Binary stars ratio in *Gaia* DR2

Blending in gravitational microlensing survey efficiency estimation

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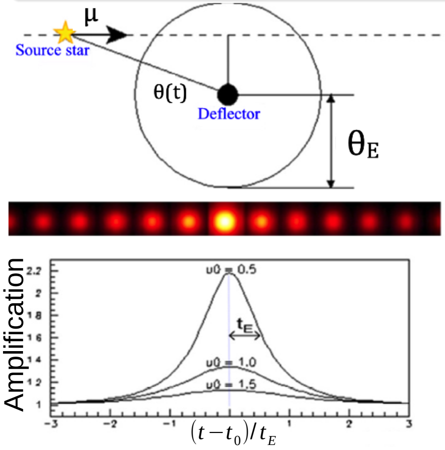
Gravitational microlensing

Microlensing

Gravitational lensing but only the **magni cation** is detected.
This magnification is **time-dependent**.
Characteristic scales : Einstein angle $_E$ (radius R_E); Einstein time $t_E = \ _E = \ .$



- Intermediate mass black holes as dark matter ($M \quad 100M$, $_E \quad 4mas$, $t_E \quad 700d$)
- Study deflector population by observing a lot of sources (in LMC) over a long period (years).
-) estimate the number of expected lenses effects, compare to observed.
-) depends on : deflector characteristics, survey parameters such as search algorithm efficiency, **number of monitored stars**, ... etc

What is the number of monitored stars : Blending in LMC

A source in the microlensing experiment can be (is) composed of **several stars**.

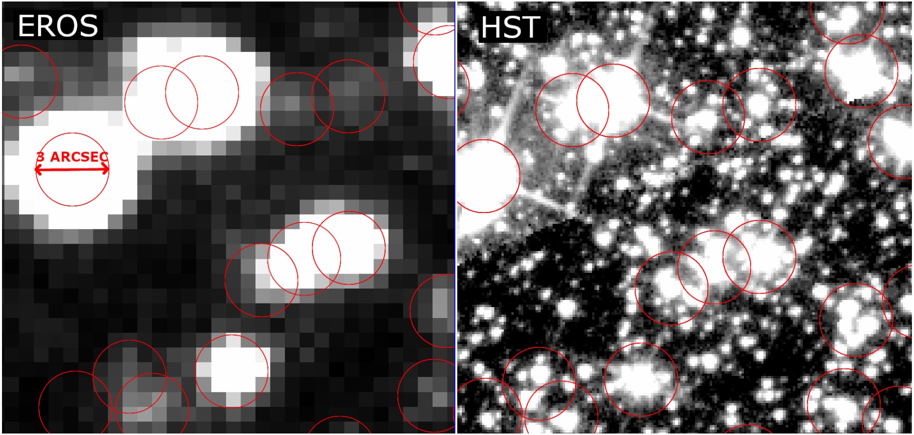


Figure: Left : image from EROS. Right : image from HST of the same zone. The red circles are identified sources in EROS and have a diameter of 3 arcsec.

What is the number of monitored stars : Blending in LMC

A source in the microlensing experiment can be (is) composed of **several stars**.

Two competing effects on efficiency:

- Greater number of monitored stars.
- Light of amplified star blended with the others) lower relative amplification.

We need to understand what is hidden behind a catalogue source.

- What is hidden behind a source ? Comparison between catalogue and HST.

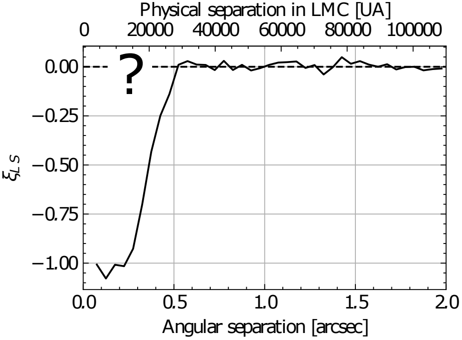


Figure: Spatial correlation function of HST toward LMC

- What is hidden behind a source ? Comparison between catalogue and HST.

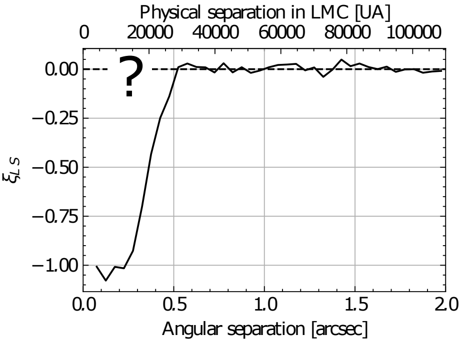


Figure: Spatial correlation function of HST toward LMC

- In HST : minimum separation of 0:5 arcsec ! 25000 AU in LMC.

Beyond HST

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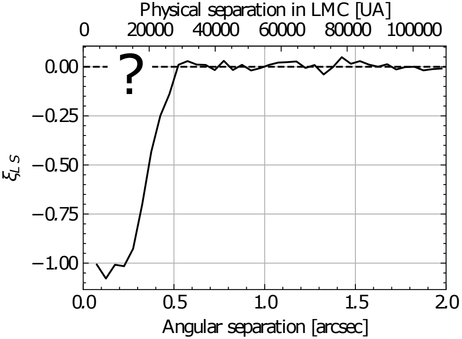

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- Einstein radius projected in LMC R_E 200AU (for a deflector of 100M).
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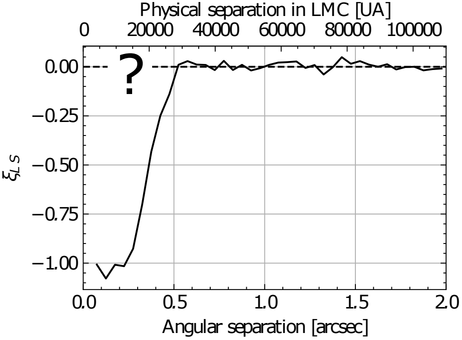

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- R_E < separation < 25000 UA : **uniform or clustered ?**

Use of *Gaia* DR2

Aim : quantify the unresolved physical binary population in HST, in the scope of the blending.

We use *Gaia* DR2 to study nearby stellar clustering, and we extrapolate the results to the LMC (50 kpc).

- between 100 and 600 pc, parallax relative error $< 20\%$
- absolute magnitude interval, in *Gaia* completeness domain
- $30°$ radius cones along galactic north and south

Red lines : *Gaia* completeness range.
Black lines : selected range.
Total number of stars : 1.76×10^5.

First remarks

Uniform random distribution : $dP = 2 \quad nN \sin \quad d \qquad 2 \quad nN \quad d$

n : stellar density
N : total number of stars
: angular separation
P : number of pairs

Overabundance at small scales.

pairs with separation $<$ 10 arcsec : 99 % of stars appears only once
) binary stars largely dominating.

Minimal separation in Gaia DR2

- Can't resolve stars closer than 0.4 arcsec.
- Density fluctuations (instrumental effects)) discard pairs < 2 arcsec

Figure: Angular separation 2D distribution along ecliptic longitudinal and latitudinal axis, red circle has 2 arcsec radius.

Binary rate estimation

Divide the sample in distance shells, and for each :

Count pairs by physical separation

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Binary rate estimation

Divide the sample in distance shells, and for each :

- Count pairs by physical separation
- Subtract random coincidences contribution
- Normalize to number of stars in shell

Binarity rate estimation

We t the weighted mean to a lognormal distribution.

Integrate between R_E (200 AU) and 25000 AU.

Results

Binary rate (sep > 200 AU)

$f_{BS}(200AU) = 1.1\%$ 0.2 (stat)

Systematics (WIP):

- Gaia parallax selection : ok
- magnitude range limited to GAIA completeness

Extrapolating toward LMC :

- neighbourhood   LMC
- 6 magnitude ranges

$$p(x) = \frac{A}{x\sqrt{2\ \ ^2}} \exp\left(\frac{(\ln x \quad)^2}{2\ ^2}\right)$$

separation with maximal probability :

$$\text{mode} = e^{\quad\ ^2}$$

Conclusion

We quanti ed the binary system rate in unresolved separation domains (HST in LMC).

- Was not studied in the past microlensing experiments.
- Small binary rate in our separation domain. : 2% (preliminary) (assuming validity of extrapolation from nearby to LMC)
-) Limited impact on heavy lenses microlensing survey e ciency (! on constraints on black holes fraction in dark matter)

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Thanks for your attention.

Backup

Parallax relative errors

Figure: Caption

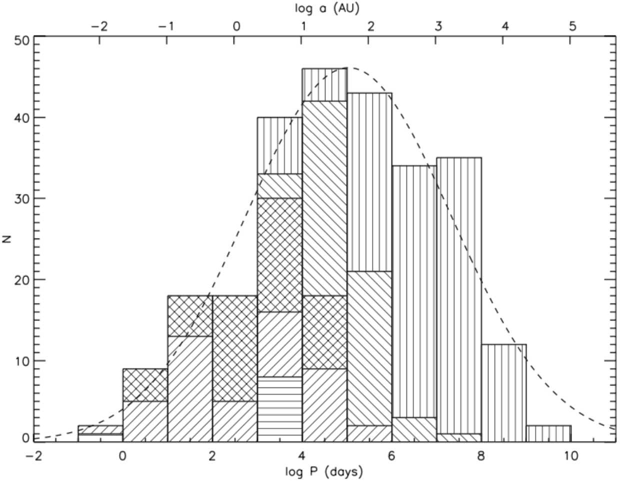

Figure: From Raghavan et al. 2010