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# THE IMPACT OF THE MASS SPECTRUM OF LENSES IN QUASAR MICROLENSING STUDIES.

# CONSTRAINTS ON A MIXED POPULATION OF PMBHS AND STARS.

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TIME-DOMAIN COSMOLOGY WITH STRONG GRAVITATIONAL LENSING
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# The Impact of the Mass Spectrum of Lenses in Quasar Microlensing Studies. Constraints on a Mixed Population of Primordial Black Holes and Stars

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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 compared with the Einstein radius, the mass of the monochromatic population matches the geometric mean (GM) of the mass spectrum. Otherwise, the best-fit mass can be larger. Taking into account the degeneracy with the GM, 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 intermediate mass black holes ($\sim 100 M_{\odot}$) unlikely but allows, within a $2\sigma$ confidence interval, the presence of a large population ($\gtrsim 40\%$ of the total mass) of substellar black holes ($\sim 0.01 M_{\odot}$).

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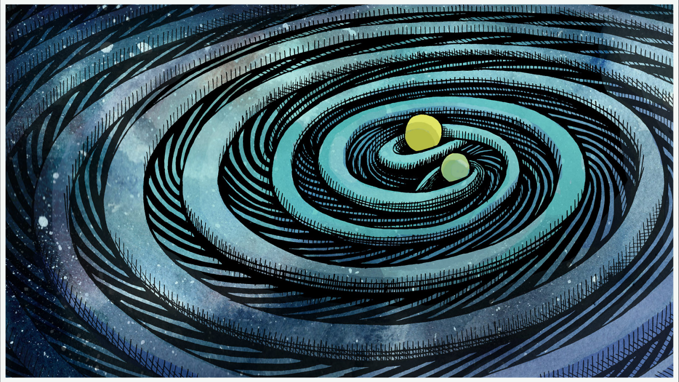
# Introduction: PMBHs as DM?



- Quasar microlensing as a tool to extract properties of any population of compact objects in the lens galaxy.
- Does the Primordial Massive Black Holes (PMBHs) constitute a fraction of the Dark Matter (DM)?
- *LIGO:* recent data show unexpected BH mergers with low spin and unusual masses
- Could these PMBHS be hidden within a population of compact objects in the lens galaxies (i.e. stars…)?

# Motivation

- To study the goodness when the PDF of a bimodal mass spectrum is approximated by the PDF of a single-mass mode.

# Methodology

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

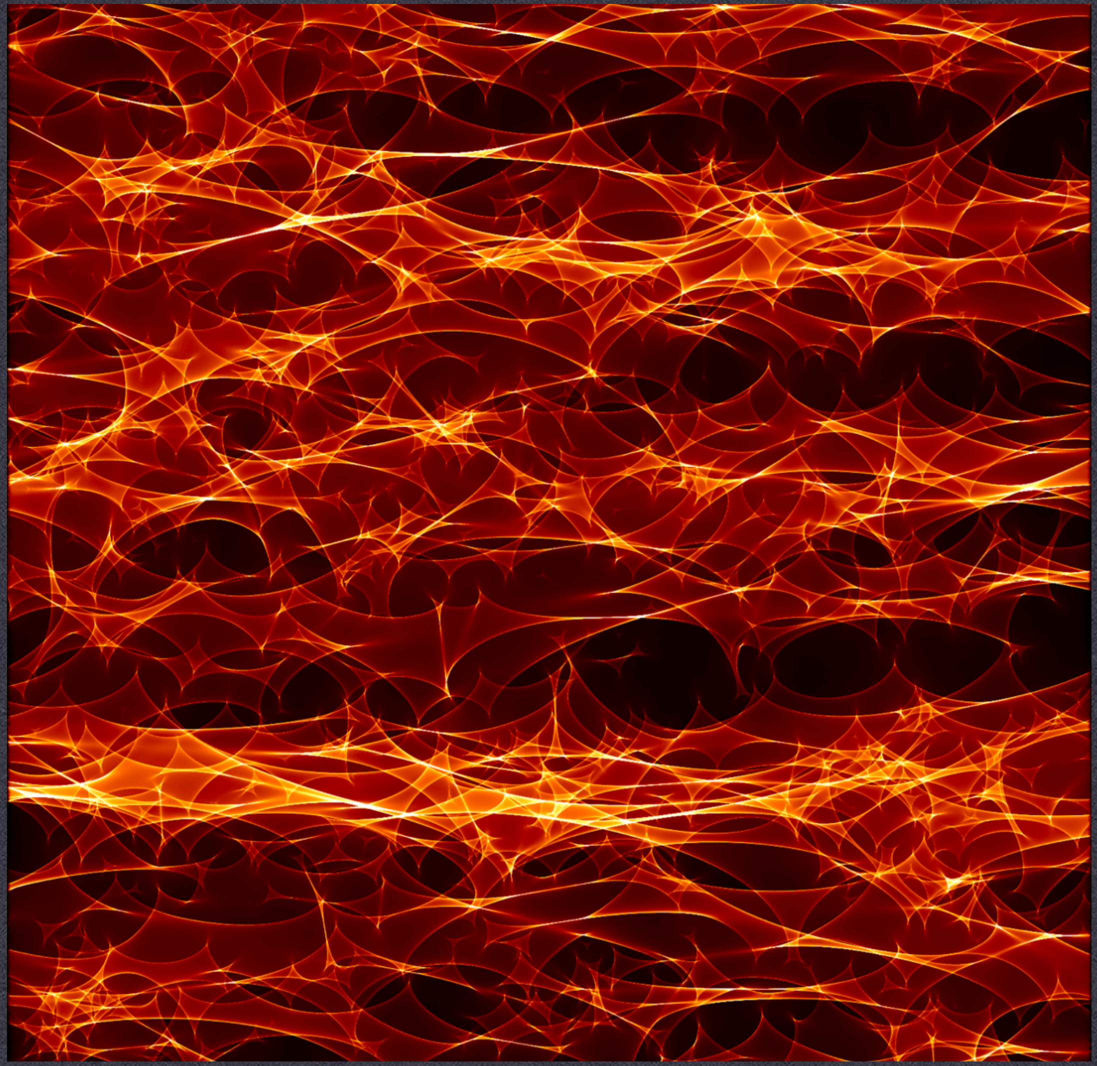
# Mocks and Models

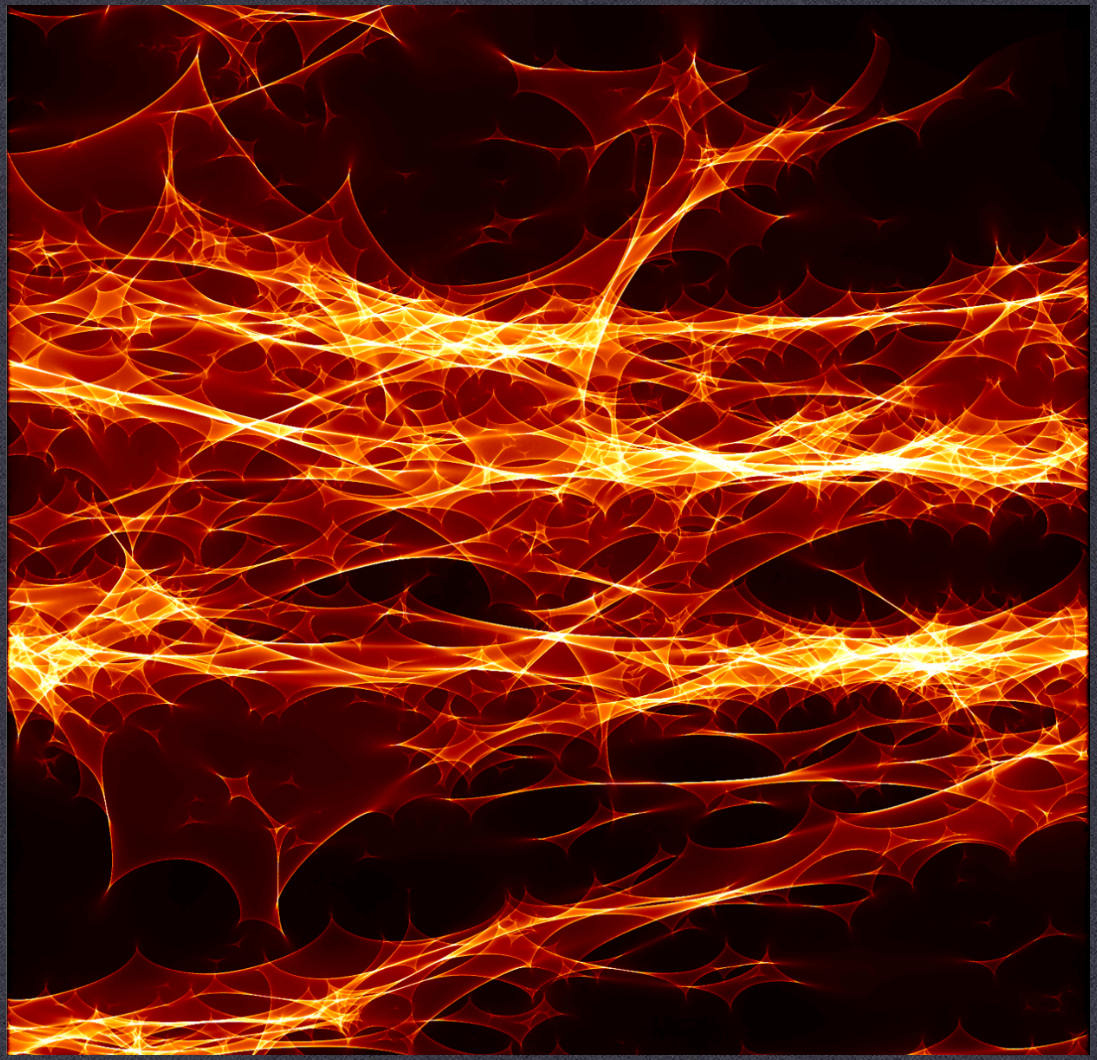
| MOCK - Bimodal Distribution | MODEL - Single Mass Distribution |
|---|---|
| $\kappa_T = \kappa_{star} + \kappa_{BH} = 0.55$<br>$\kappa_{star} = \kappa_{BH} = 0.275$ | $\kappa_T = \kappa_{smooth} + \kappa_\bullet = 0.55$<br>$\kappa_\bullet = variable$ |
| $M_{BH} = variable$<br>$M_{star} = 0.01$ |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

- $M_{BH} = \{0.0625, 0.125, 0.25, 0.5, 1.0\}$ for the mock distribution (*)
- $\kappa_\bullet = \{0.20 \ldots 0.55\}$ ; $M_\bullet = \{0.01 \ldots 0.2\}$ for the model distribution

(*) We set $30 M_\odot$ = 1 in our scale

# Magnification maps





*Model* *Vs.* *Mock*

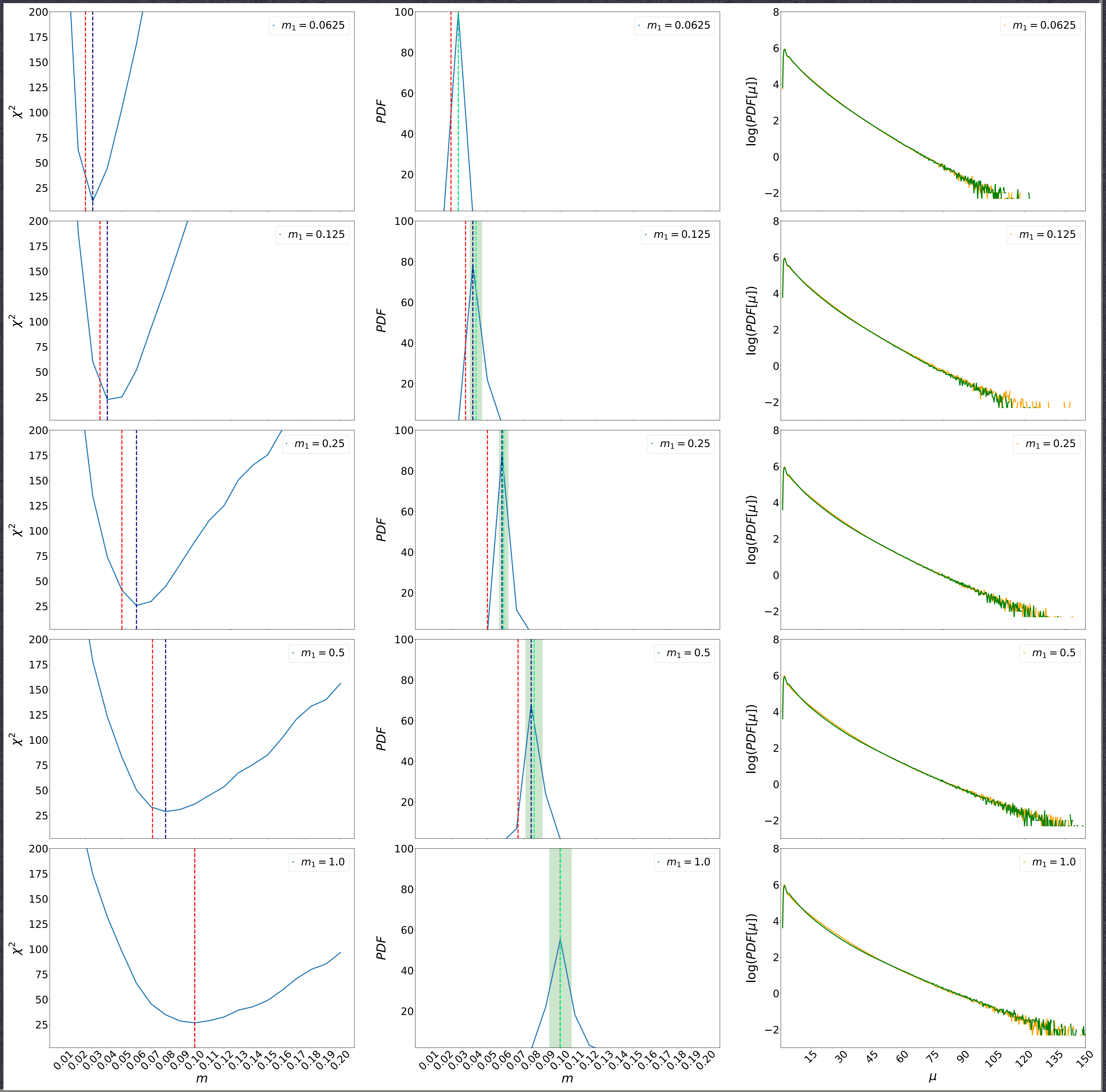
# Results

- *From top to bottom:*

BH masses from $m_1 = 0.0625$ to $m_1 = 1$

- *From left to right:*

1. $\chi^2$ with the Geometric Mean (GM) marked in red
2. PDFs inferred from $\chi^2$ with $\pm 1\sigma$ of interval in green.
3. Histograms of mock (yellow) and best-fit model (green)



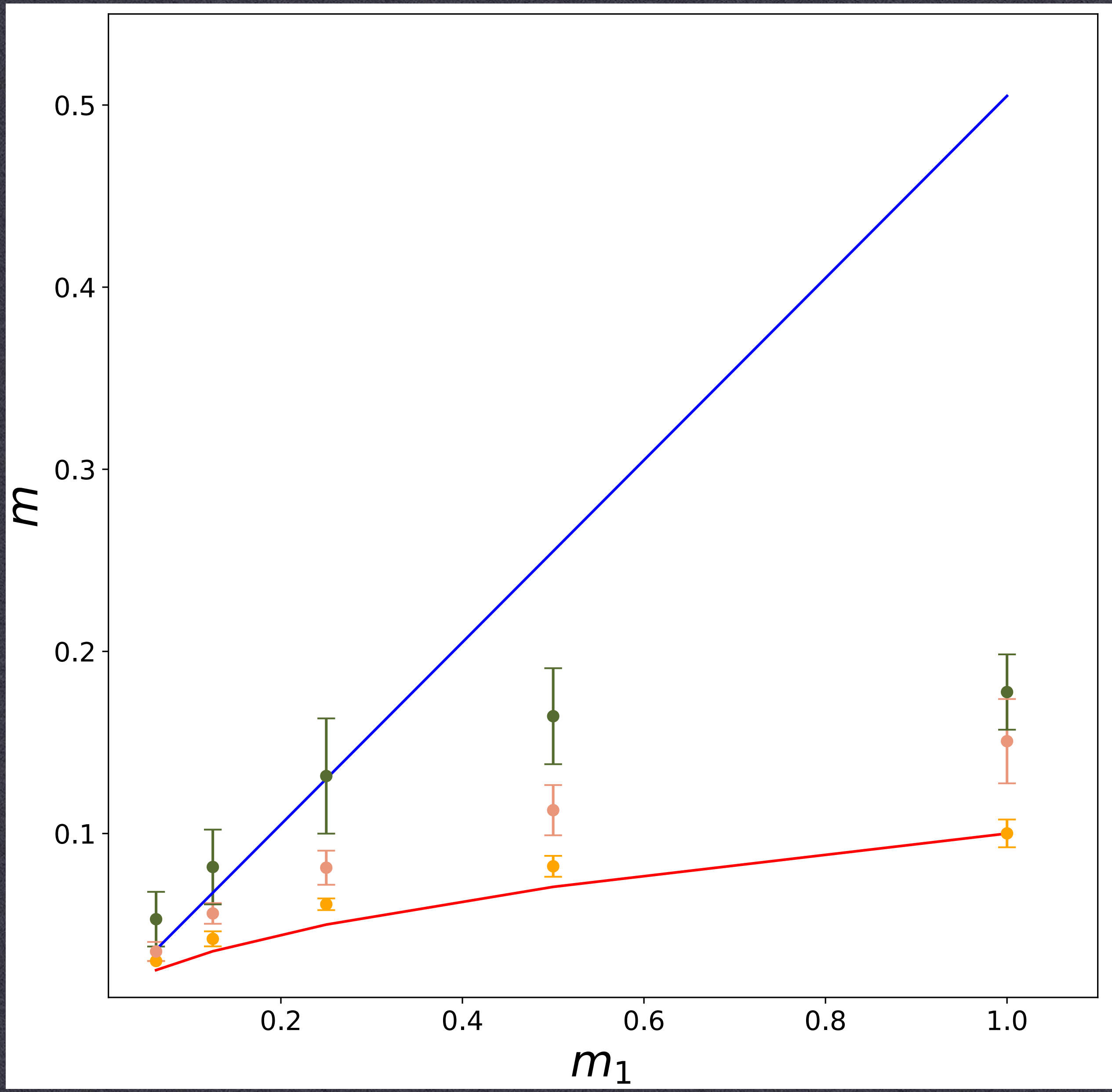
# Best-fit masses. Left: 3 different resolutions. Right: 3380x3380pix

$$M_{geom} = \sqrt{M_{BH} \cdot M_{star}}$$ (red line)

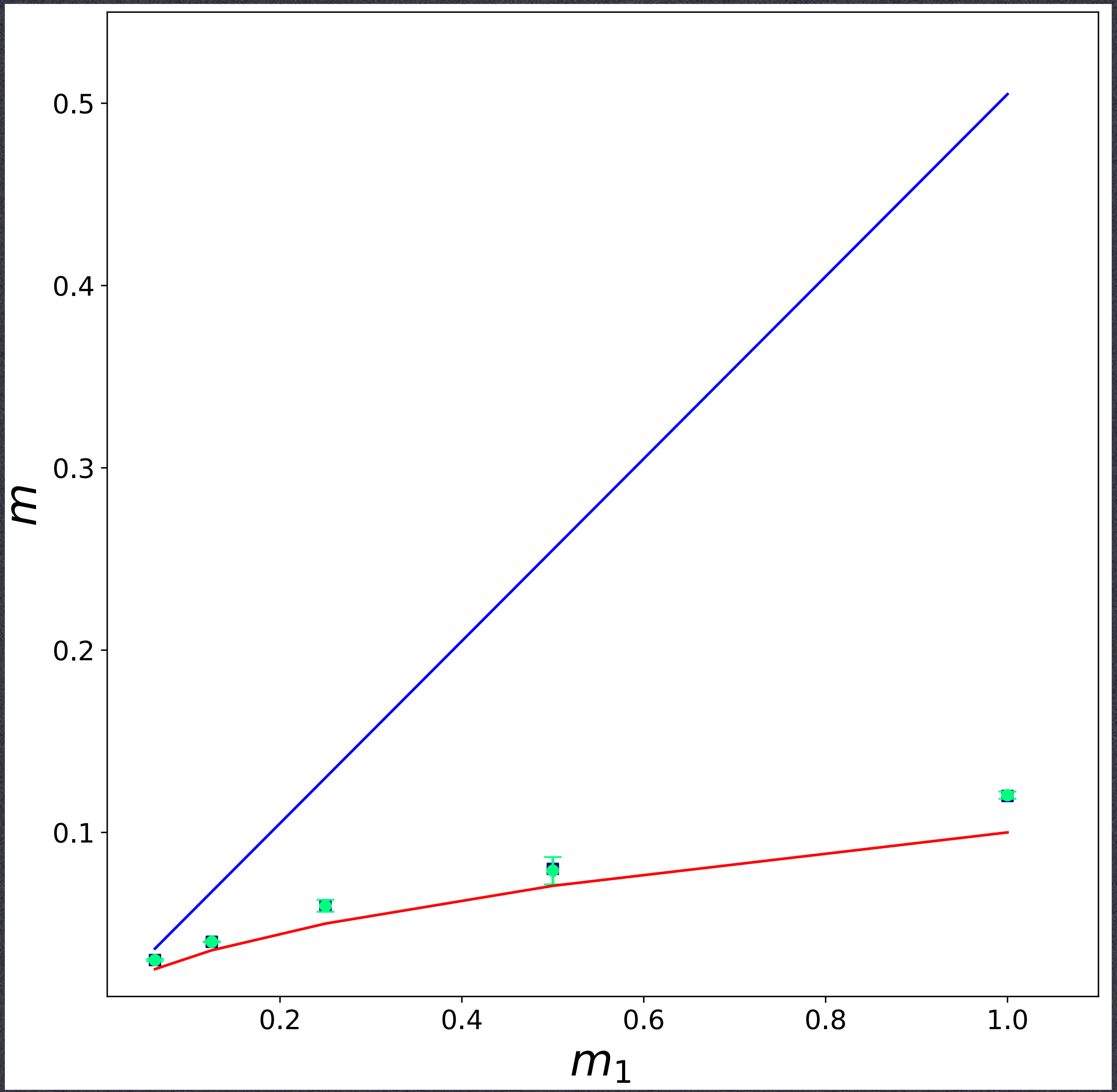
vs.

$$M_{arith} = 0.5 \cdot (M_{BH} + M_{star})$$ (blue line)

$\kappa = 0.55; \ \gamma = 0$




$\kappa = \gamma = 0.55$



# Conclusions

- A single-mass distribution can approximate very well the properties of a bi-modal distribution in the mass-ratio range studied (from 6.25 to 100) and convergence (k=0.55)

- The best-fit mass of the bimodal distribution is closer to the GM rather than the AM. However, if the pixel size is large enough (lower resolutions) the best-fit mass will take values above the GM.

- Mediavilla et. al. (2017) demonstrated that $M_{best-fit} \sim 0.17 M_{\odot}$, that is, 0.006 in our scale. As we have obtained from our comparison between PDFs, the best-fit single mass is basically the geometric mean and then,

$$M_{BH} \leq \frac{(0.17)^2 \cdot M_{\odot}}{M_{*}/M_{\odot}} \leq 0.096 M_{\odot} \text{ , for a } M_{*} = 0.3 M_{\odot}$$

no significant population of PMBHs is expected in this mass range.

- However, a significant contribution from very small BHs can not be discarded, although simulations including a smooth mass component are needed to have a clearer picture.

# THANKS FOR YOUR ATTENTION !