Breaking the low mass planet detection limit with AO methods

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Abstract

AO follow-up observations have proven to be an efficient method for mass and distance precise measurements. Future space surveys such as **Euclid and Roman surveys** will provide hundreds new follow-up events. The process and explotation of these new data require fast and rigorous methods of treatment.

Here we present the AO follow-up exemple of **OGLE-2013-BLG-0132** mass and distance precise measurement (Rektsini 2024).

In addition, we introduce a **new tool** that can extract the star parameters (position and flux) and can be adapted to different observational instruments (Rektsini in prep.)

METHOD

High angular resolution follow-up observations provide source-lens relative proper motion and flux ratio measurements that constrain the mass and distance of the lens.

Here, we used Keck AO observations for the microlensing event OGLE-2013-BLG-0132 (Mroz 2017) which is confirmed to be a Saturn-mass planet orbiting an M-dwarf. We deduced the source-lens separation and flux ratio using DAOPHOT (Stetson 1987).

Now, we introduce a new tool that calculates the source-lens positions, fluxes and orientation using a mehtod given by C. Alard. An exemple of this method's results can be found in (Vandorou 2020).

The key point of this new tool is its architecture that allows it to be easily adapted to the observational tool's requirements. Our goal is to be able to use this tool for space based surveys as Roman or a Euclid-Roman joint survey (as in Bachelet 2022) but also ground-based telescopes as Keck.

In Fig.3 we use a simulated image of two stars using a Gaussian PSF and retrieve the star parameters using C. Alard's method, a median background fit, a bilinear interpolation and AMOEBA as a minimization algorithm.

The user can choose :

- A PSF model
- The minimization algorithm to derive the best-fit solution
- The interpolation method
- How to fit the background level
- How to calculate the best-fit model

CONCLUSIONS

- We tested our code on a simple case, using an empirical Gaussian PSF model and derived the two star parameter solutions.
- We are running the code on the same simulated data as in Bachelet et al. 2022.
- We will run the code on Keck follow-up observations.
- Possibility to use different wavelength band filters.
- The code will be open source.
- Open to any new ideas suggestions for more functions/cases!

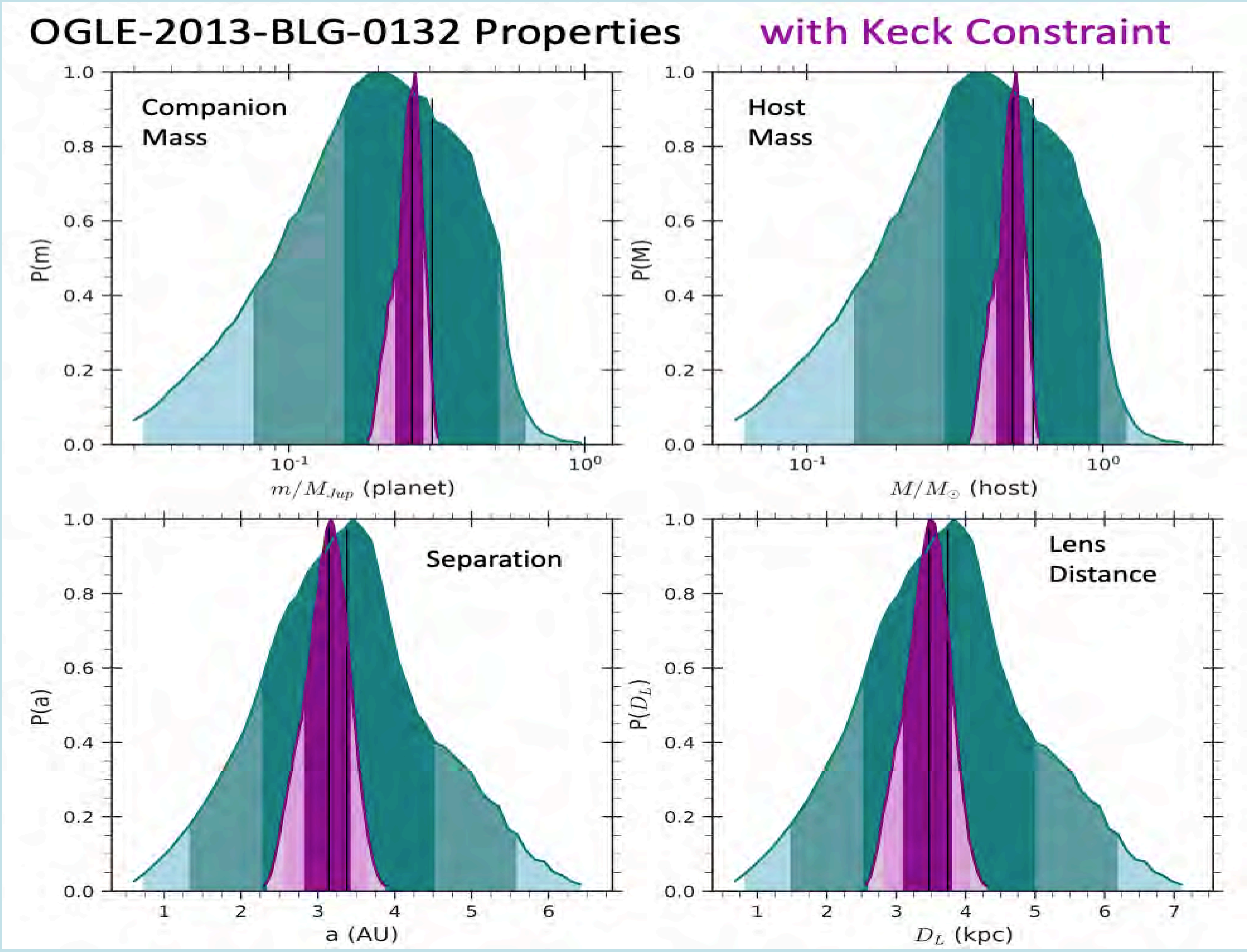

Fig. 1 - Physical properties of OGLE-2013-BLG-0132. Bayesian posterior probability distributions for the planetary companion mass, host mass, their separation, and the distance to the lens system are shown with only light-curve constraints in cyan and with the additional constraints from our Keck follow-up observations in purple. The central purple and cyan areas indicate the standard deviation (Rektsini 2024).

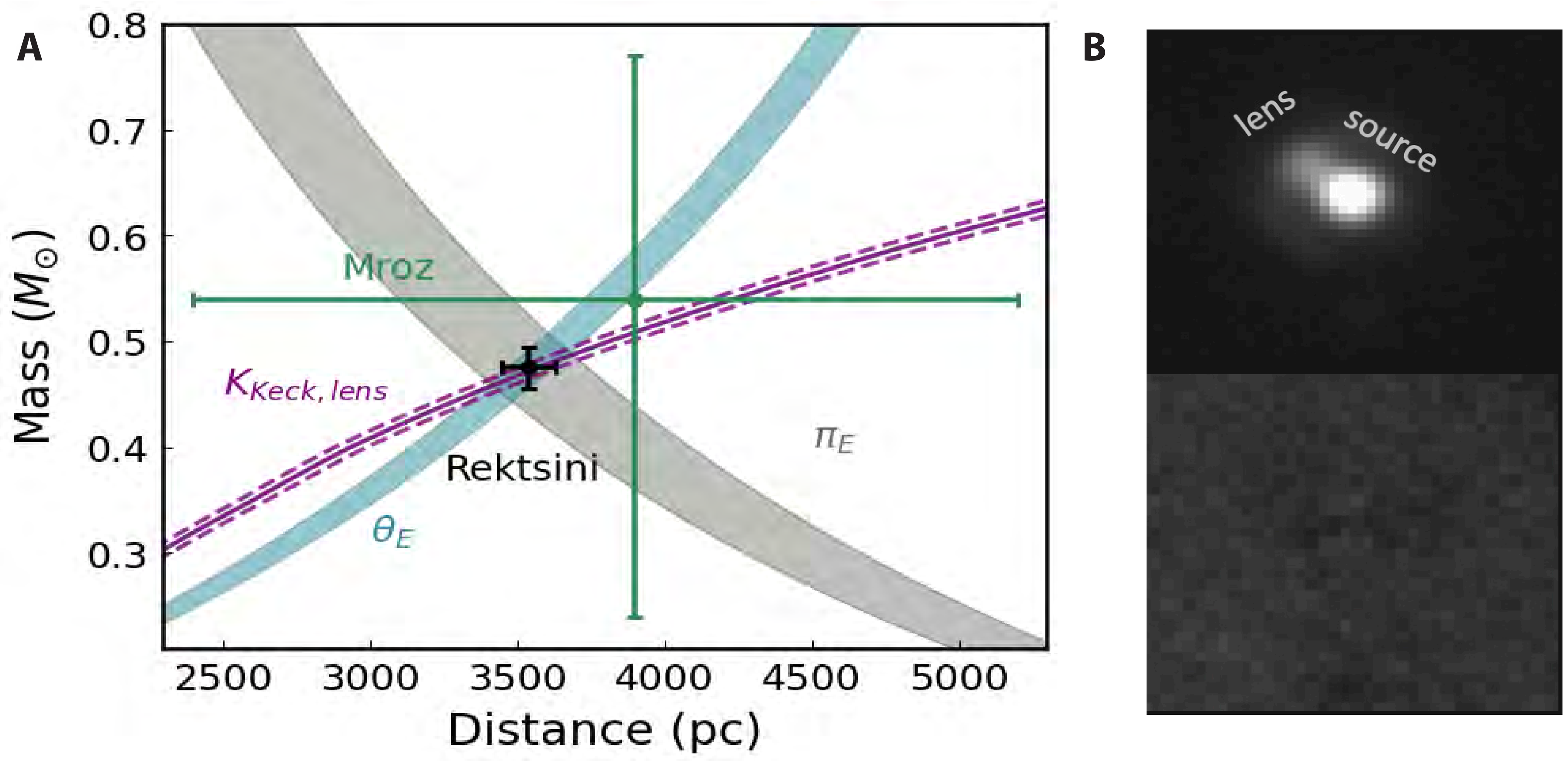

Fig. 2 - A) Mass-distance estimate for the lens. The purple curve represents the constraint from the **K-band lens flux** measurement, the seagreen curve shows the **Einstein angular radius** measurement and the grey curve represents the **microlensing parallax** calculated using the (AO) constraints. The intersection between the three curves defines the estimated solution of the lens physical parameters. **B)** Close-up (2.5"× 2.5") Keck frame of the source and lens and the 2-star PSF fit resdiual.

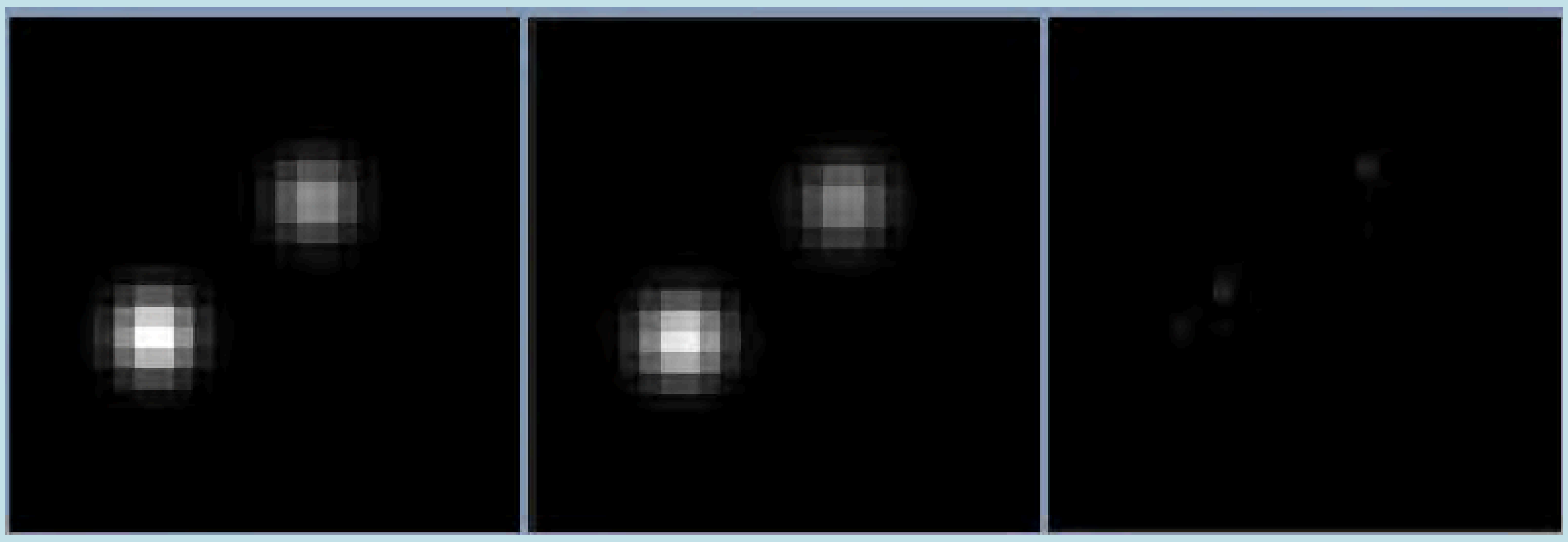

Fig. 3 - Simulated image of two stars using an empirical Gaussian PSF model. Starting from left to right we show the two-star simulated image, the six-parameter best fit we calulate and finally the residuals of the best fit solution (Rektsini in prep.).

References

Rektsini et al 2024 (accepted)
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