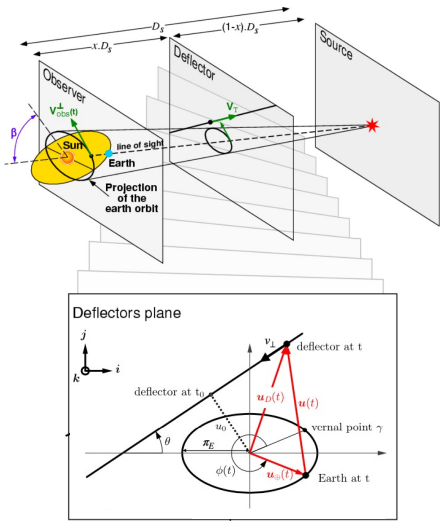
# Impact of parallax on long duration microlensing events toward the Magellanic Clouds

T. Blaineau & M. Moniez *A&A* 636, L9 (2020)

## 2 questions related to the search for intermediate mass black holes in the halo

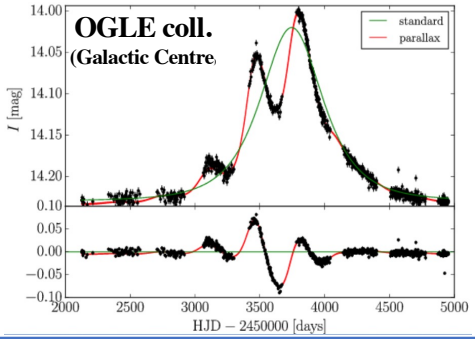
*- How parallax affects the efficiency of detection of long duration events ?*

*- What proportion of events have a noticeable parallax effect?*




### *multi-year duration events have more chances to be affected by annual parallax*

- Apparent trajectory of the lens w/r line-of-sight is an **hypocycloid**
- **u(t)** (and magnification) shows modulations with 1 year characteristic time



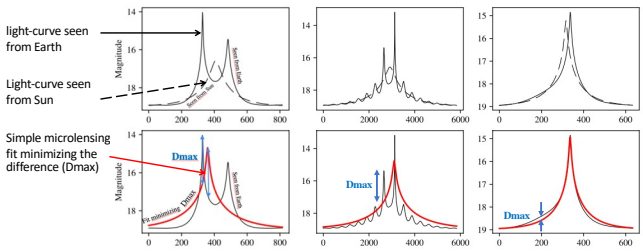

## What is the risk to miss microlensing events toward LMC using a standard analysis ?

*-> use max difference (best PSPL fit - event with parallax)*

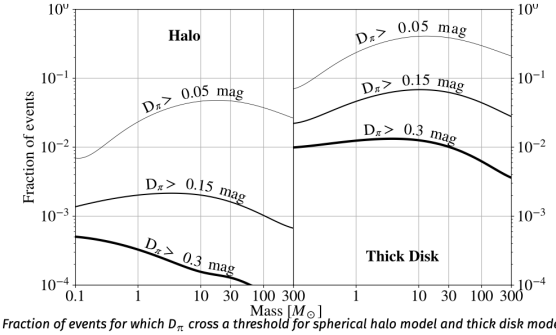
- to be as general as possible we simulate "analytical" light curves
- we quantify the distance between the event seen from the earth and the fitted one seen from the Sun

$$D_\pi = \min_{t_E,t_0,u_0} \{\max_t |m_\oplus(t) - m_\odot(t,t_E,t_0,u_0)|\}$$

Simulated parallax microlensing — Fitted PSPL microlensing




- In the worst case scenario we miss **at most 6% of events**.




*Fraction of events for which $D_\pi$ cross a threshold for spherical halo model and thick disk model.*

Robustness has been tested with respect to **blending** (with up to 50% contribution).

- For **halo** heavy objects **> 95% of the light-curves deviate by less than 0.05mag** from a simple microlensing.
- For **thick disk** heavy objects **> 92% of the light-curves deviate by less than 0.15mag** from a simple microlensing.

In both cases, pre-filtering by standard algorithms (assuming only one significant bump) is not significantly affected by parallax

## What is the proportion of events toward LMC that have a detectable parallax ?

*-> integrated difference (best PSPL fit – event with parallax)*

- We also simulate "analytical" light curves
- Survey characterized by 3 parameters
  - *Total number of observations: $N_{obs}$*
  - *Sampling frequency (# observations/day): $f_{obs}$*
  - *Photometric precision (assumed constant): $\sigma_{phot.}$ (mag)*
- Proxy of the $\chi^2$ of the best *standard* microlensing fit to an hypothetically observed light curve containing $N_{obs}$ observations, sampling a microlensing light curve $m_\oplus(t)$ (with parallax) with a constant photometric precision $\sigma_{phot.}$:

$$\tilde{\chi}^2_\pi = N_{obs} + \frac{f_s}{\sigma^2} \min_{t_E,t_0,u_0} \int_{-\infty}^{+\infty} (m_\odot(t,t_E,t_0,u_0) - m_\oplus(t))^2 \, dt$$

Fitted PSPL microlensing — Simulated parallax microlensing

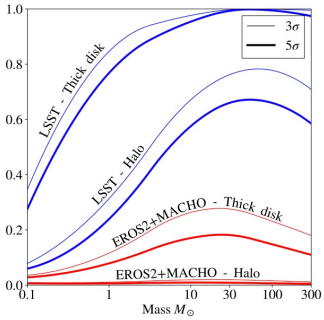
(The integral term is a distance between parallax and non-parallax measured curves)

- If this pseudo- $\chi^2$ is large, then parallax is significant. For large $N_{obs}$, the probability of non-detection of parallax is quantified from:

$$\text{p-value} = \frac{1}{2\pi} \int_{\frac{\tilde{\chi}^2_\pi - N}{\sqrt{2N}}}^{\infty} e^{-x^2/2} dx$$

What proportion of events have a noticeable parallax effect ?

- **very few** in EROS+MACHO, a much higher proportion for LSST




*Fraction of event with parallax effect that can be measured with 3σ or 5σ significance level.*

### Perspectives

For most lenses heavier than 10 $M_\odot$ towards the LMC and SMC, LSST-like surveys should be able to detect and quantify the parallax, allowing a better determination of the lensing configuration parameters, and a distinction between models (halo or thick disk) for the dark matter structure.