Stellar binarity rate in *Gaia* EDR3

Blending in gravitational microlensing surveys

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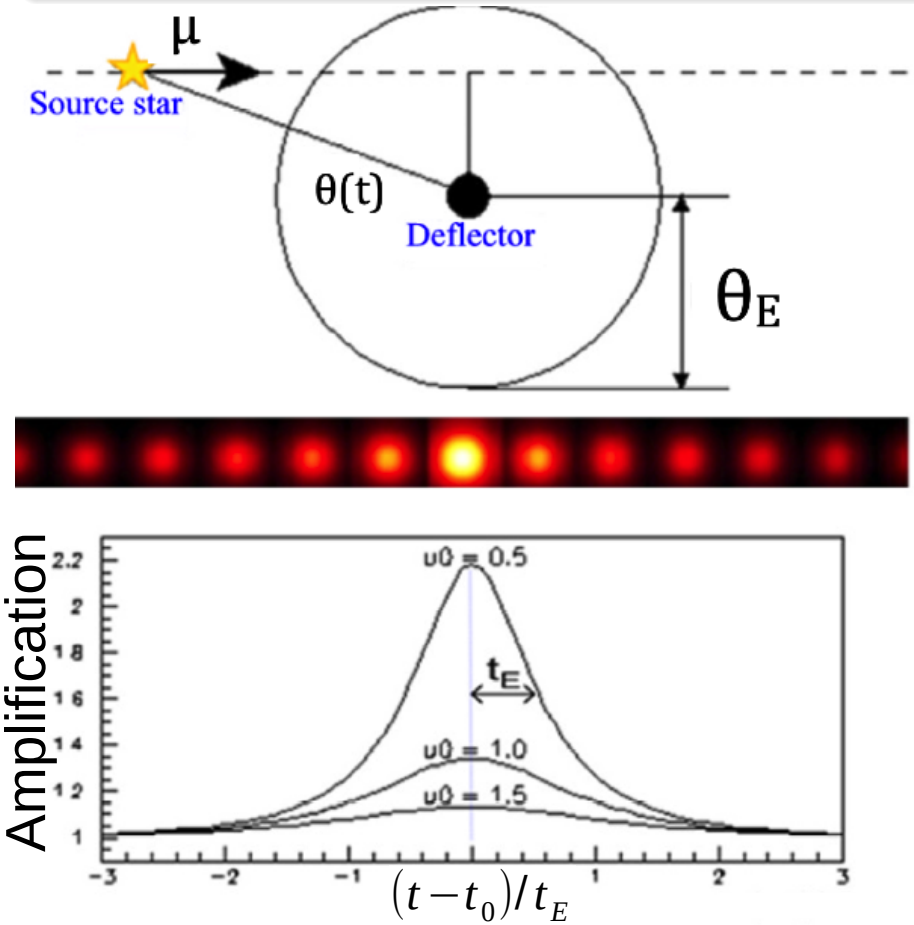
Gravitational microlensing

Microlensing

Gravitational lensing but only the **magnification** is detected.
This magnification is **time-dependent**.
Characteristic scales : Einstein angular radius θ_E (R_E); Einstein time $t_E = \theta_E/\mu$.



Search for heavy lenses as dark matter :

- Intermediate mass black holes as dark matter ($M \sim 100 M_\odot$, $\theta_E \sim 4mas$, $t_E \sim 700d$)
- Study deflector population by observing a lot of sources (in the Large Magellanic Cloud, LMC) over a long period (years).
- $\Rightarrow$ estimate the number of expected lenses effects, compare to observed.
  $\Rightarrow$ depends on : survey efficiency, **number of monitored stars**, ... etc

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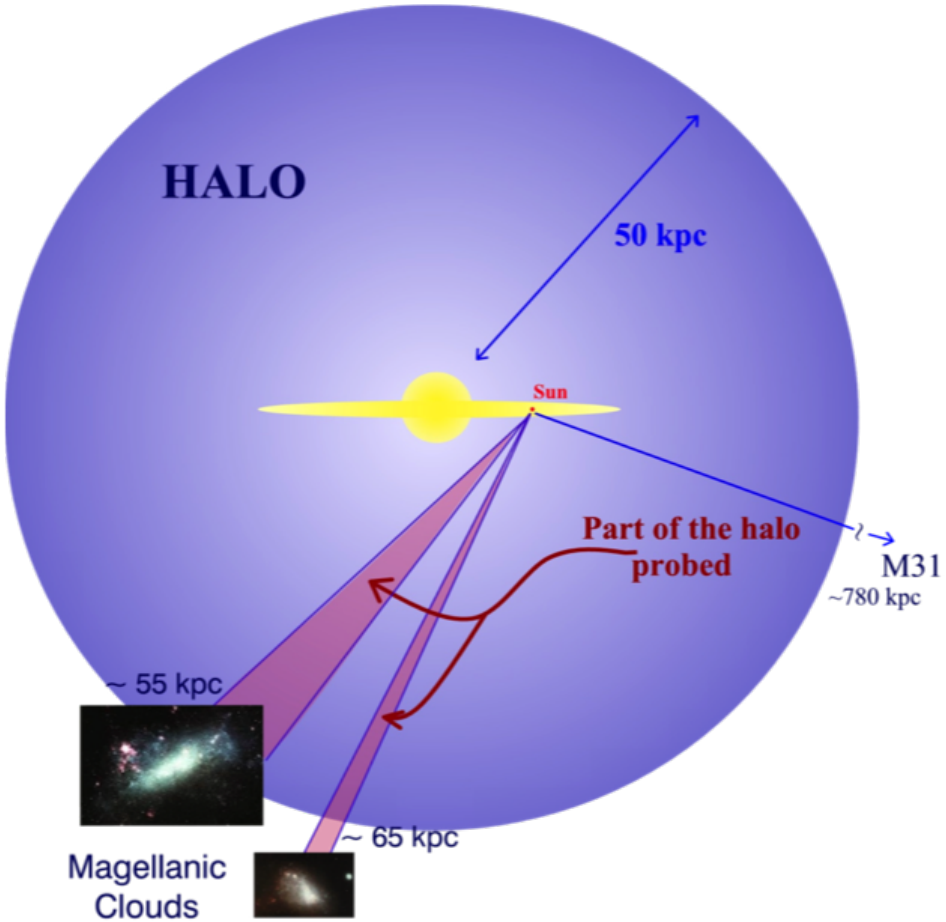

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What is the effective number of monitored stars : Blending in the LMC

A source seen in an on-earth telescope can be (is) composed of **several stars**.

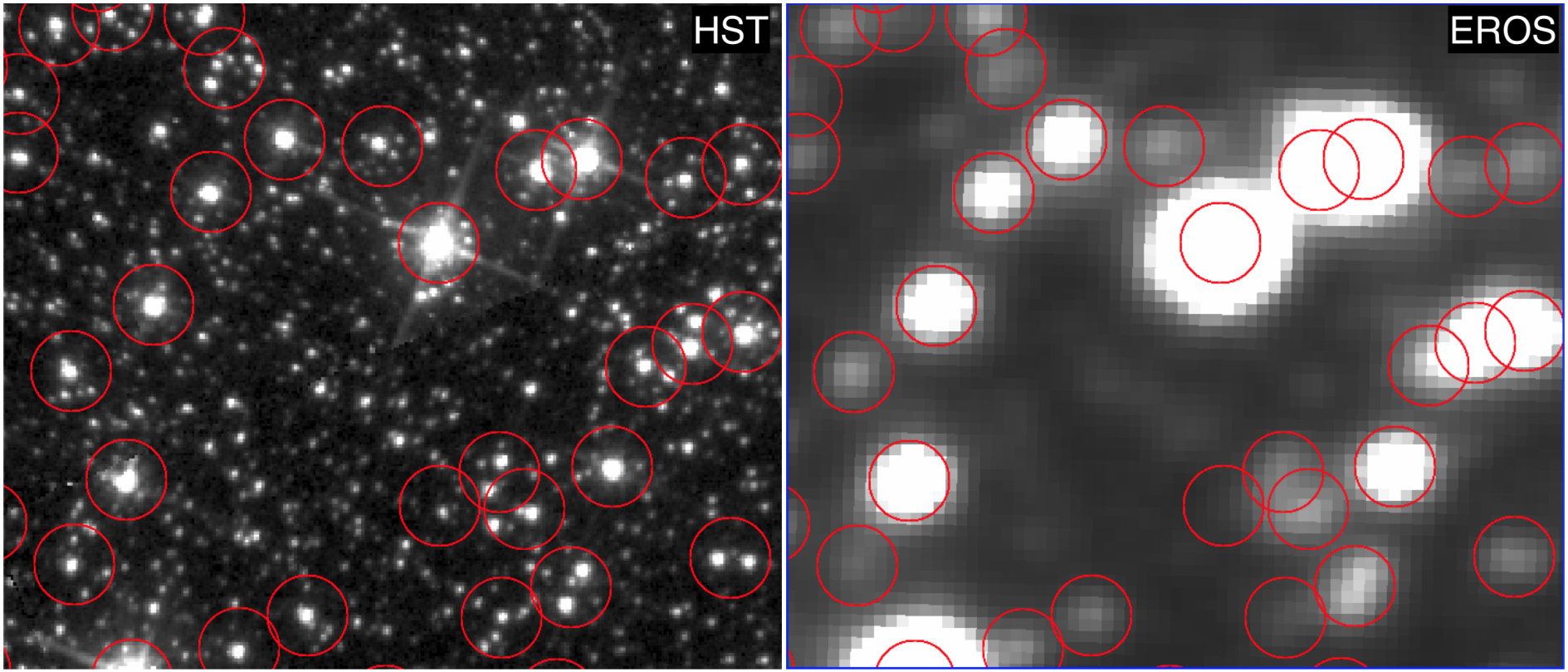

Figure: Left : image from Hubble. Right : image from EROS of the same zone. The red circles are identified sources in EROS and have a diameter of 3 arcsec.

What is the effective number of monitored stars : Blending in the LMC

A source seen in an on-earth telescope can be (is) composed of **several stars**.
Two competing effects on number of detection:

- 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

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

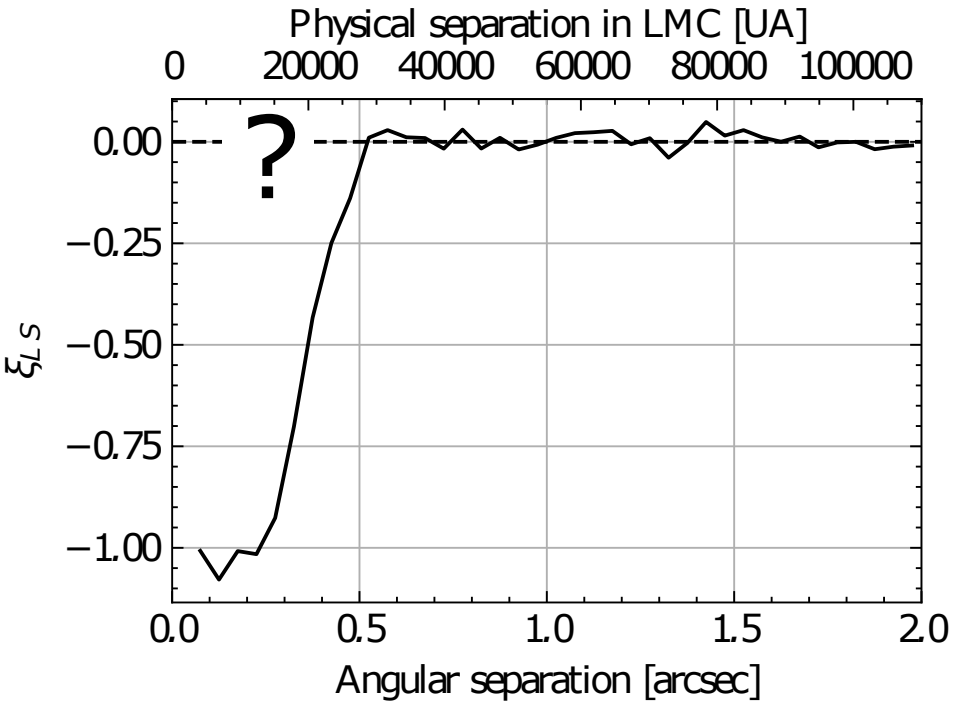

Figure: Spatial correlation function of HST toward LMC

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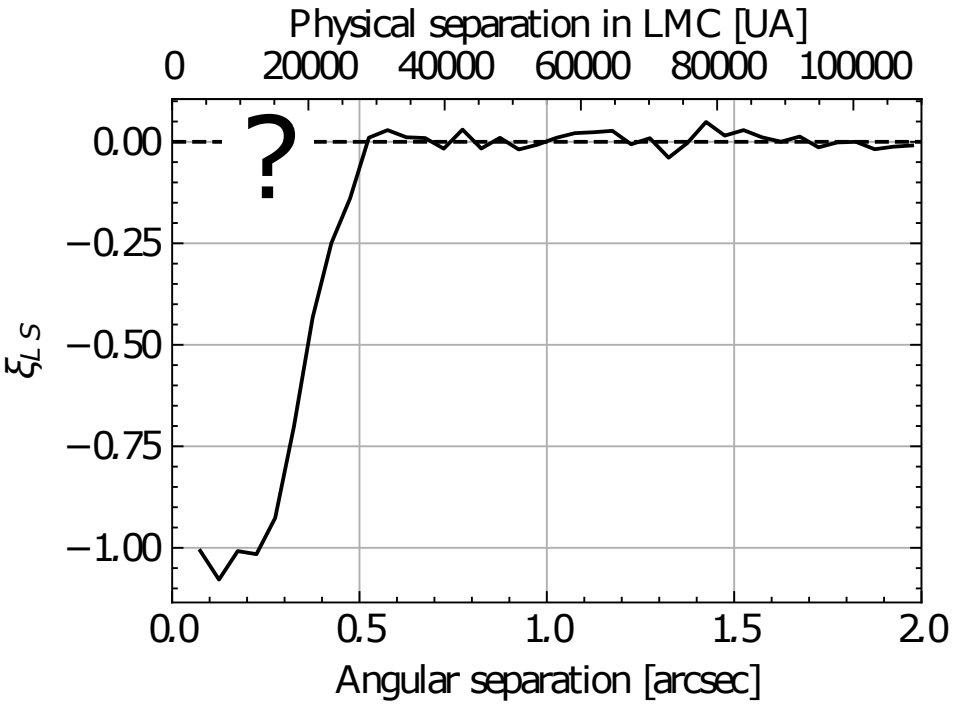

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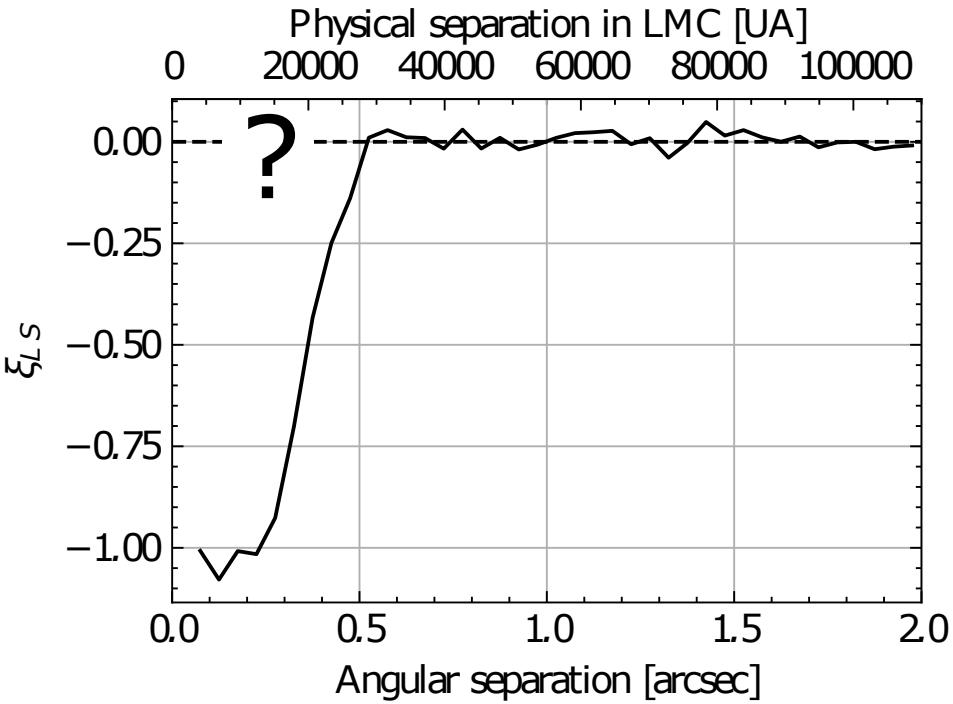

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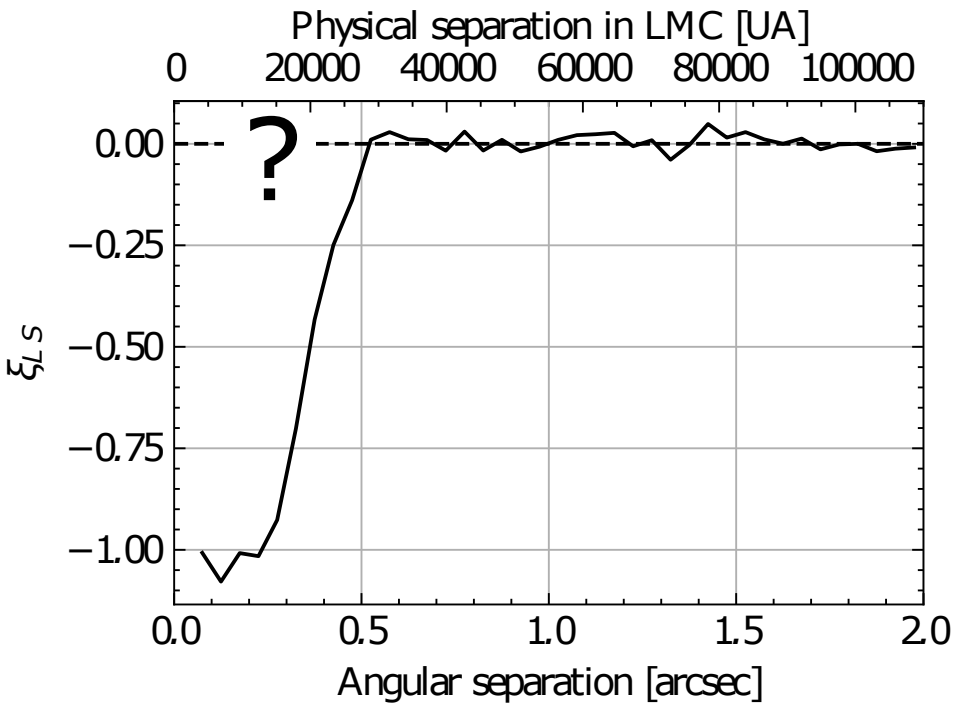

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- $R_E <$ separation $<$ 25000 UA :

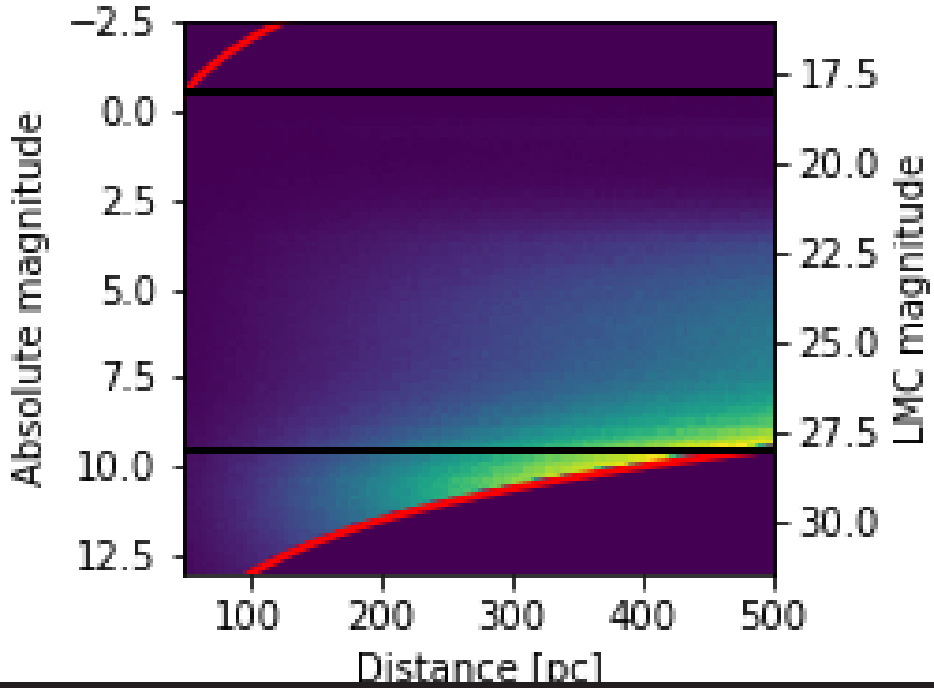
  uniform or clustered ?

Use of *Gaia* EDR3

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

We use *Gaia* EDR3 to study nearby stellar clustering ($\rightarrow$ 3D data), and we extrapolate the results to the LMC (50 kpc).

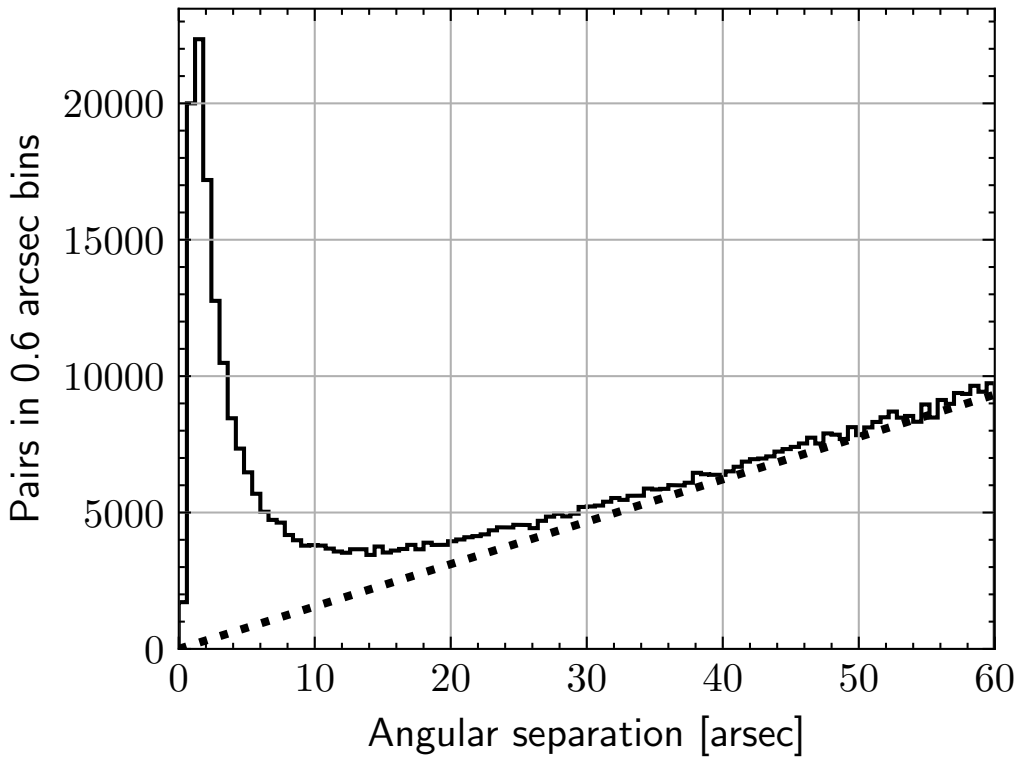
- between 50 and 500 pc, parallax relative error $< 20\%$
- absolute magnitude interval, in *Gaia* completeness domain
- 20° outside the galactic plane



Red lines : *Gaia* completeness range.
Black lines : selected range.

First remarks

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



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

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

Minimal separation in *Gaia* EDR3

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

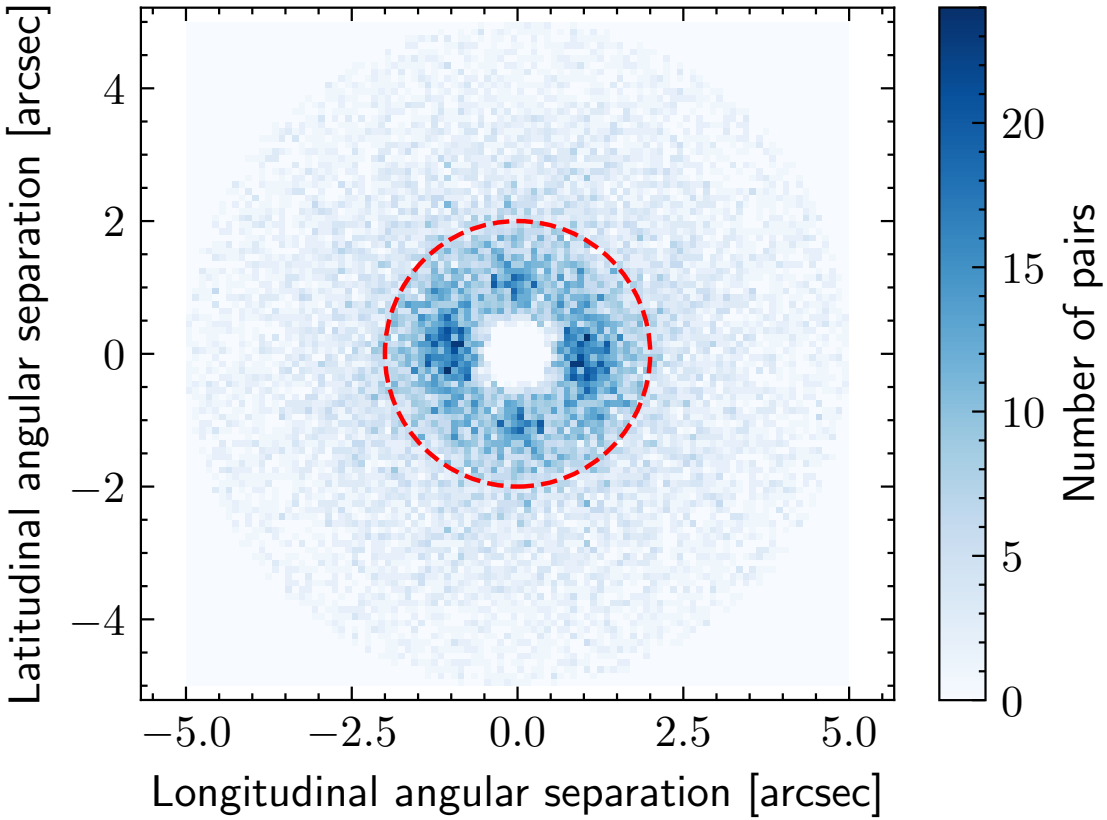
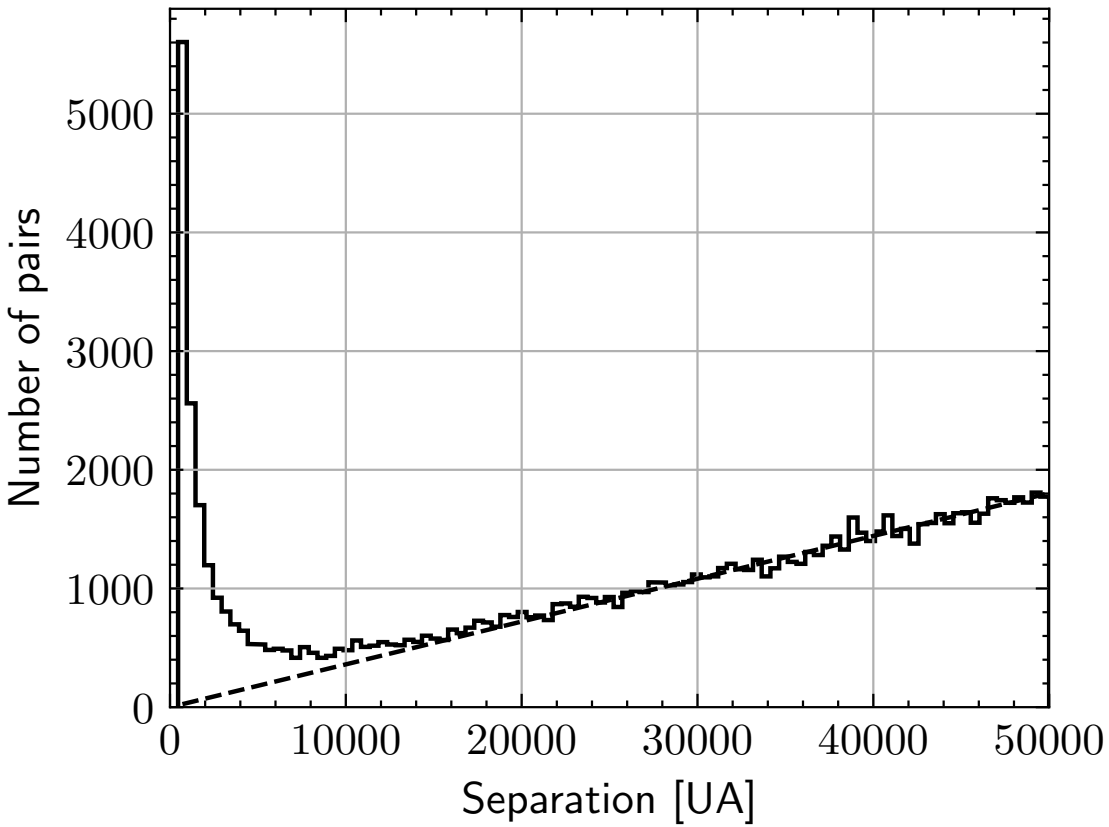


Figure: Angular separation 2D distribution along ecliptic longitudinal and latitudinal axis, red circle has 2 arcsec radius.

Stellar binarity rate estimation

- Divide the sample in radial distance shells, and for each :
  - Count pairs by physical separation (in AU)



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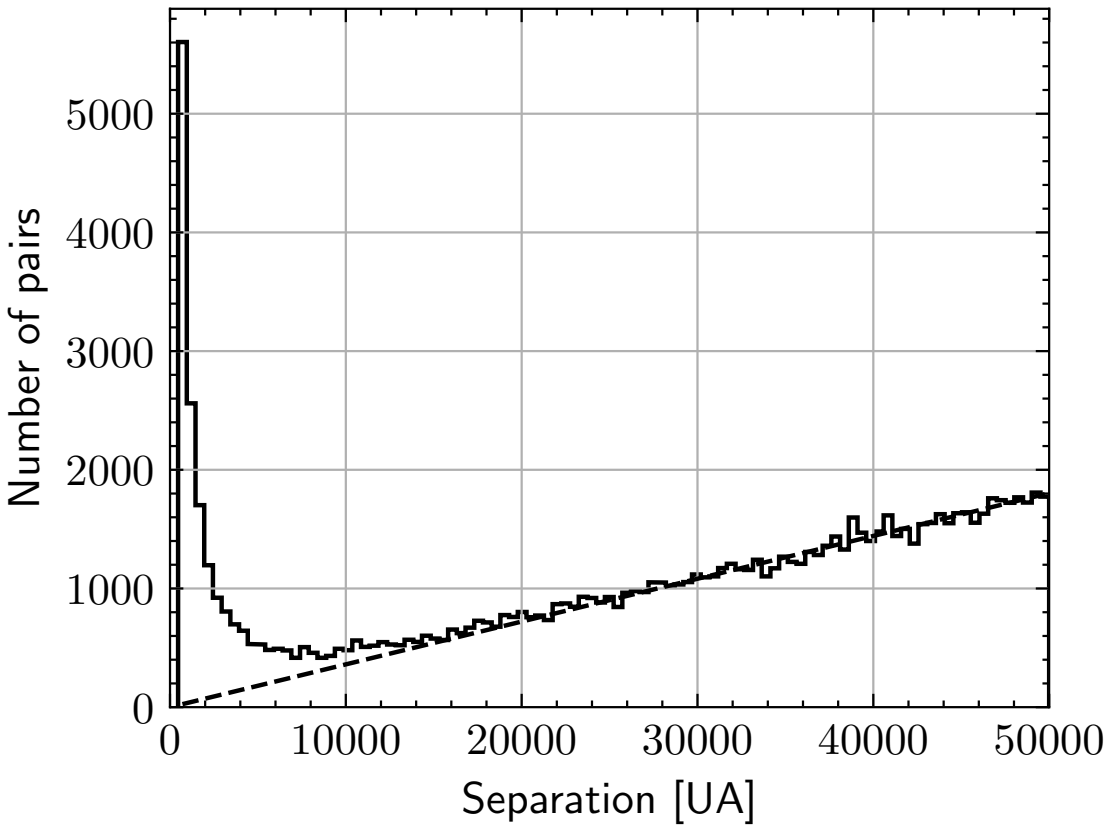

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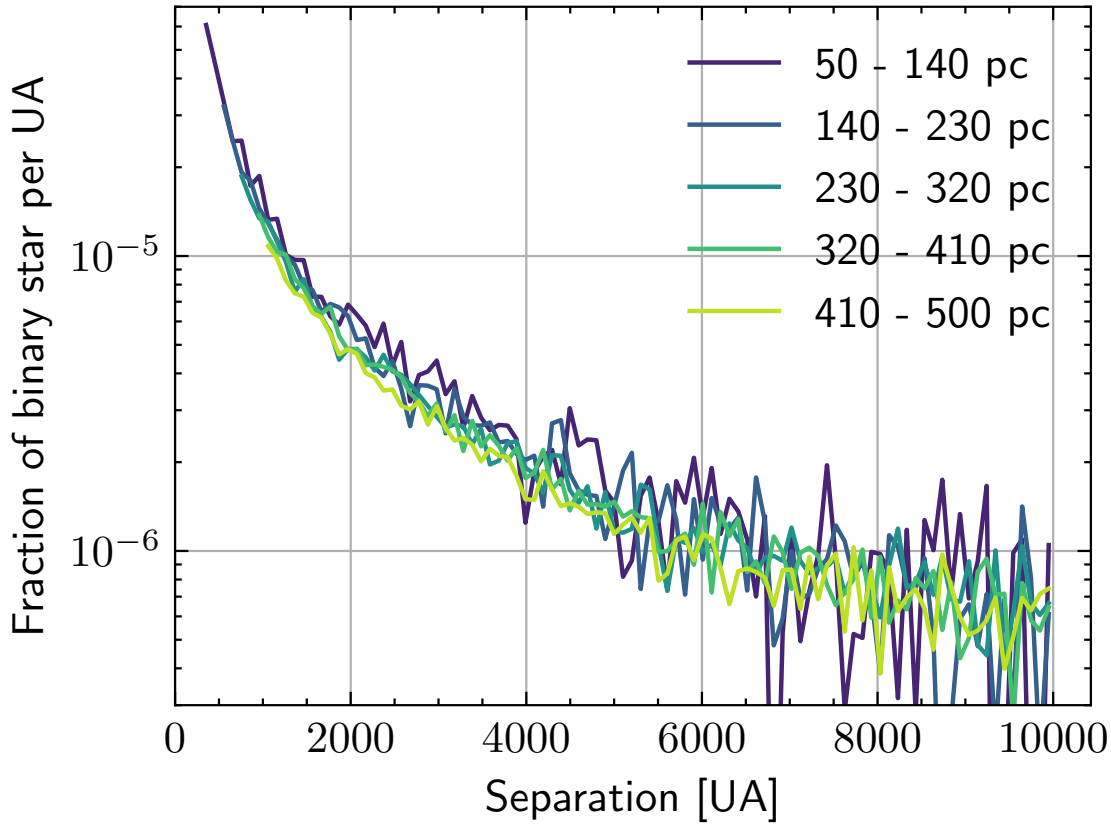
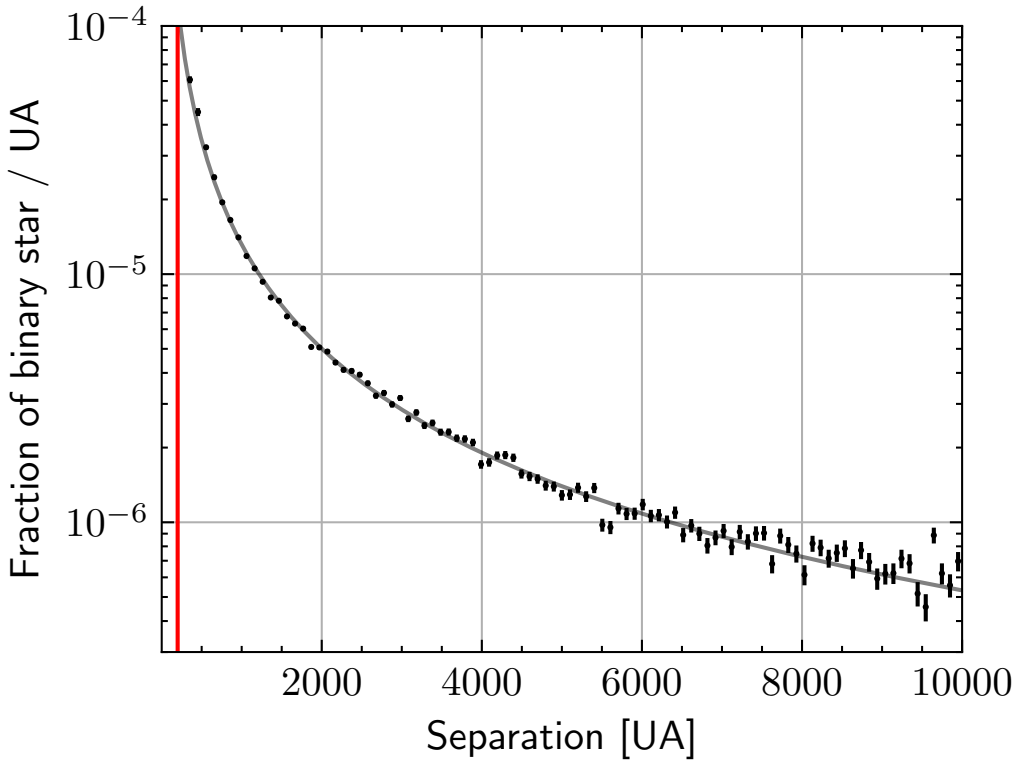
  - Subtract random coincidences contribution
  - Normalize to number of stars in shell



Stellar binarity rate estimation

We fit a power-law function to the weighted mean.



Integrate between R_E (200 AU) and 25000 AU.

Stellar binarity rate (sep $>$ 200 AU)

$$f_{BS}(200AU) = 2.75\% \pm 0.04 \text{ (stat)}$$

Discussion & Conclusion

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

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- Stellar binarity rate (for separation $>$ 200 AU) : $\sim$ 2.75% (assuming validity of extrapolation from neihgbourhood to LMC)
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Thanks for your attention.

Backup

Parallax relative errors

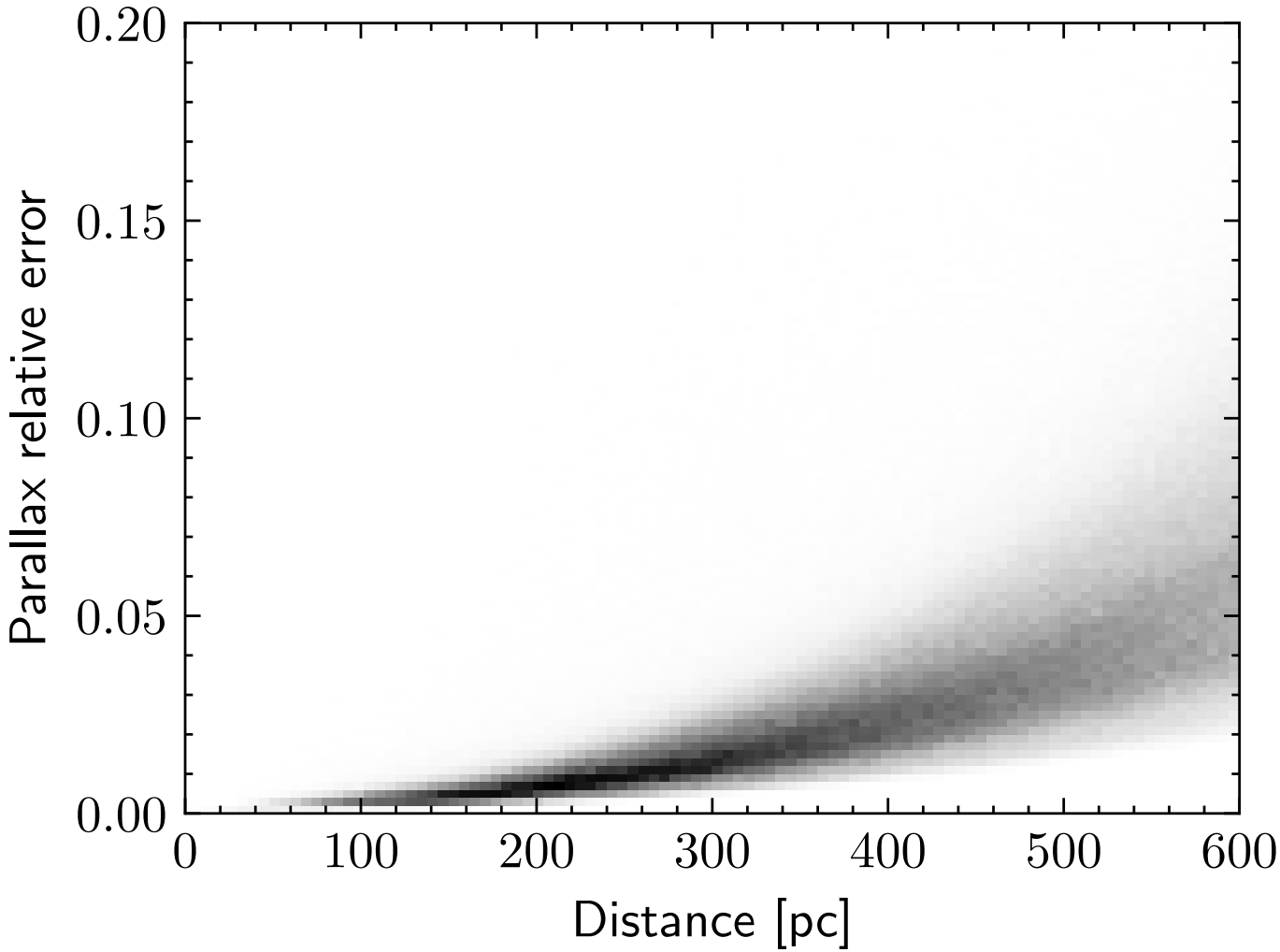

Figure: Caption

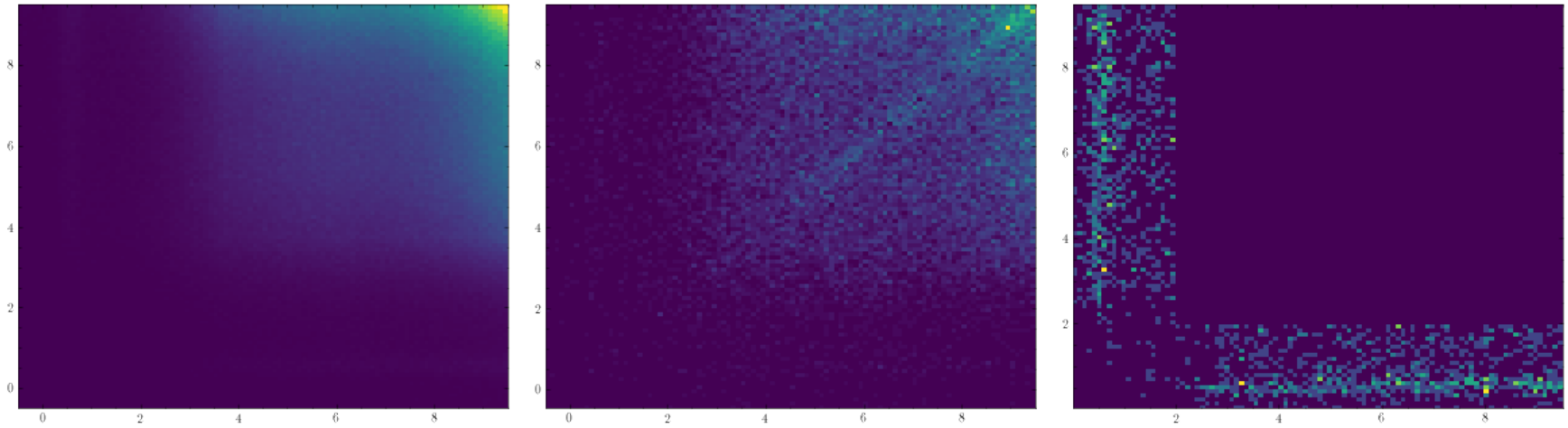

Figure: Left : accidental pairs; Center : binary stars; Right: Red clump binary stars

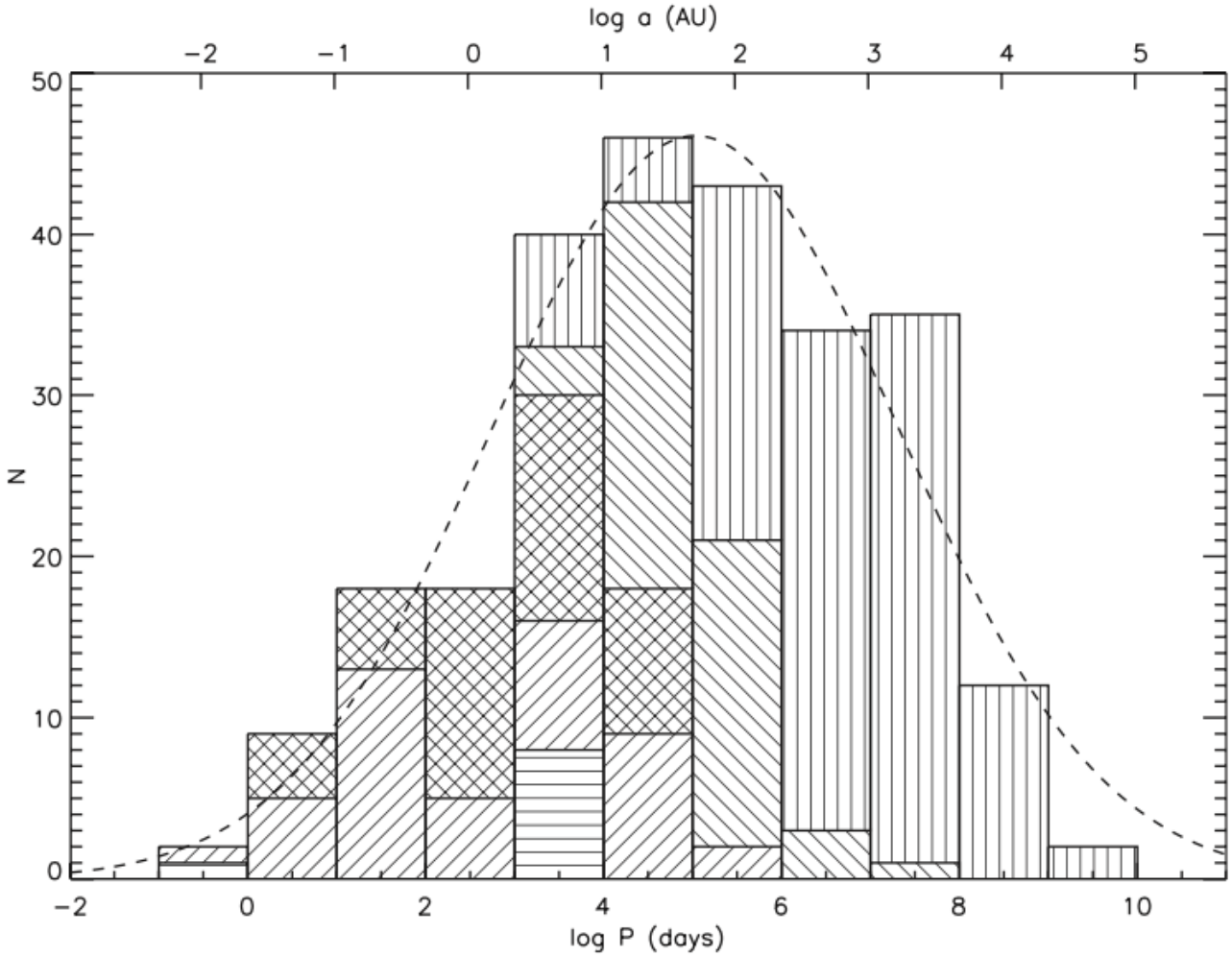

Figure: From Raghavan et al. 2010