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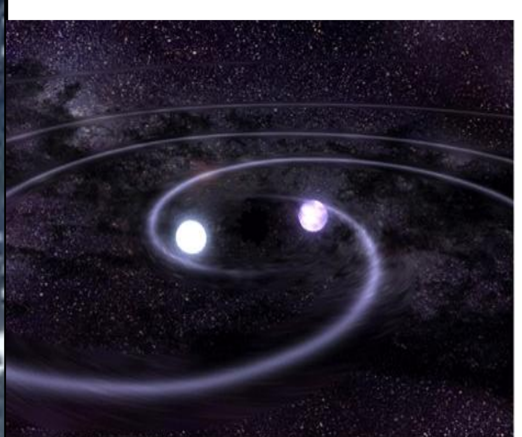
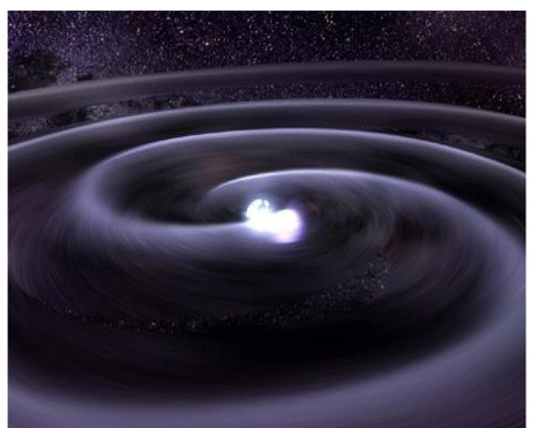
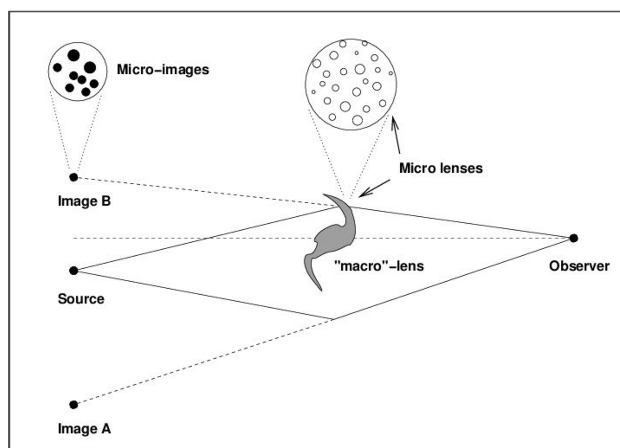
Abundance of LIGO/Virgo Black Holes from Quasar Microlensing

INTRODUCTION

- The nature of the dark matter (DM) still constitutes a jigsaw piece.
- After some unusual black hole mergers (BBH) detected by the LIGO/Virgo Gravitational Wave (GW) experiments, new astrophysical compact objects as the Primordial Black Holes (PBHs) were reconsidered again.
- The microlensing in quasars allows to distinguish between different objects (characterized by their mass and abundance) in the lens galaxies.
- Could a significant population of PBHs of intermediate mass be hidden within the stars and be a promising DM candidate?

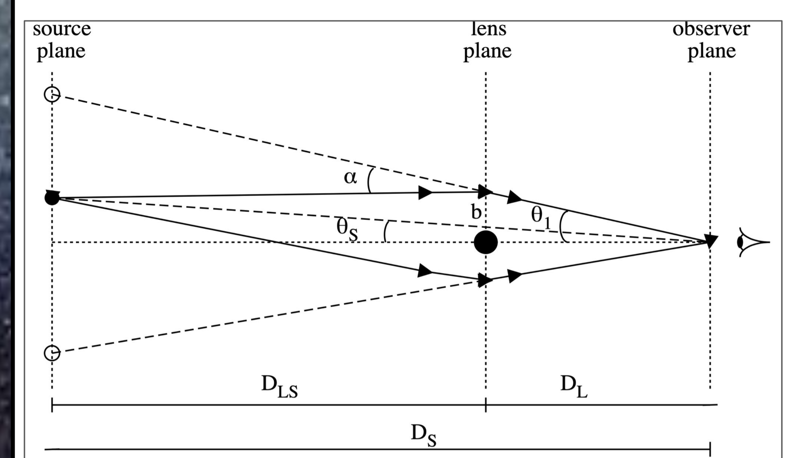


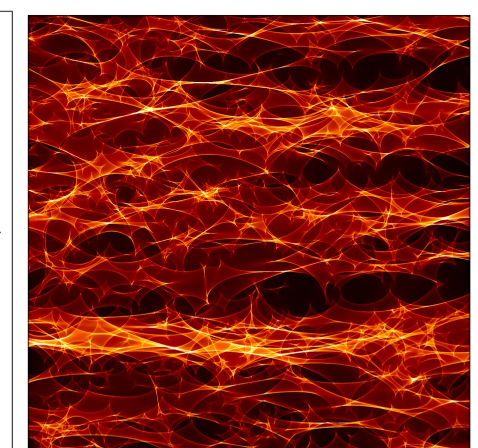


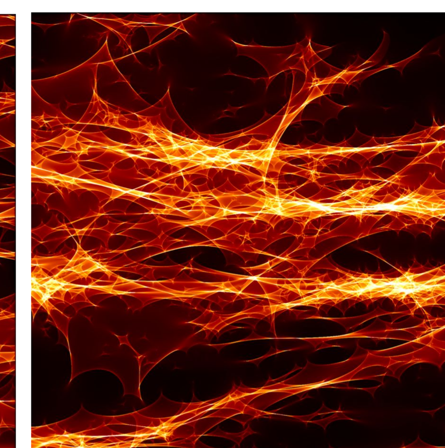


METHODOLOGY

- With the Inverse Polygon Mapping algorithm (IPM; Mediavilla et al 2011, 2016) we compute microlensing magnification maps, considering the mass fraction between each compact object (single vs. bimodal distribution).
- Gravitational microlensing measurements of optical magnitudes (easily transformed to magnifications) are our references to compare the simulations (Pooley et al. 2007).
- We calculate the Probability Density Functions (PDFs) and use a Bayesian statistical method to obtain the final abundances.





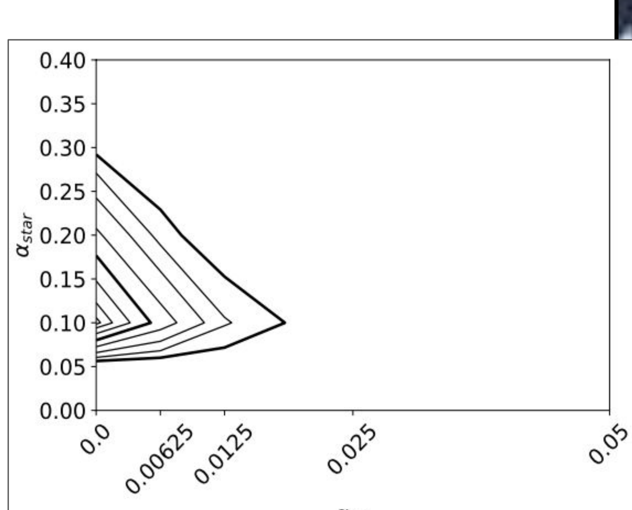


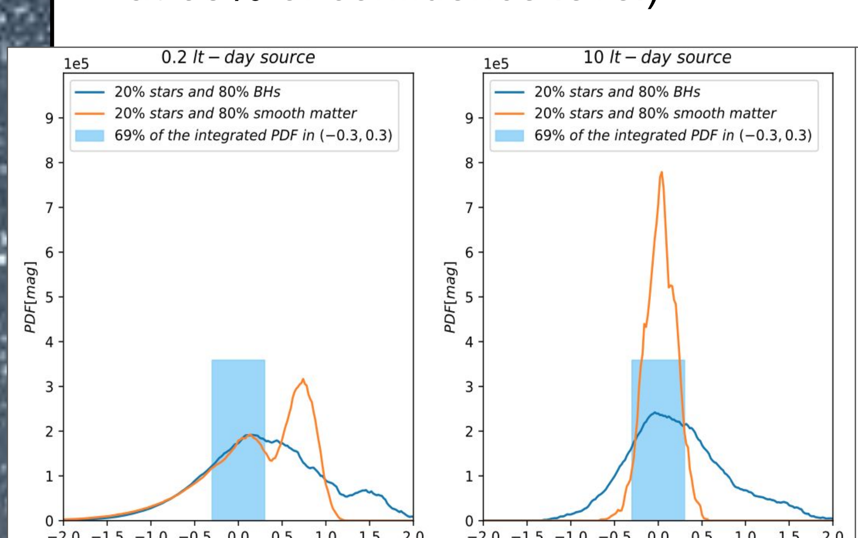
RESULTS

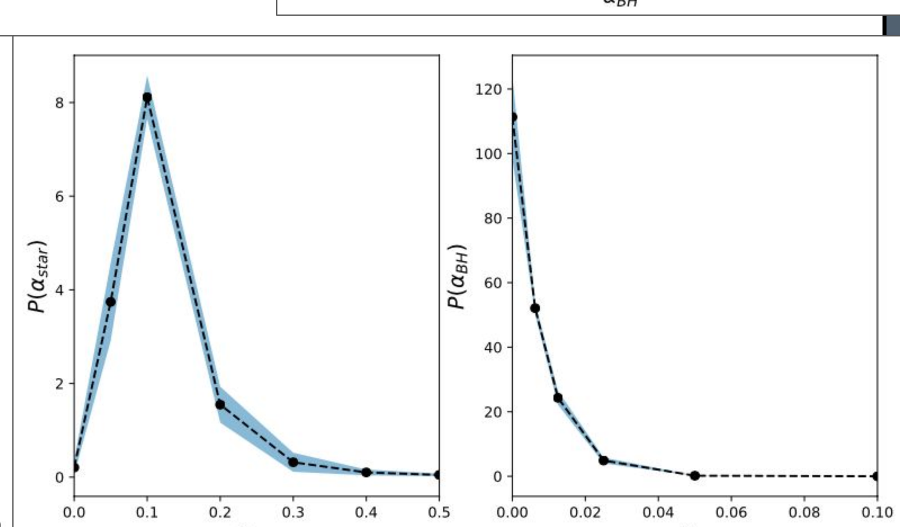
- In Fig. 1 (left) we show the histograms for an infinitesimal and a finite-size source (0.2 vs. 10 lt-day). Variations in the fraction of stars-BHs-smooth matter and the respective comparison with the optical data (blue shadowed region) reveals a clear change in the shape of the expected abundance.
- A more general scenario varying the abundances for stars+BHs+smooth matter, as well as covering 9 pair systems of (κ,γ) is shown in Figs. 2,3:

  The 2D joint PDF presents a maximum at 10% of stars with zero contribution from the BHs.

  According to the 1D PDF, a very small fraction of BHs is expected (less than 1% of the total matter at 68% of confidence level)







CONCLUSIONS

- The importance of a finite source size is clear when we want to compare the simulations with magnitude observations. The observed statistics can only be explained if the source size is comparable to the Einstein radius of the microlenses.
- On the other hand, results of the stars/BHs abundances+smooth matter (Fig. 1) discard any evidence of a significant population of PMBHs according the observed magnifications in the optical range (*) (**).
- In the second study, we considered a mixed population of stars and BHs and the presence of a smooth dark matter component to determine the fraction of abundance of each parameter. As a result, we are able to provide a quantitative limit to the abundance of BHs or any compact object of this range of masses (Figs. 2 and 3):

  We estimate a 13% contribution from the stars (in agreement with previous works) and less than 1% from BHs with masses ~30$M_\odot$

(*) Most of the events are placed between the -0.3 and 0.3 range in optical observations (see Pooley et al. 2007). Thus, if we look at the blue curve (corresponding to stars+BHs) there should be more events in the high magnitude limit (never observed and therefore, excluded from microlensing).

(**) The 20% of the stars is not a random/convenient choice but based on several studies that confirmed this total fraction of stars in the lens galaxies. However, a deeper analysis considering different abundances for stars+BHs was also carried out in the complement study providing the same conclusions.