Mass Measurement of Microlensing Exoplanets with HST

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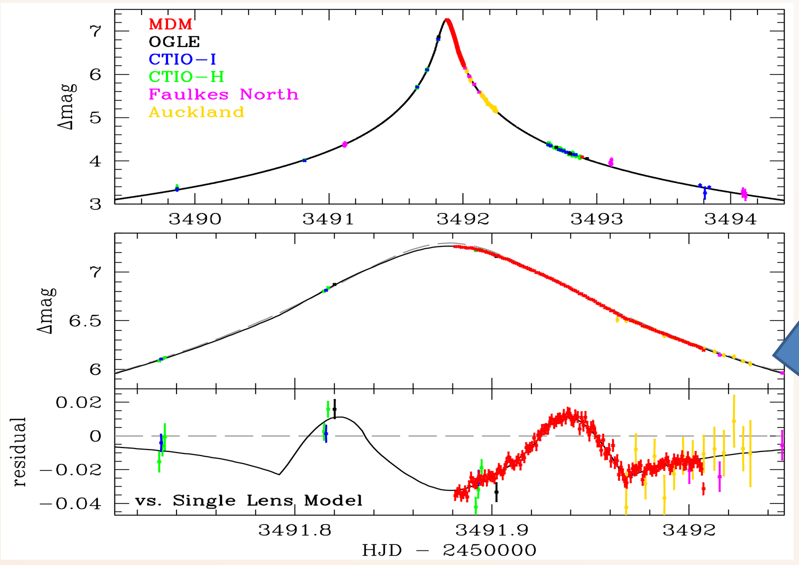
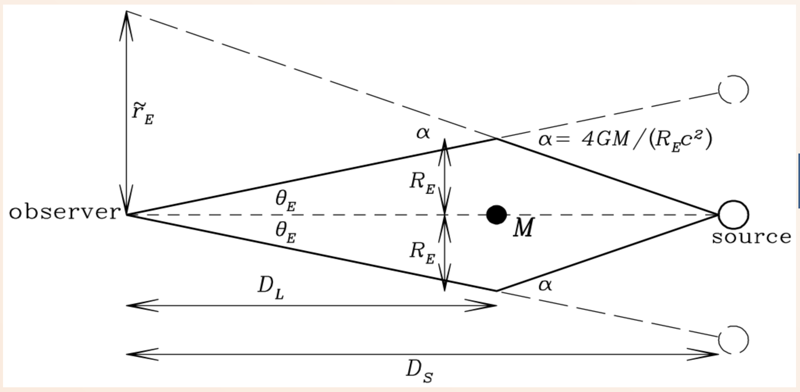
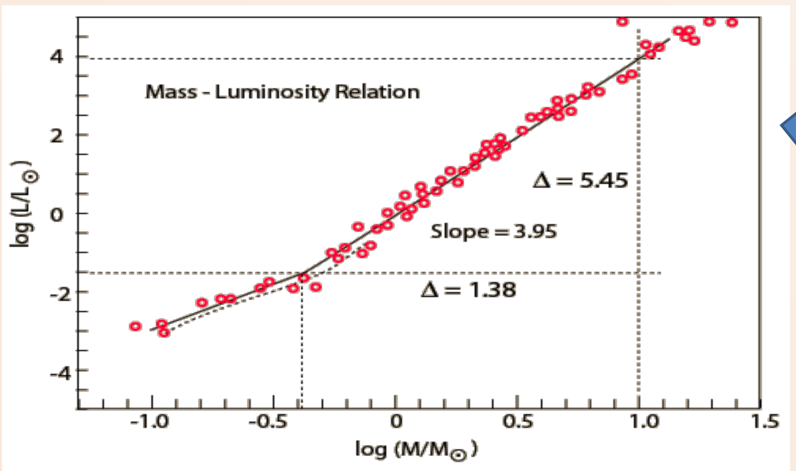
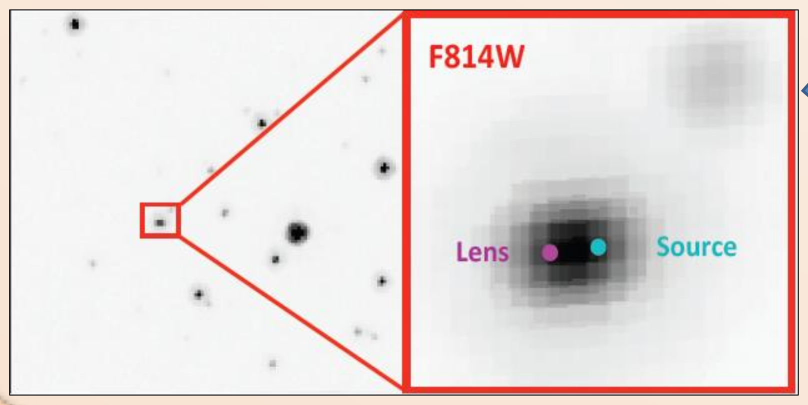
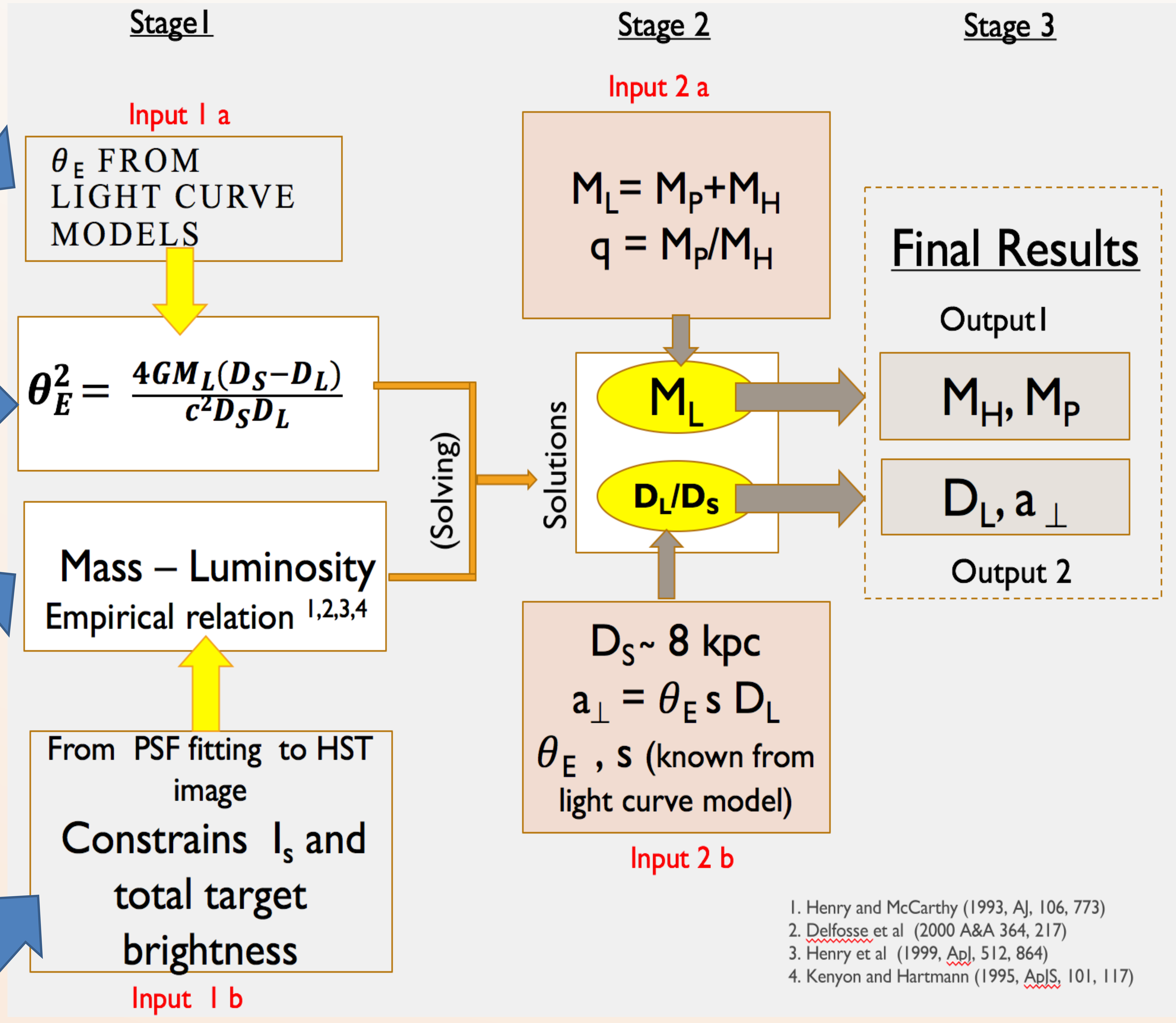
Mass Measurement of Microlensing Exoplanets with Finite Source Effect and Lens Detection (Eg. OGLE-2005-BLG-169)











The HST follow-up is taken 6.5 years after the peak of the microlensing event and we can see the lens and the source are partially resolved. By detecting the lens and source separately, we can measure the separation and hence the relative lens-source proper motion.

Mass & Distance Measurements

- Host mass M_H: 0.687 ± .021 $M_\odot$
- Planet Mass M_P: 14.1 ± 0.9 $M_\oplus$
- Lens Distance D_L: 4.1 ± 0.4 kpc
- Projected Separation($a_\perp$): 3.5 ± 0.3 AU

The mass measurements are verified in 3 different passbands of HST and 3 others in Keck AO independently. More details : Bennett, Bhattacharya+ 2015, Batista+ (including Bhattacharya+) 2015

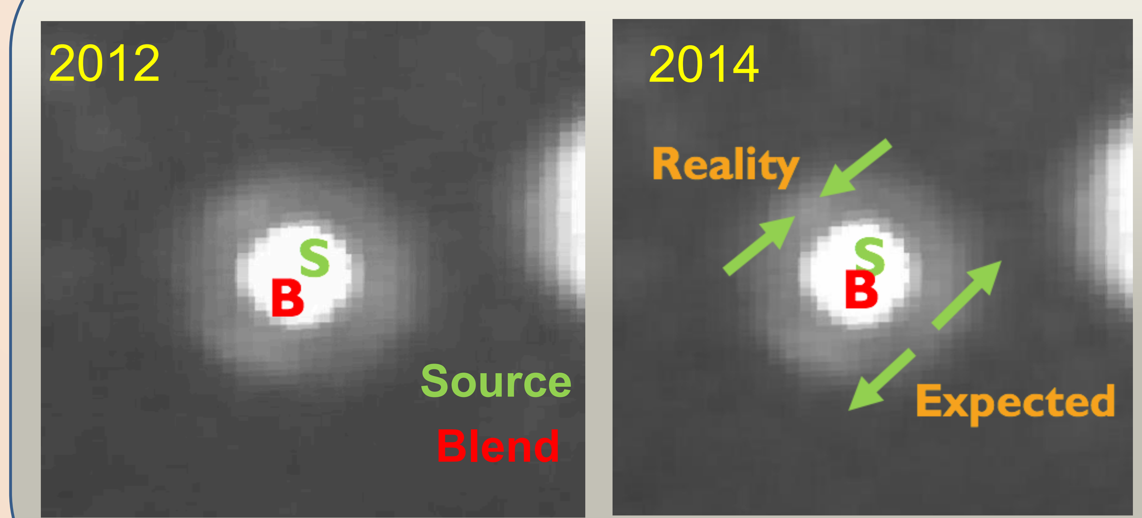
M_L = Lens Mass
M_H = Host Mass
M_P = Planet Mass
q = Planet-Host mass ratio
D_L = Lens distance
D_S = Source distance
θ_E =Angular Einstein Radius

Mass Measurements with WFIRST Microlensing Survey

- This method will be the primary mass measurement method for WFIRST Microlensing exoplanets.
- WFIRST will observe 6 seasons of 72 days spread over 4.5 years. Hence it will observe the source and lens coming closer, microlensing and then resolving out. As a result, WFIRST will be following up its own discoveries.
- WFIRST IR pixel scale same as HST pixel scale ~0.11 mas. Hence HST will be ideal for precursor observations in preparation of WFIRST.
- WFIRST will observe 7 bulge fields and take ~40000 images in F149W (wide IR) and ~800 images in F184W (between H and K) and ~800 images in Z087 of each field. It is already shown with only 8 dithered images in each passband with HST that the method works for as low as Uranus mass planet. The huge number of dithered images by WFIRST will help to construct a much better PSF than current and will yield a higher precision.
- It is also shown the excess flux on top of source is not necessarily due to the lens primarily. In that case we consider the possibility of companions to the source or the lens or a nearby unrelated star. We can still put an upper limit on the mass measurement of the planet. Details: Bhattacharya+ 2017.

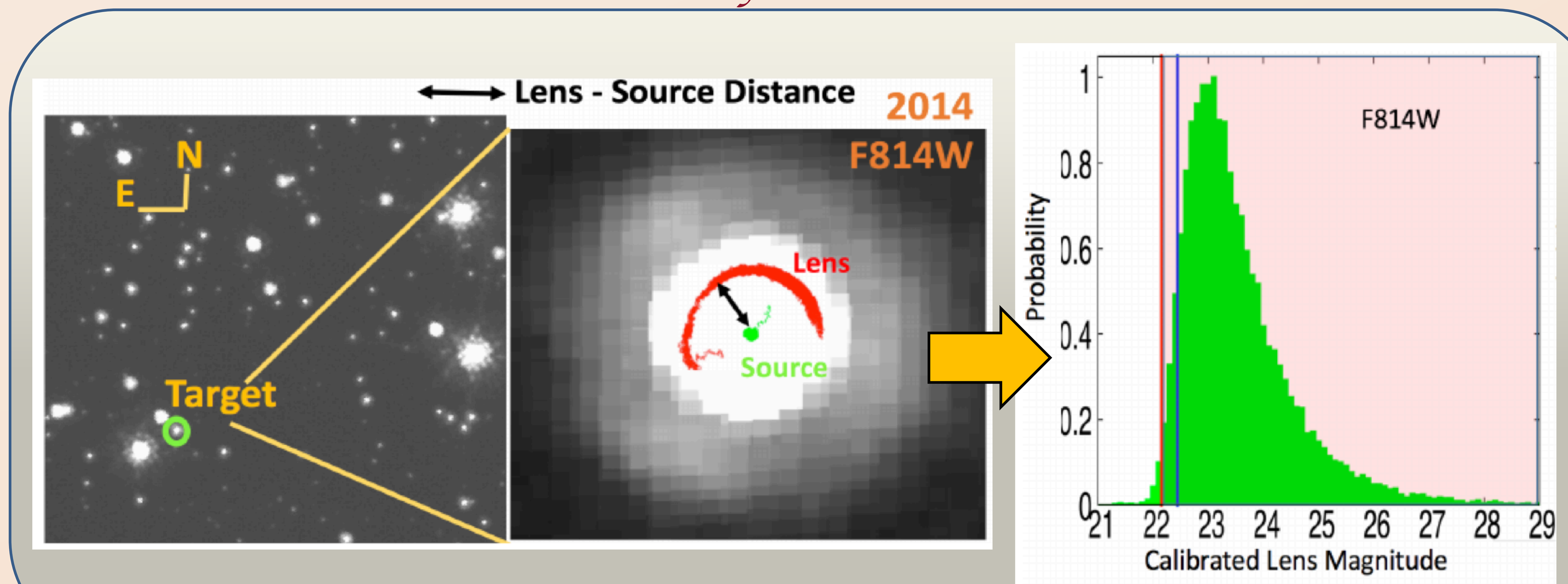
Further Development of Mass Measurement Method: Accounting for Contamination from Binary Companions or Nearby Unrelated Stars

Dual Star Fit



The example of MOA-2008-BLG-310 shows that detection of excess flux on top of the source does not necessarily confirm the unique detection of lens. A dual star fit on left shows that in two epochs, the source and the blend stars are closer in 2014 compared to 2012, whereas the source and the lens are expected to separate out further in 2014.This shows the excess flux is primarily not due to the lens. It is possible that the excess flux is due to either a companion to lens or source or a nearby unrelated star and the lens. A triple star MCMC PSF fitting yields the distribution of lens brightness. An upper limit of lens brightness at 99% along with the method described above gives the upper limit on host mass: 0.64 $M_\odot$ planet mass: 70 $M_\oplus$ lens distance: 7.8 kpc.

Triple Star Fit



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