# The Impact of the Mass Spectrum of Lenses in Quasar Microlensing Studies. Constraints on a Mixed Population of Primordial Black Holes and Stars.

We show that quasar microlensing magnification statistics induced by a population of point microlenses distributed according to a mass-spectrum can be very well approximated by that of a single-mass, ”monochromatic”, population. When the spatial resolution (physically defined by the source size) is small as compared with the Einstein radius, the mass of the monochromatic population matches the geometric mean of the mass-spectrum. Otherwise, the best-fit mass can be larger. Taking into account the degeneracy with the geometric mean, the interpretation of quasar microlensing observations under the hypothesis of a mixed population of primordial black holes and stars, makes the existence of a significant population of massive black holes (~100M⊙) unlikely but allows, within a two-σ confidence interval, the presence of a large population (40% of the total mass) of very small black holes (~0.01M⊙).

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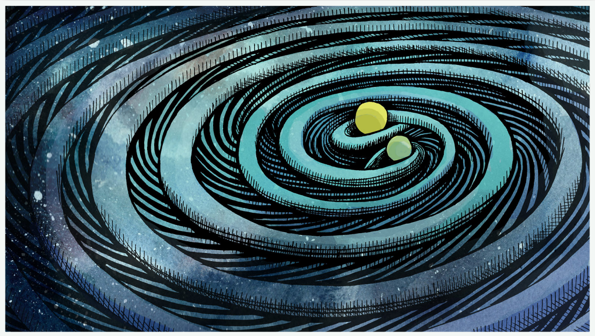
# Context

- Quasar microlensing as a useful tool to extract properties of any population of compact objects of the lens galaxy.
- Could be the PBHs a fraction of the DM?
- LIGO: recent data show unexpected BH mergers (low spin & unusual masses)
- Hypothesis already analyzed by *Mediavilla et al. 2017* but only for a single-mass population of microlenses
- May these PMBHS can be hidden within a population of compact objects (i.e. stars…)?

# Motivation & Methodology

- To investigate the role of the Geometric Mean (GM) when the PDF of a bimodal mass spectrum is approximated by the PDF of a single-mass model and to study the goodness of this approximation.

- Simulation of mock (bimodal distribution - stars+PBHs) and model (single mass distribution - stars) to obtain their PDFs and check these results with the Mediavilla et al. (2017) data. (*)

| MOCK - Bimodal Distribution | MODEL - Single Mass Distribution |
|---|---|
| $\kappa_T = \kappa_{star} + \kappa_{BH} = 0.55$<br>$\kappa_{star} = \kappa_{BH} = 0.275$ | $\kappa_T = \kappa_{smooth} + \kappa_{\bullet} = 0.55$<br>$\kappa_{\bullet} = variable$ |
| $M_{star} = 0.01$<br>$M_{BH} = variable$ | $M_{\bullet} = variable$ |

(*) Mass ratios are $M_{BH}/M_{star}$= 6.25,12.5,25,50,100 with $M_{star}$=0.01 in our scale ($30M_{\odot}$ = 1). $M_{\bullet}$ goes from 0.01 to 0.2.

# Results

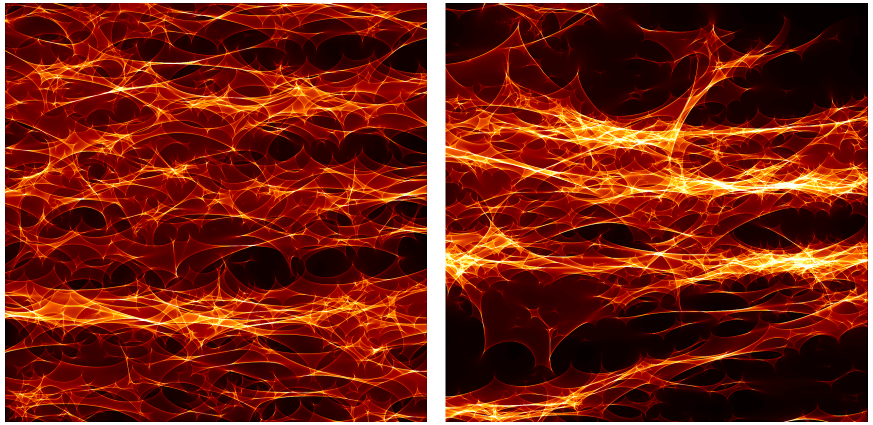


**Fig 1.** Magnification maps for model (left) and mock (right)

Figure 1 clearly shows two types of structures, one (left) of small scale length corresponding to the stars contribution and other (right) of large scale associated to the stars+BHs contribution. This last one is generated by the network of PBHs.

Figure 2 shows the results for the case of $\kappa = 0.55$ and $\gamma = 0$. Each row represents each of the 5 different mocks.

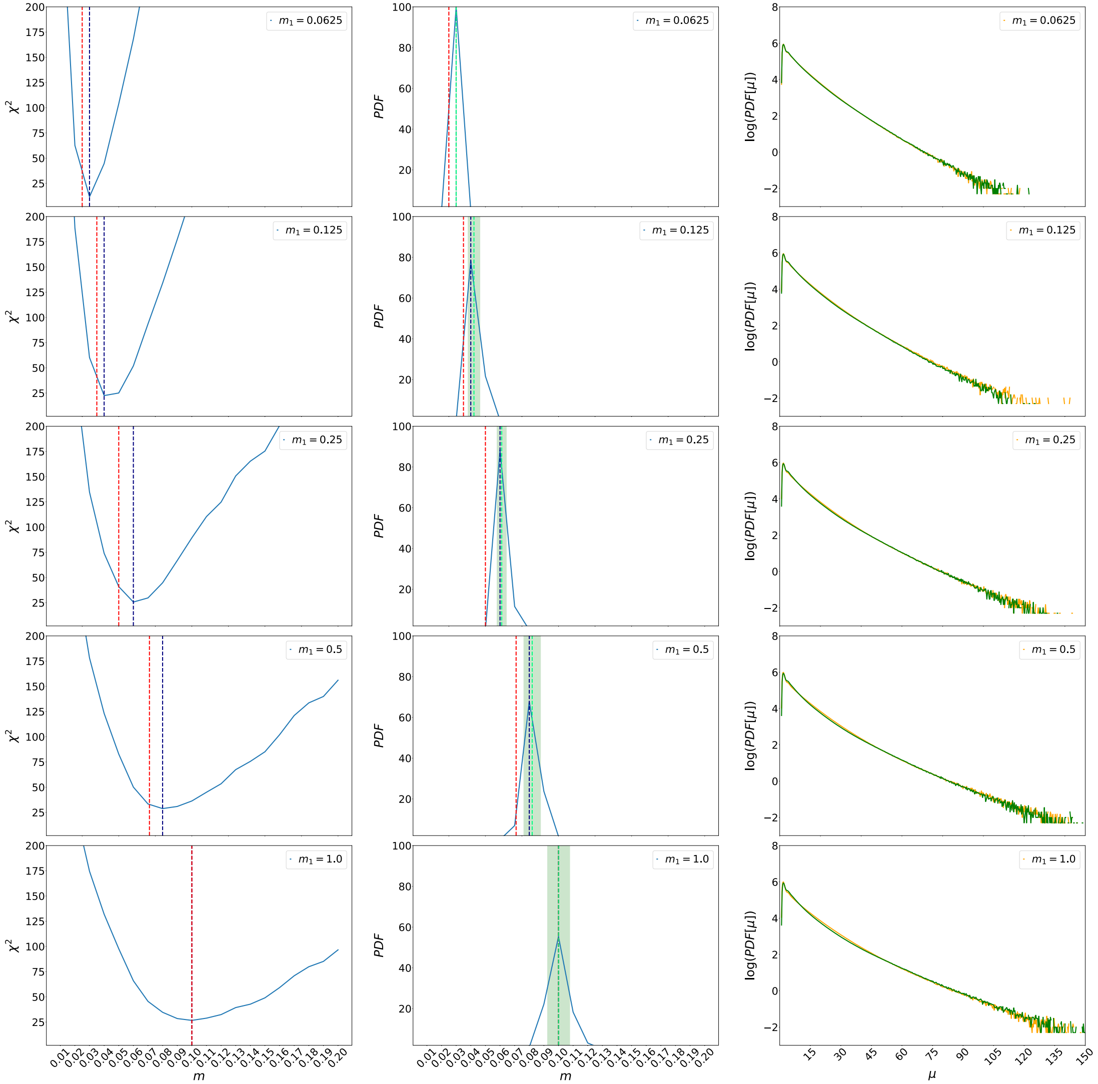
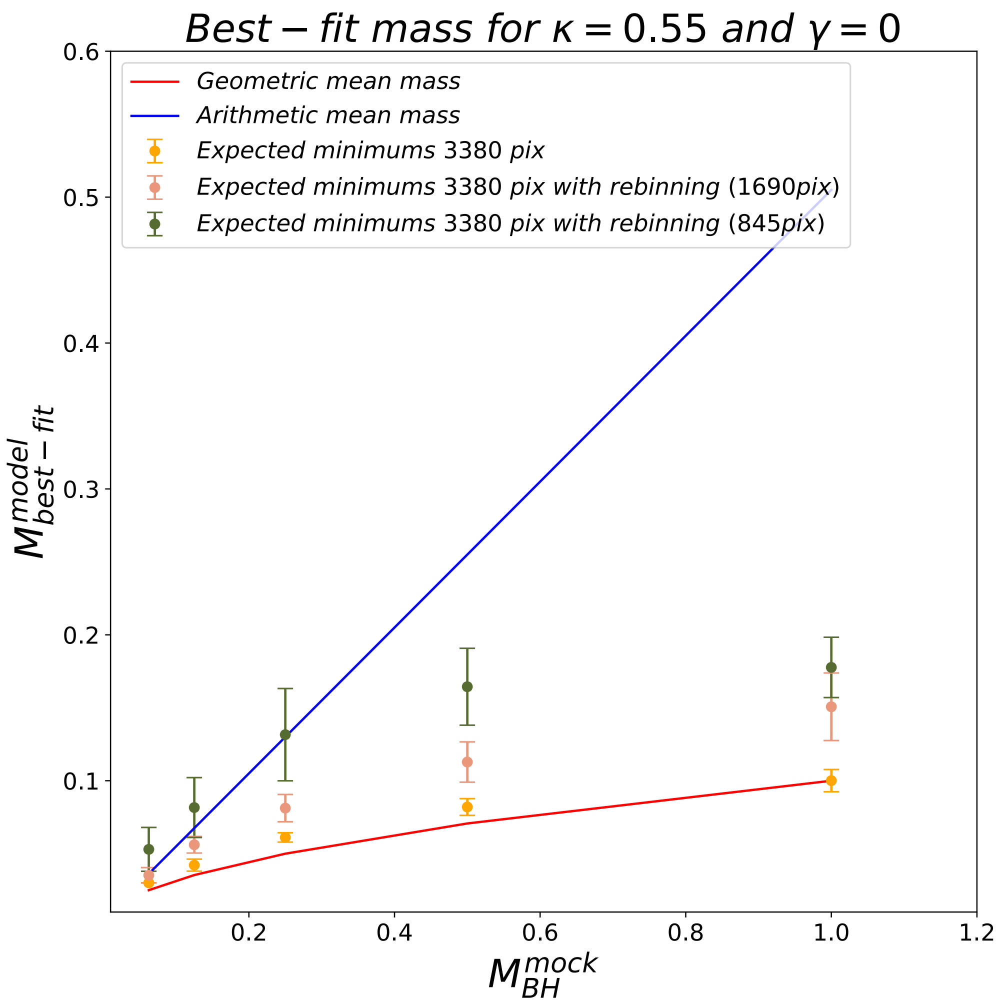
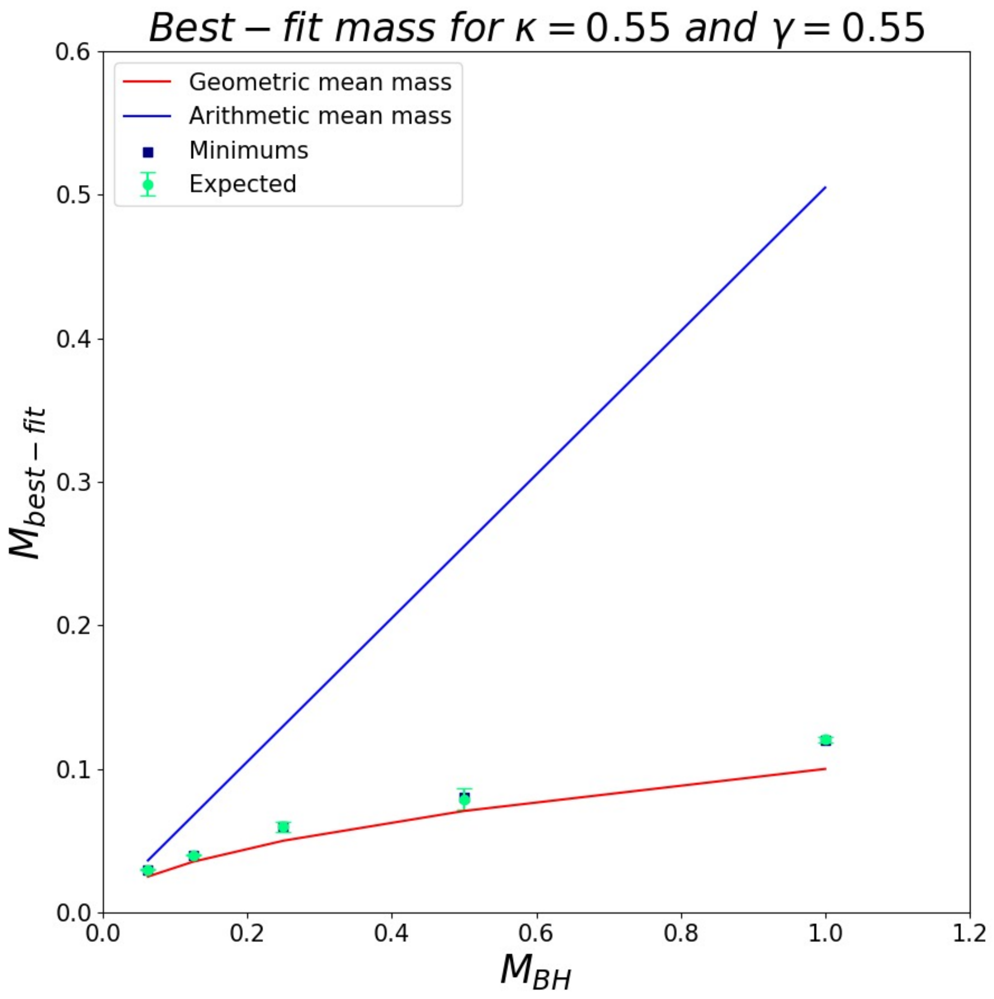



**Fig 2.** Left column: $\chi^2$. Middle: PDFs inferred from $\chi^2$. Right: mock (yellow) and model best-fit (green) histograms.




**Figs 3 and 4.** Best-fit mass versus BH mass. Left panel: case $\kappa = 0.55;\ \gamma = 0$ and three different resolutions. Right panel: case $\kappa = 0.55;\ \gamma = 0.55$ and for 3380x3380 pixels resolution. The best-fit mass matches the GM if pixel size is small as compared with the Einstein radius.

# Impact & Future Perspectives

- We conclude that the best-fit mass approaches the GM if the pixel size is much smaller than the Einstein Radius. On the contrary, if the pixel size is large enough the best-fit mass will take values above the GM.

- Intermediate mass PBHs are not expected, even when a mix of stars and PBHs is considered, according to our results (GM is far away from Mediavilla et al. 2017 measurements). However, the case for substellar mass PBHs is not discarded by microlensing observations at a 2-$\sigma$ confidence level.

- Finally, it is important to improve the study considering the contribution of a smooth matter component to the total convergence parameter ($\kappa$) to take into account the washing out of the imprints of the smaller component of the mixed population (stars or substellar PBHs) in the magnification maps.