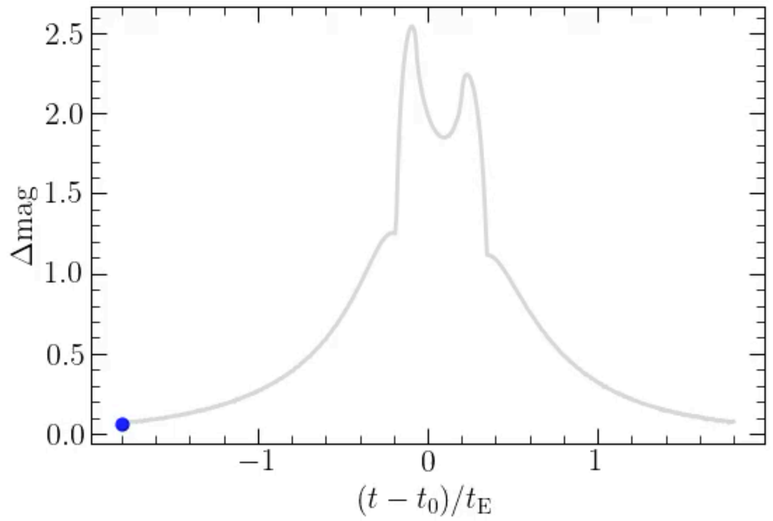
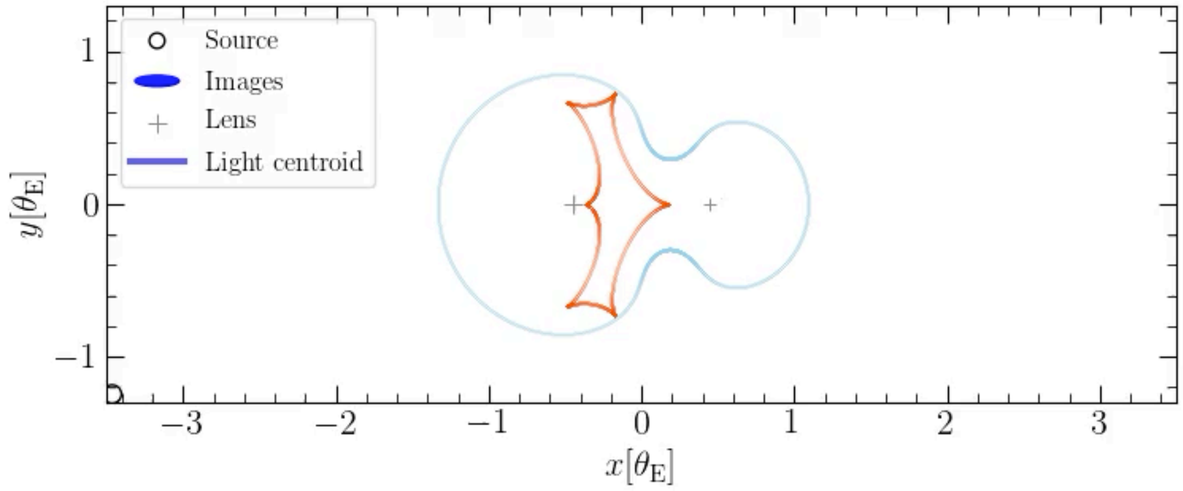
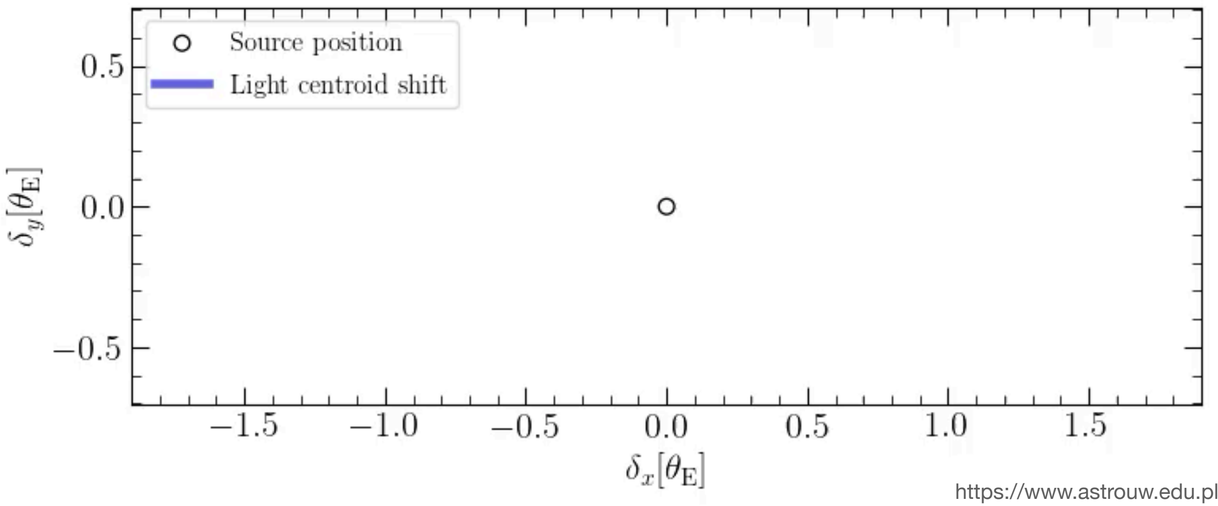




Astrometry





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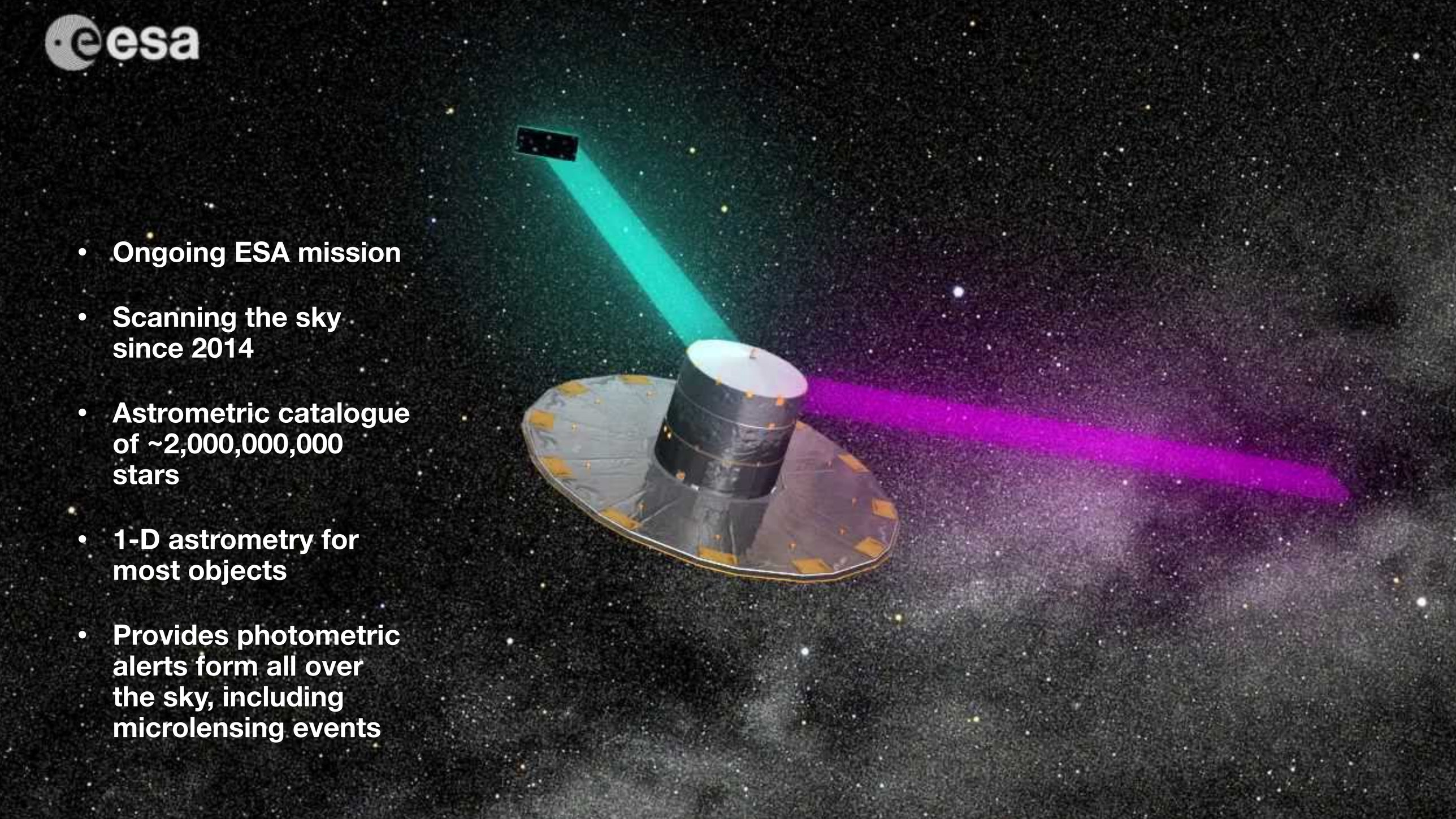
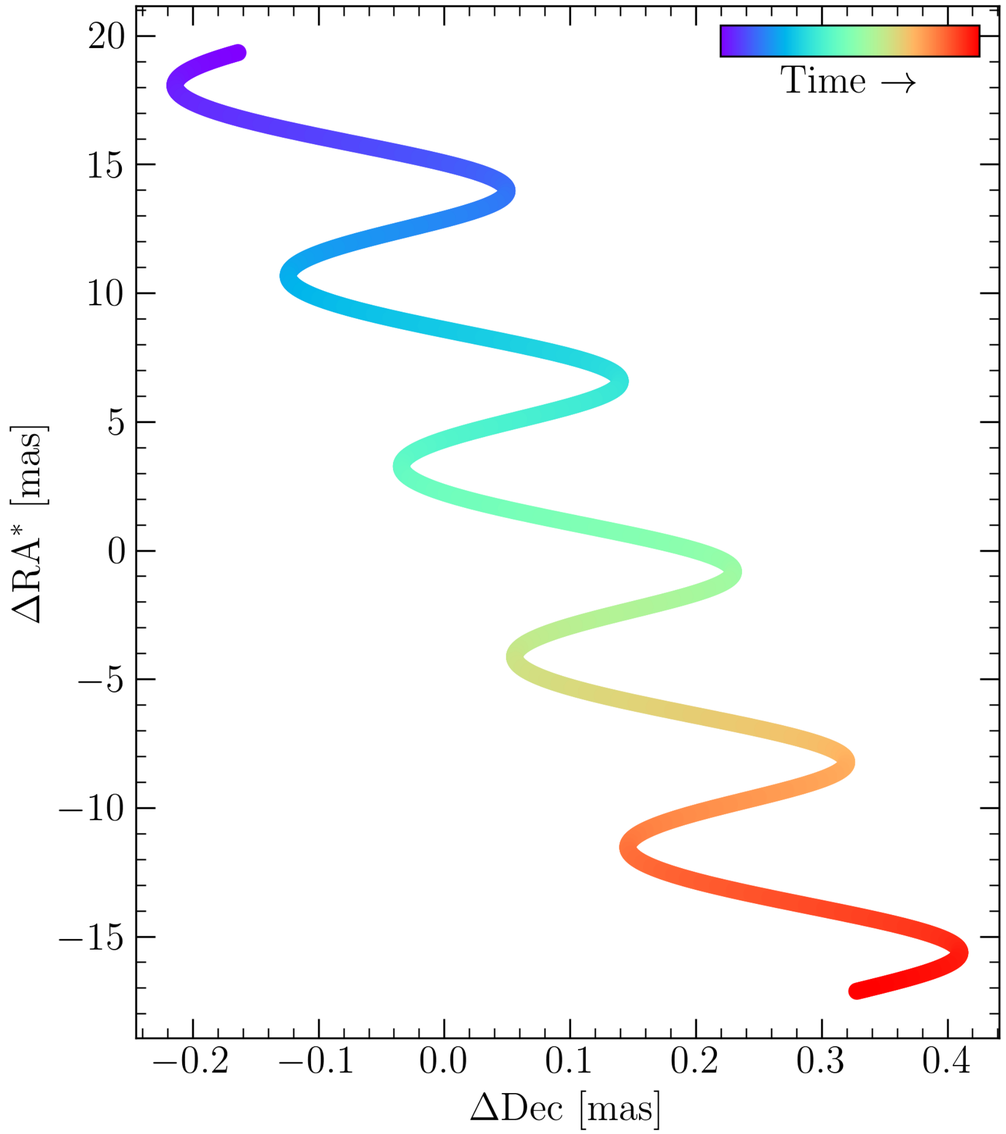
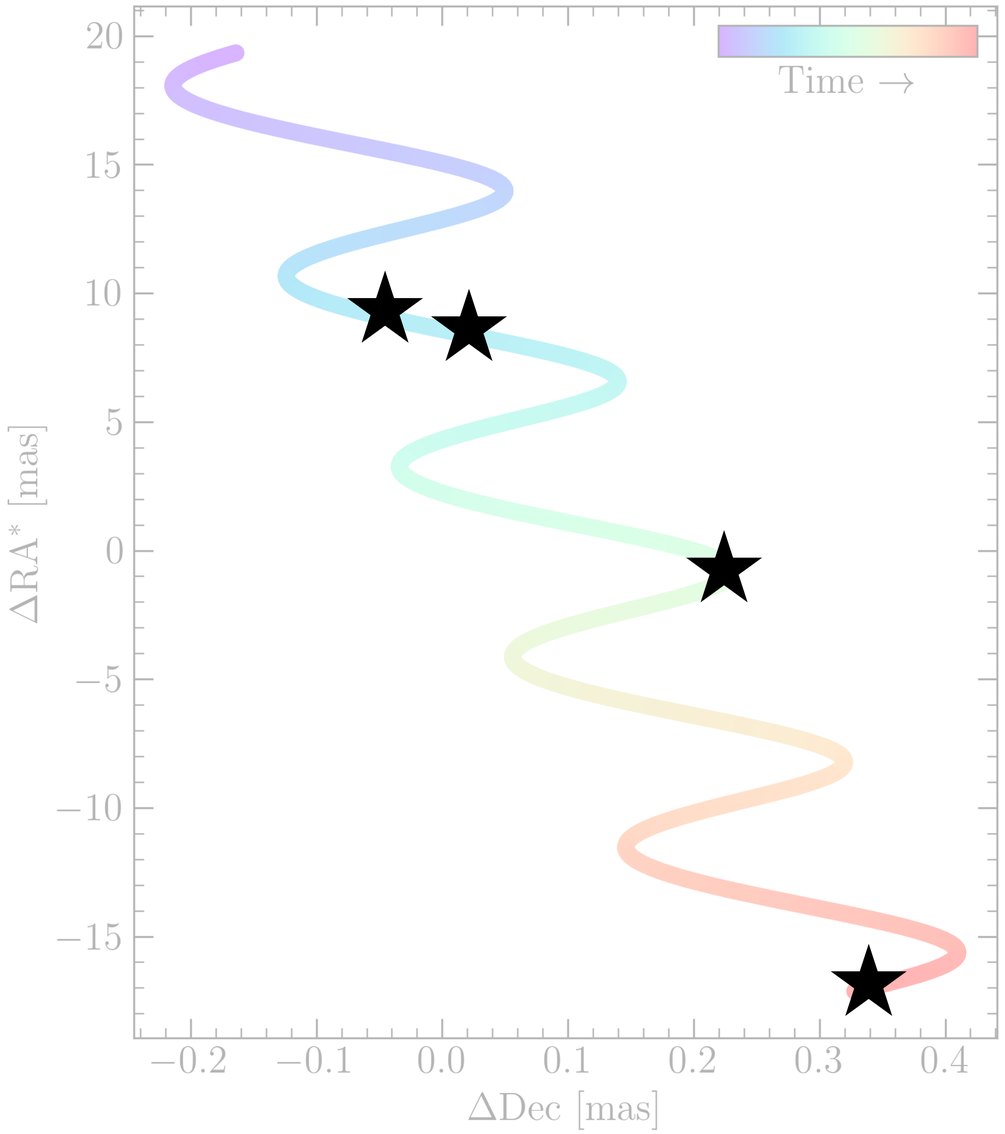


- Ongoing ESA mission
- Scanning the sky since 2014
- Astrometric catalogue of ~2,000,000,000 stars
- 1-D astrometry for most objects
- Provides photometric alerts form all over the sky, including microlensing events

Astrometry in Gaia

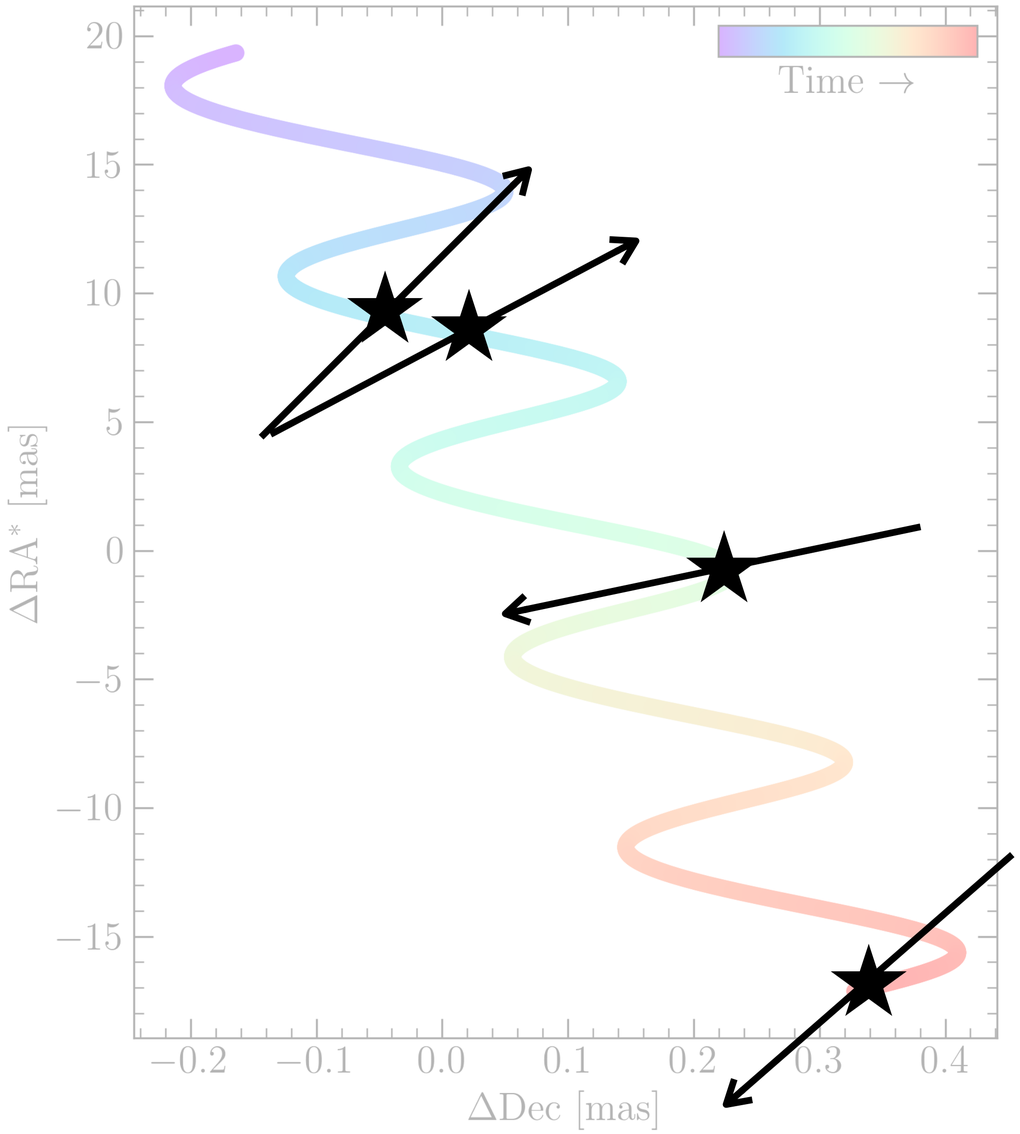


Astrometry in Gaia



★ GAIA EPOCHS

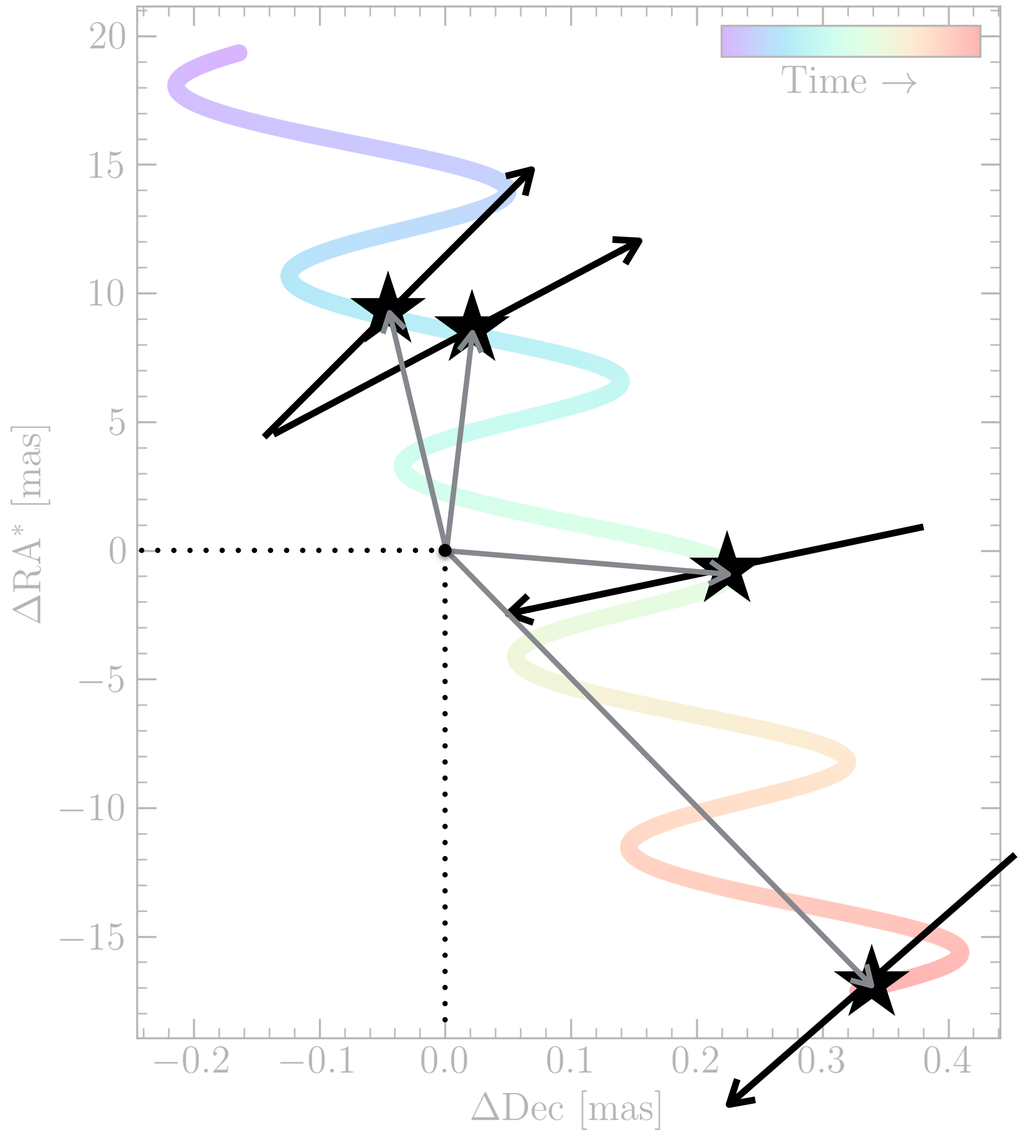
Astrometry in Gaia



★ Gaia epochs

↗ AL directions

Astrometry in Gaia

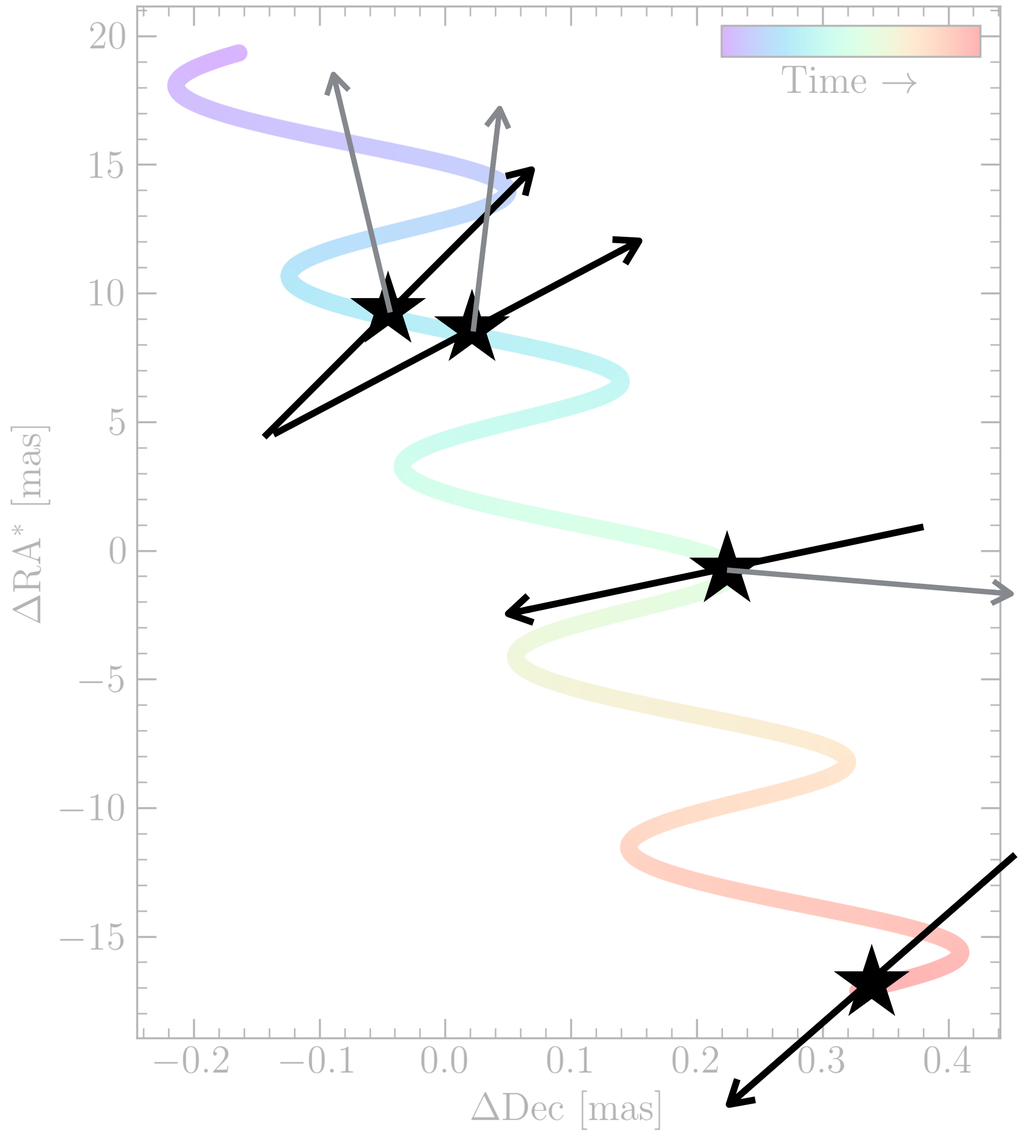


★ GAIA EPOCHS

↗ AL DIRECTIONS

↗ SHIFT VECTORS

Astrometry in Gaia



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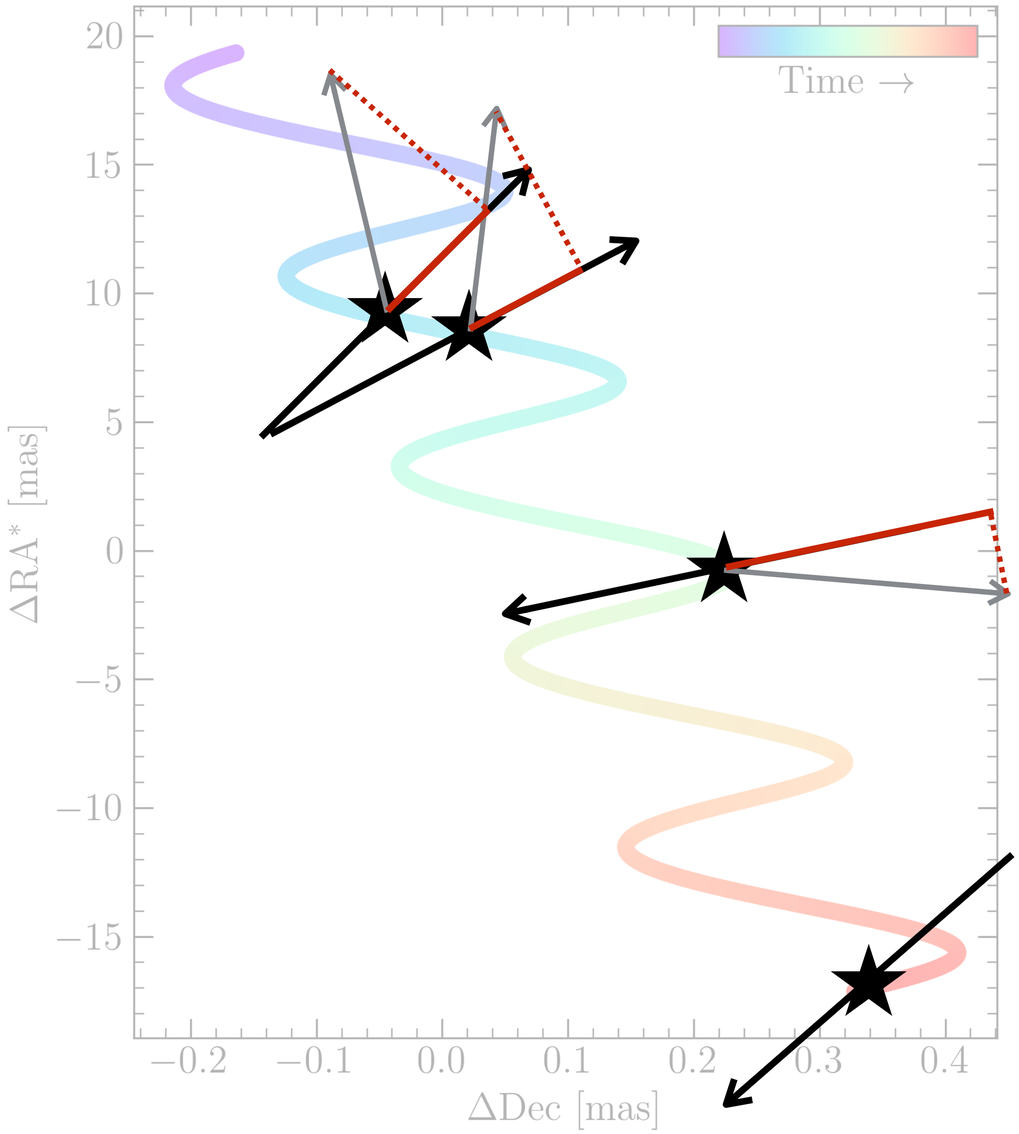
Astrometry in Gaia

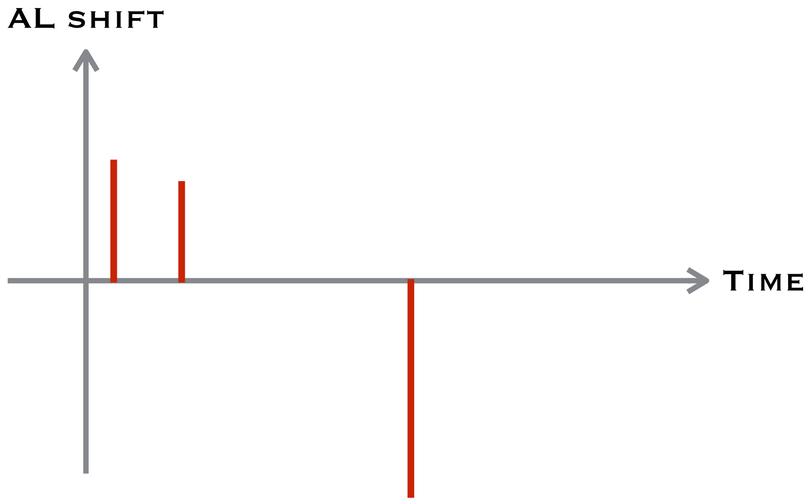


Gaia epochs

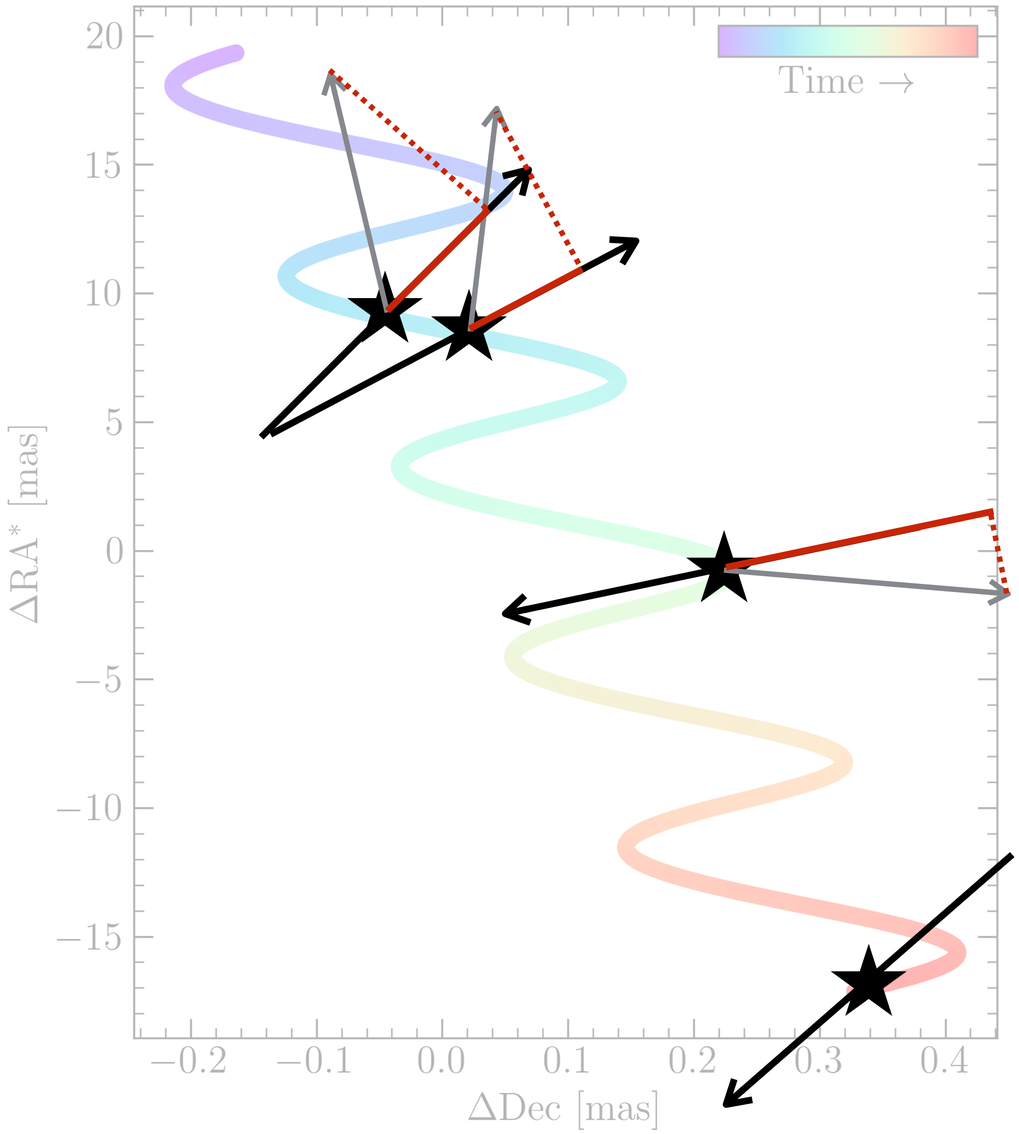
AL directions

shift vectors

AL Projections



Astrometry in Gaia



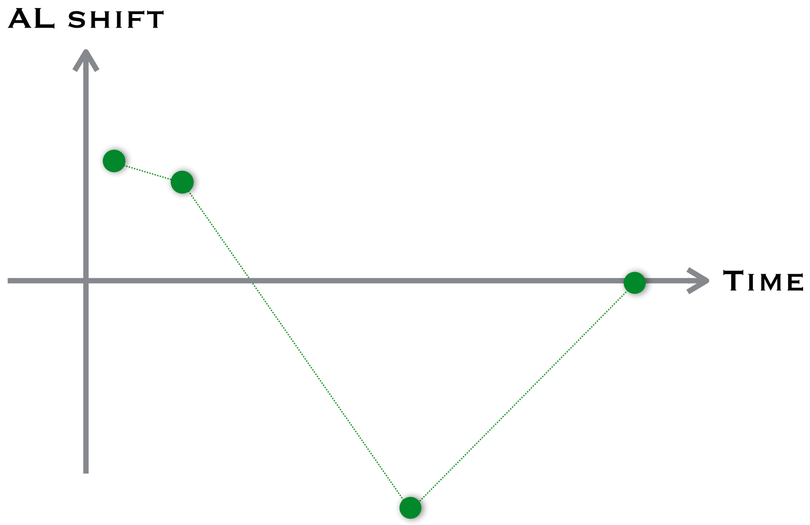
GAIA EPOCHS

AL DIRECTIONS

SHIFT VECTORS

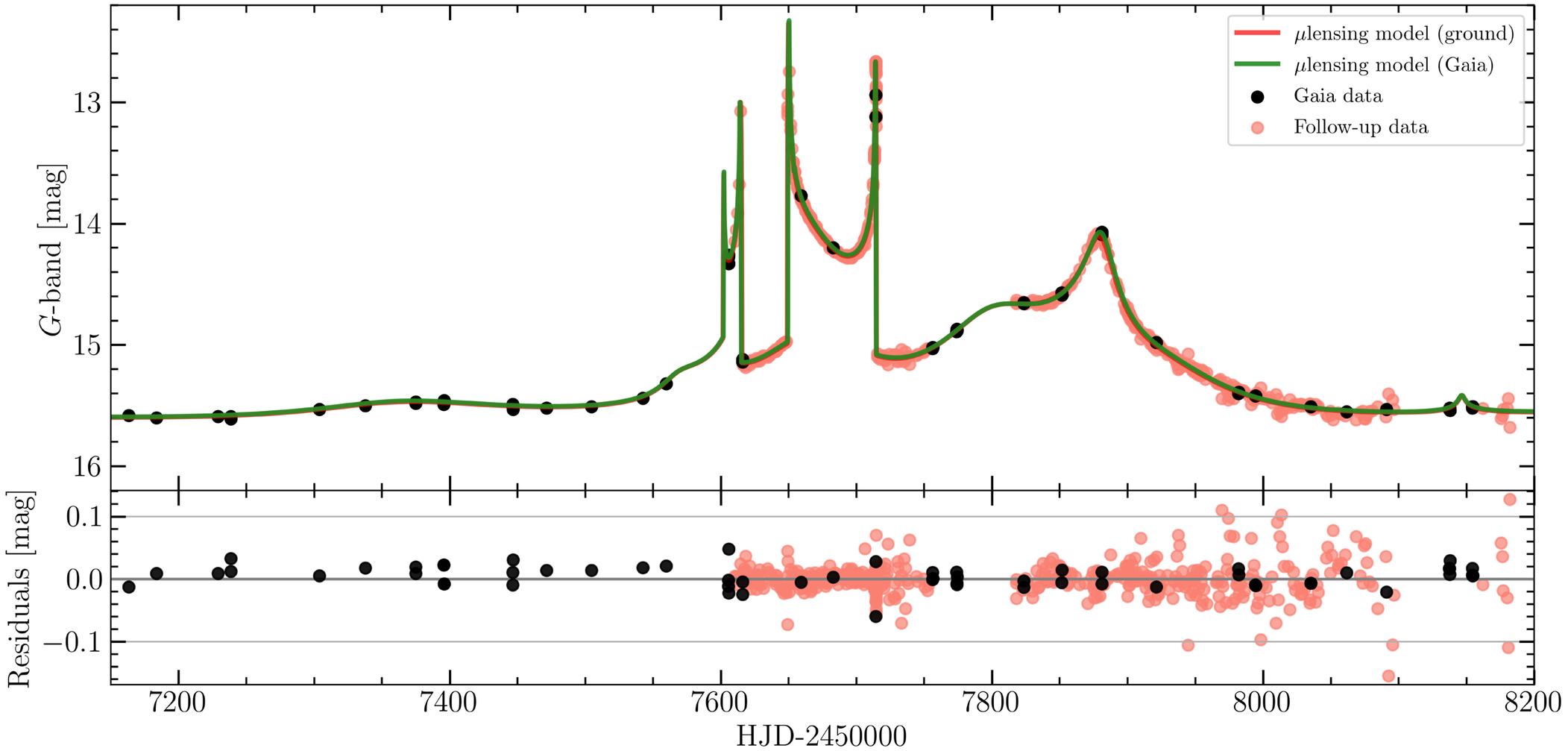
AL PROJECTIONS

GAIA TIME-SERIES



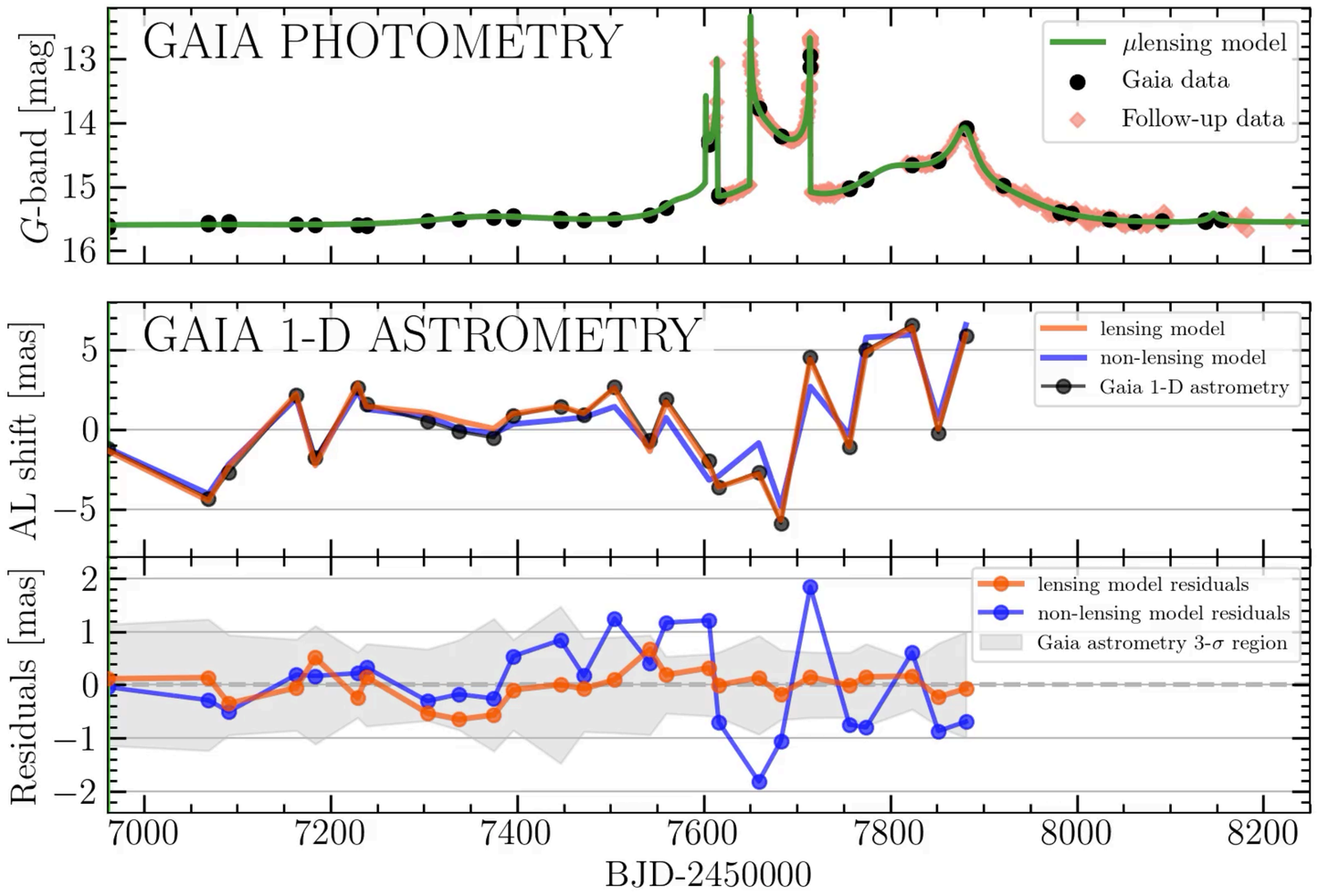
Gaia16aye - binary microlensing event

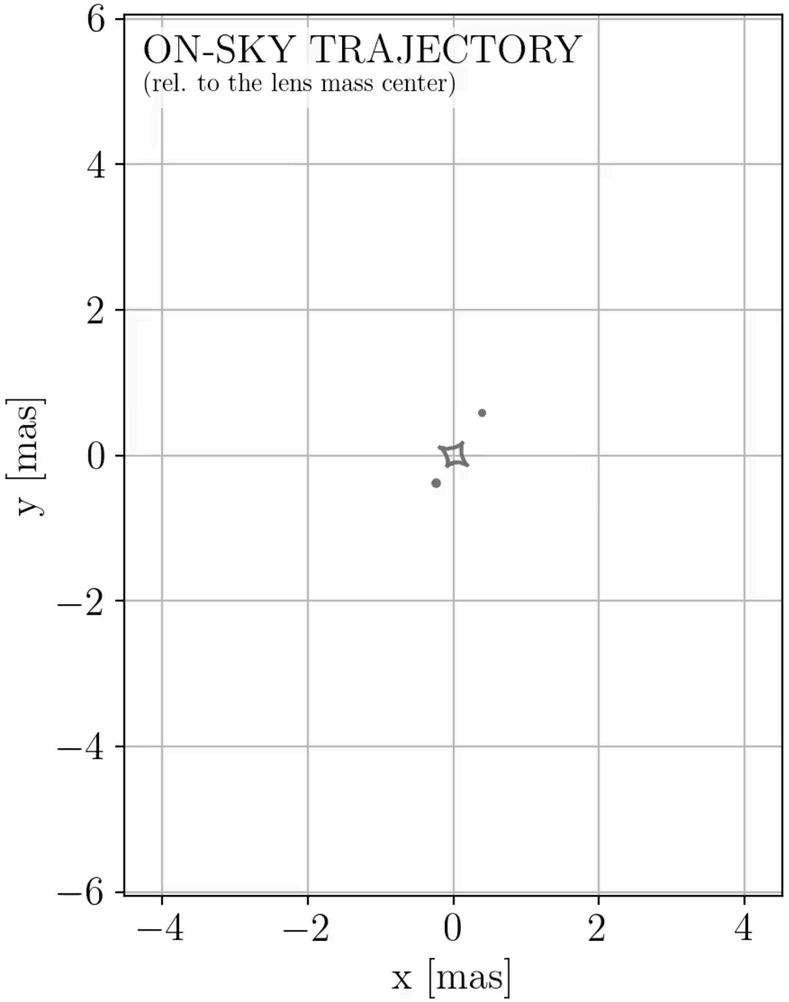
Photometry



Wyrzykowski et al. 2020

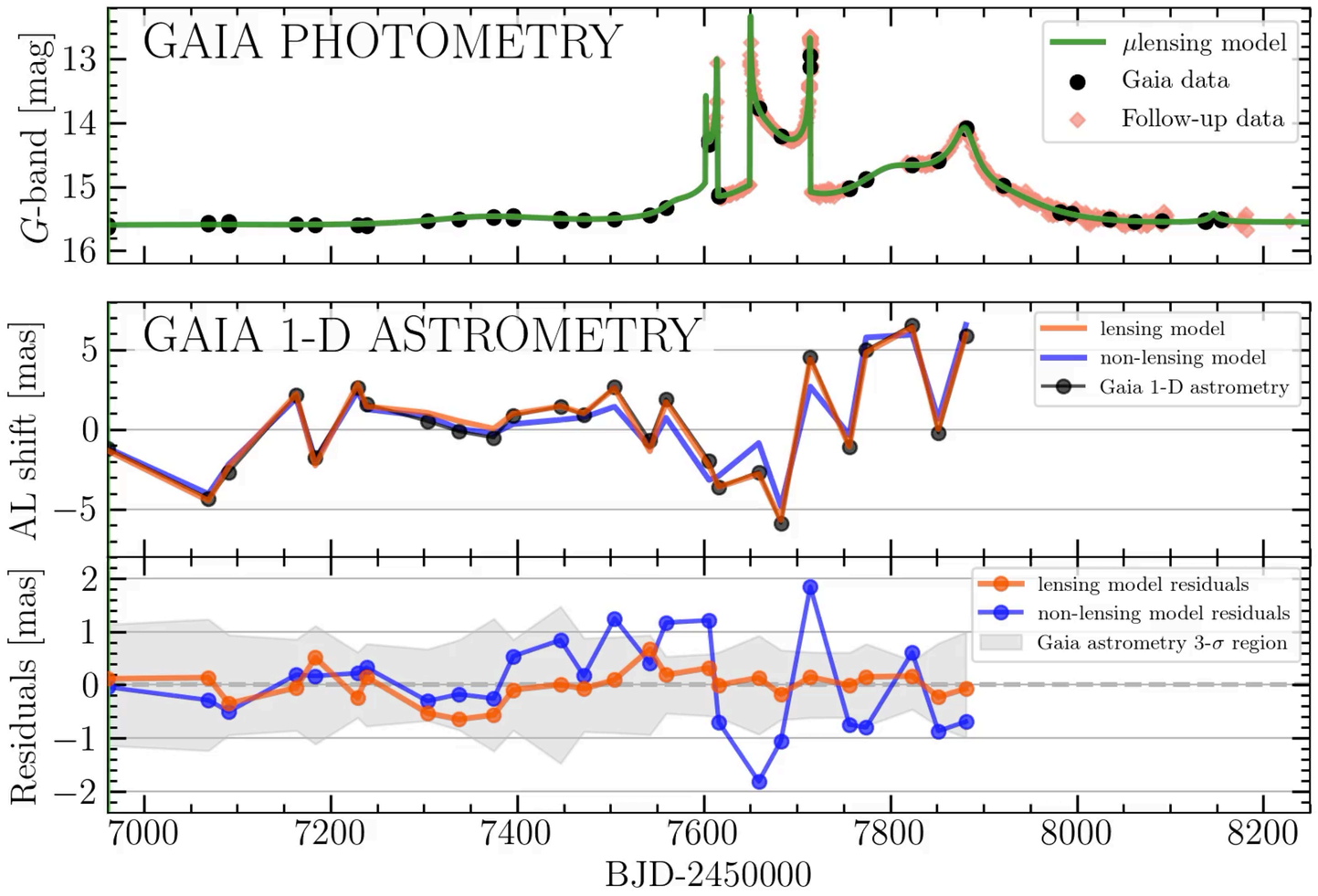
Gaia16aye: ***Gaia Image of the week*** Sep 24th 2021

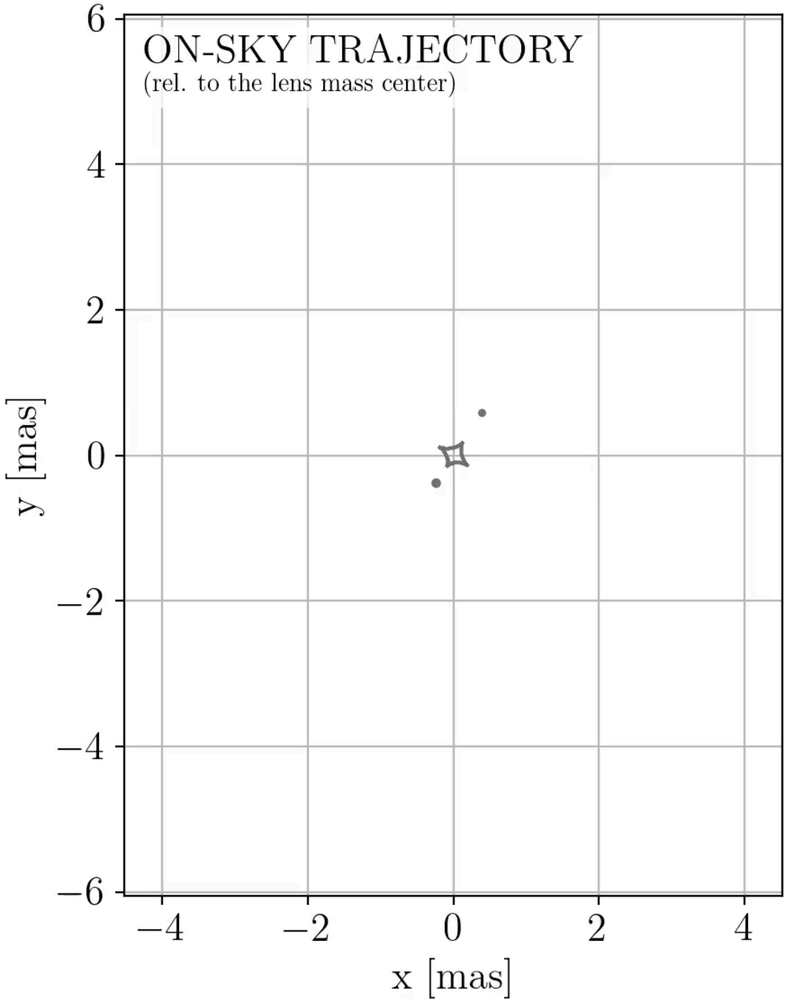




https://www.cosmos.esa.int/web/gaia/iow_20210924

Gaia16aye: ***Gaia Image of the week*** Sep 24th 2021





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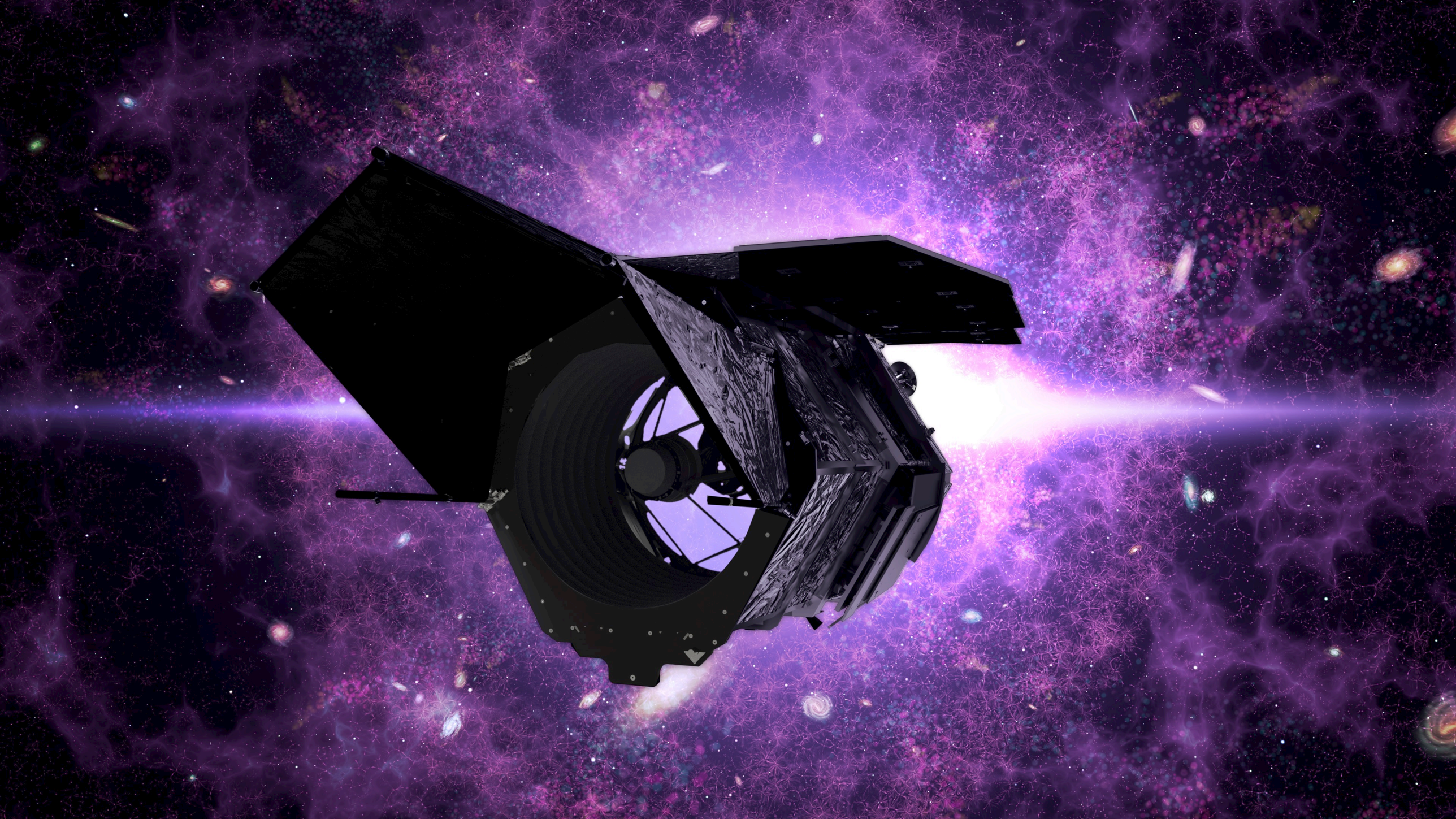
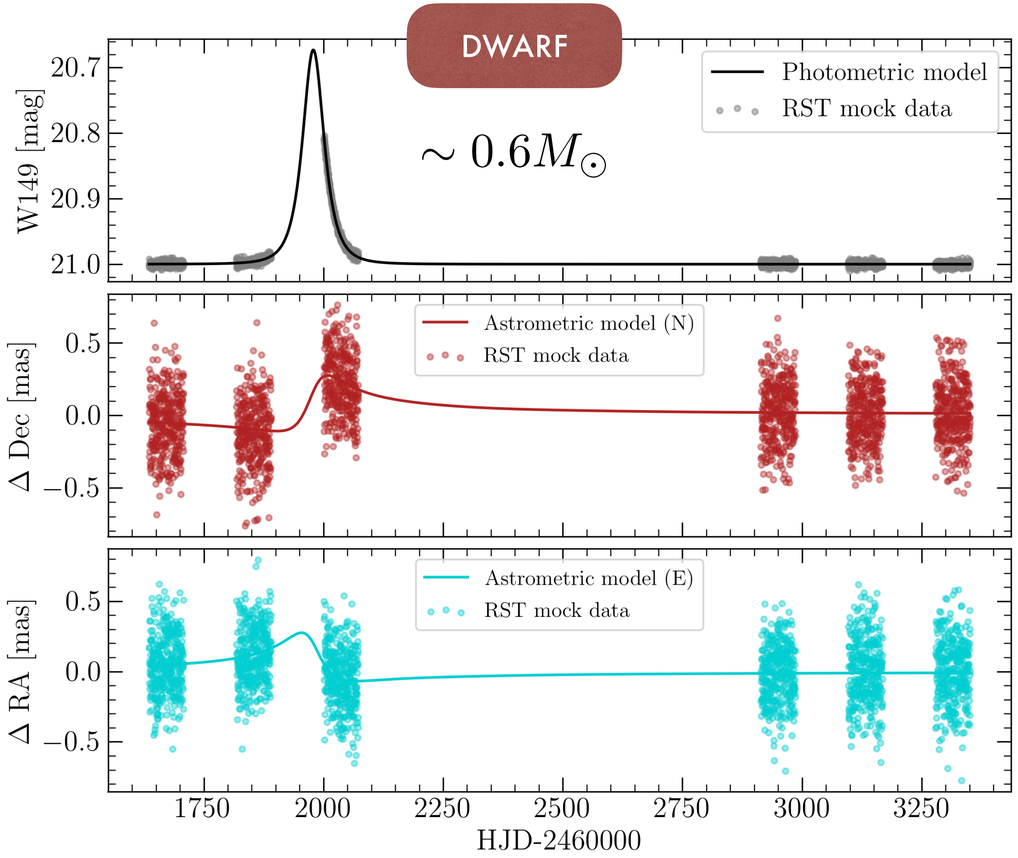
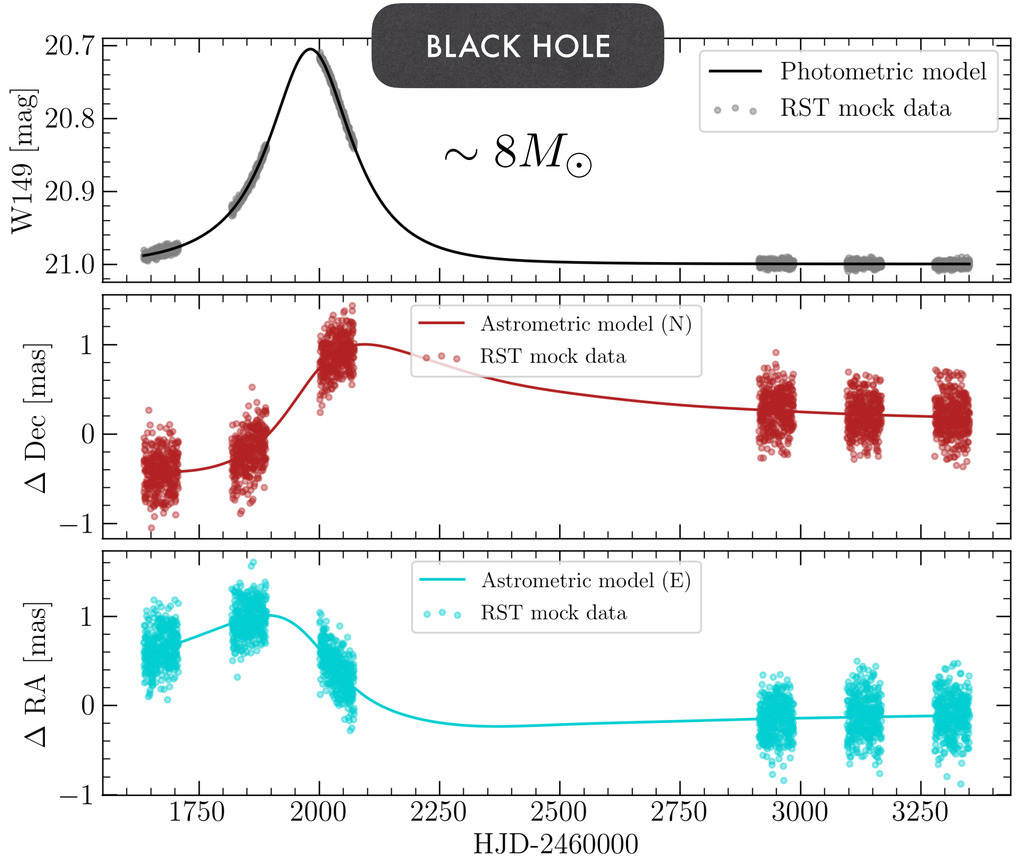


Data simulations - assumptions

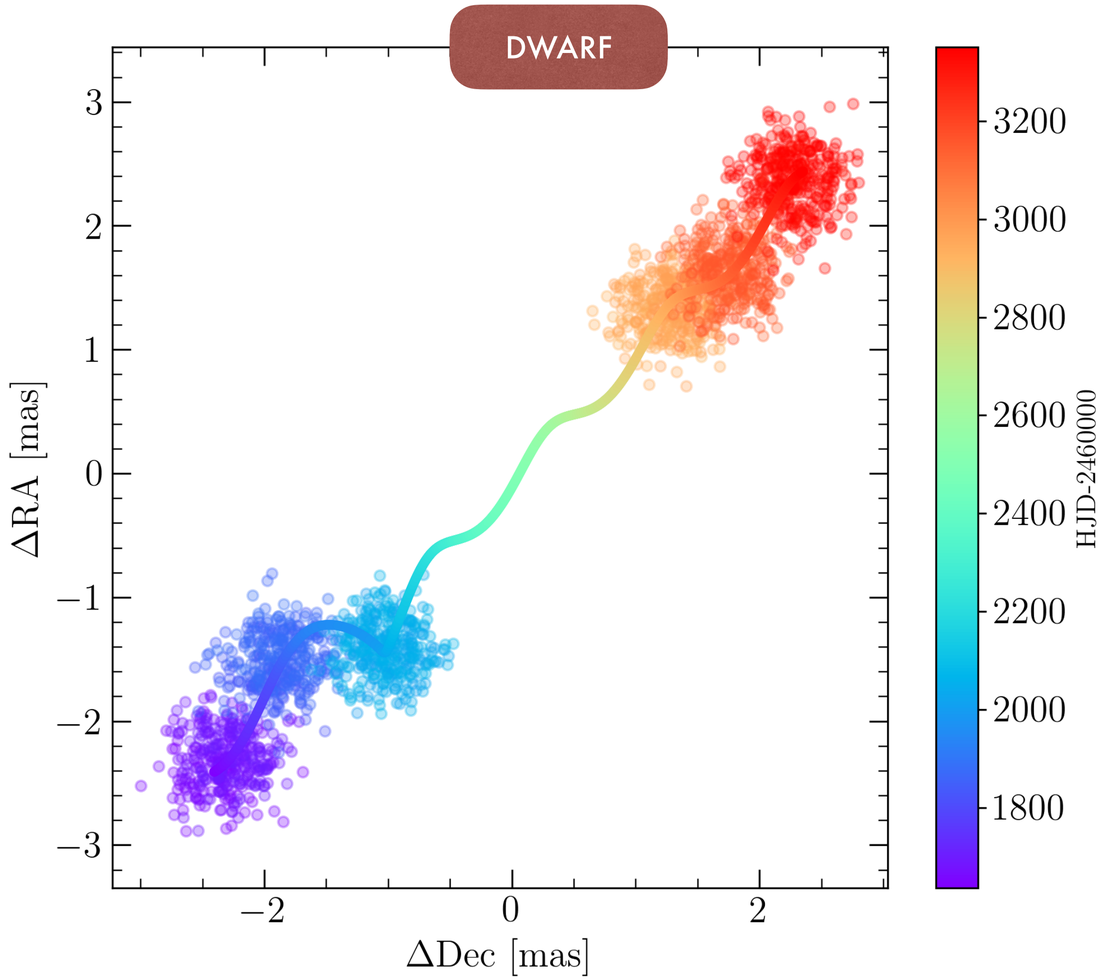
- centroiding error estimation for crowded regions
- 15 minute cadence adopted
- 3 seasons of observations at the beginning and the end of the 5-year mission

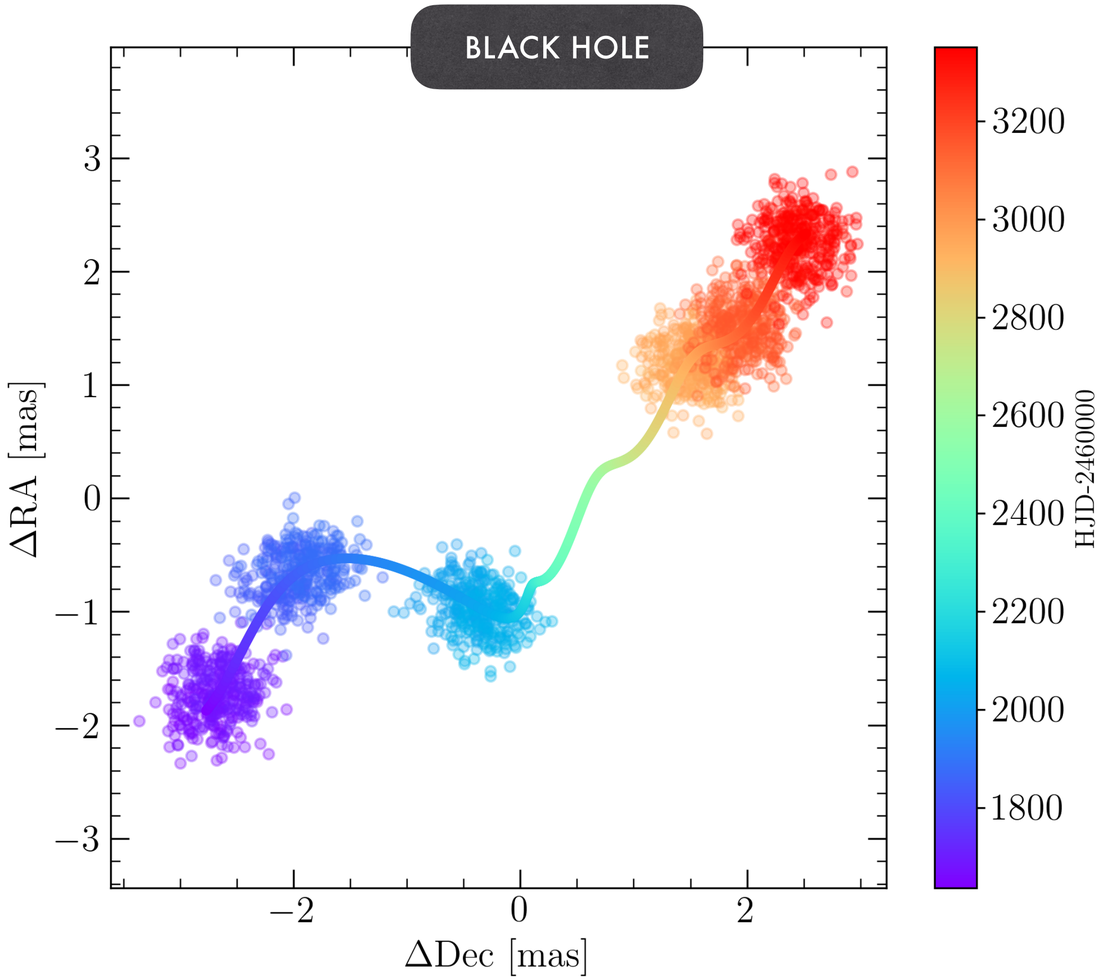
- each season 72-days long
- gaussian errors assumed
- few hours bins - to see preliminary results



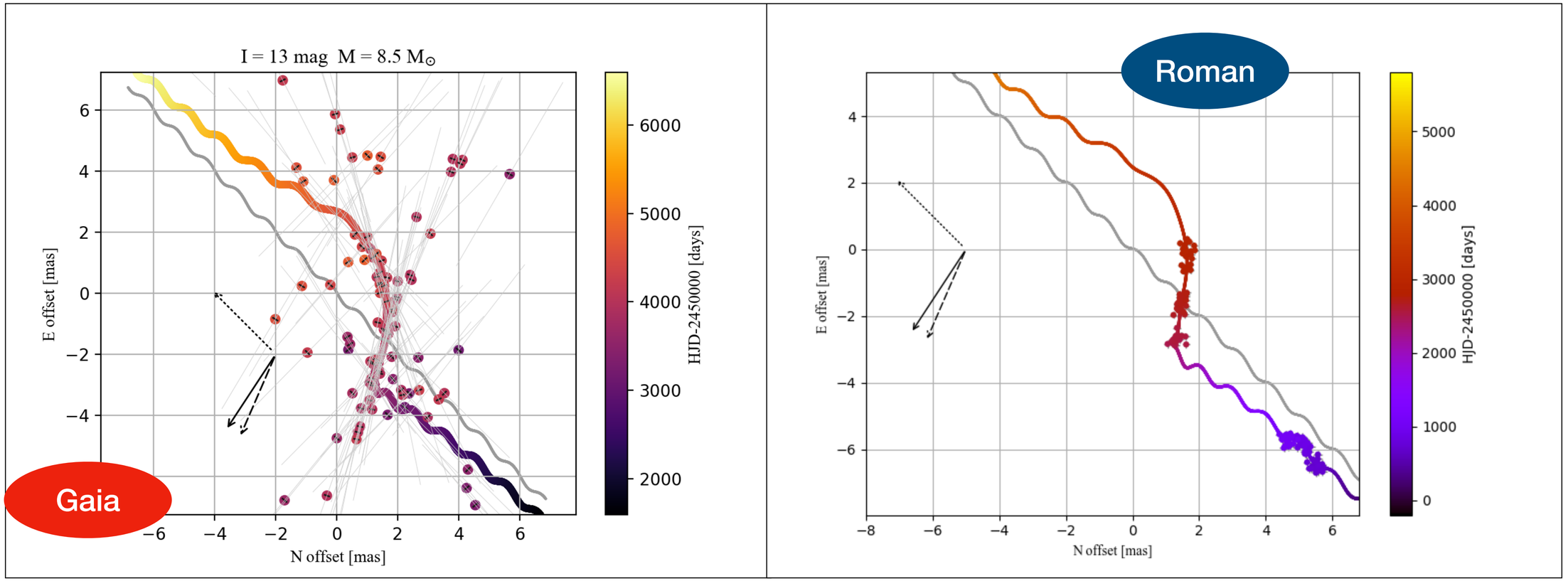


Astrometric microlensing - motion curve simulations





Comparison with the expected performance of Gaia



- Gaia not designed to accurately cover transients, especially astrometric ones
- Gaia provides good accuracy only along the scan direction
- Cadence: 15min vs ~30days
- Main problem for Gaia: precision drops dramatically with brightness

Summary

- It will be possible to detect astrometric microlensing signal in the Gaia data
- Roman performance in the context of astrometric microlensing looks very promising
- Roman will allow to routinely measure masses of fairly standard lenses, not only extreme cases
- Astrometric microlensing will provide $\theta_{\rm E}$ measurements even for faint or completely dark lenses, like isolated stellar mass black holes