# Binary stars ratio in Gaia DR2 <br> Blending in gravitational microlensing survey efficiency estimation 

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## Gravitational microlensing

## Microlensing

Gravitational lensing but only the magnification is detected.
This magnification is time-dependent.
Characteristic scales: Einstein angle $\theta_{E}$ (radius $R_{E}$ ); Einstein time $t_{E}=\theta_{E} / \mu$.


- Intermediate mass black holes as dark matter $\left(M \sim 100 M_{\odot}, \theta_{E} \sim 4\right.$ mas, $\left.t_{E} \sim 700 d\right)$
- Study deflector population by observing a lot of sources (in LMC) over a long period (years).
- $\Rightarrow$ estimate the number of expected lenses effects, compare to observed.
- $\Rightarrow$ 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 $\Rightarrow$ lower relative amplification.
We need to understand what is hidden behind a catalogue source.


## Beyond HST

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Comparison between catalogue and HST.


Figure: Spatial correlation function of HST toward LMC

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- Einstein radius projected in LMC $R_{E} \sim 200 A U$ (for a deflector of $100 \mathrm{M}_{\odot}$ ).
- 2 sources closer than $R_{E}$ are lensed together

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- 2 sources closer than $R_{E}$ are lensed together
- $R_{E}<$ separation $<25000$ UA : uniform or clustered ?

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## 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
- $30^{\circ}$ radius cones along galactic north and south



## First remarks

Uniform random distribution: $d P=2 \pi n N \sin \alpha d \alpha \approx 2 \pi n N \alpha d \alpha$

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

- Overabundance at small scales.
- pairs with separation $<10$ arcsec : $99 \%$ of stars appears only once $\Rightarrow$ binary stars largely dominating.


## Minimal separation in Gaia DR2

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


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

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- 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 fit the weighted mean to a lognormal distribution.


Integrate between $R_{E}(200 \mathrm{AU})$ and 25000 AU .

## Results

## Binary rate (sep > 200 AU )

$$
f_{B S}(200 A U)=1.1 \% \pm 0.2 \text { (stat) }
$$

Systematics (WIP):

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

Extrapolating toward LMC :

- neighbourhood $\rightarrow$ LMC
- $\neq$ magnitude ranges


$$
p(x)=\frac{A}{x \sqrt{2 \pi \sigma^{2}}} \exp \left(-\frac{(\ln x-\mu)^{2}}{2 \sigma^{2}}\right)
$$

separation with maximal probability :

$$
\operatorname{mode}=e^{\mu-\sigma^{2}}
$$

## Conclusion

We quantified 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 : $\lesssim 2 \%$ (preliminary) (assuming validity of extrapolation from nearby to LMC)
- $\Rightarrow$ Limited impact on heavy lenses microlensing survey efficiency ( $\rightarrow$ 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

