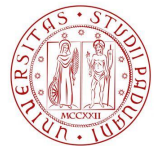


Primordial Black Holes in globular clusters

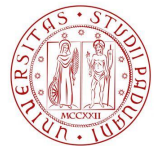
Nicola Bellomo
University of Padova
GraSP 23/10/2024



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What are Primordial Black Holes (PBH)?

- BHs that formed in the radiation-dominated era, before BBN.



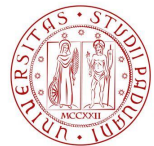
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DISCLAIMER:

The purpose of this talk
is not to advocate pro
or against PBHs!



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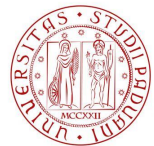


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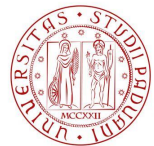


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- $f_{\text{PBH}}(1 \text{ PBH per Universe})$ link to Beyond SM Physics.



(A possible) PBH formation scenario

Kalaja, Bellomo+, 1908.03596

Mechanism: gravitational collapse of a order unity perturbation during the radiation dominated era.

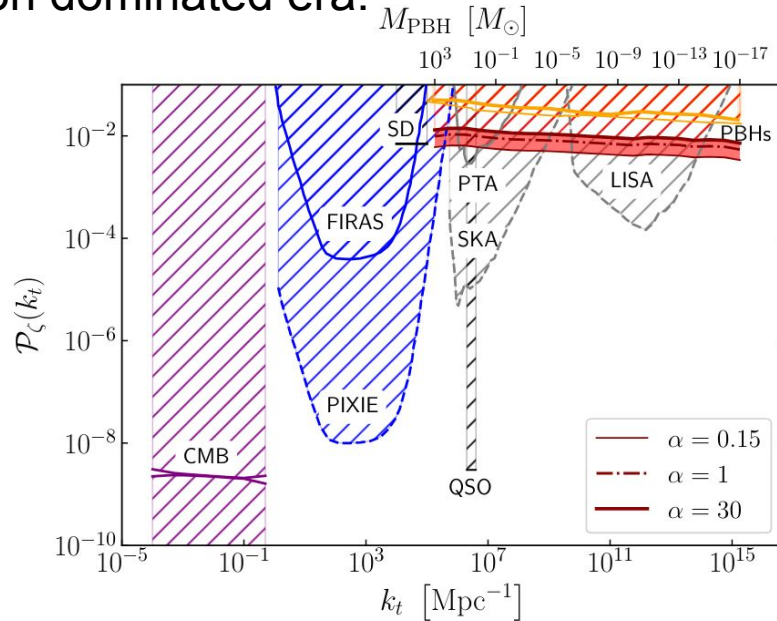


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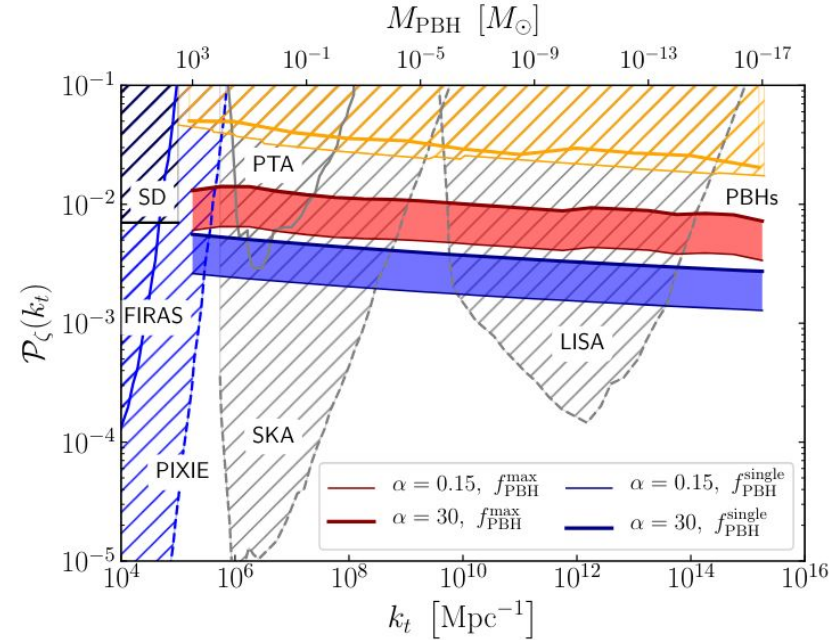
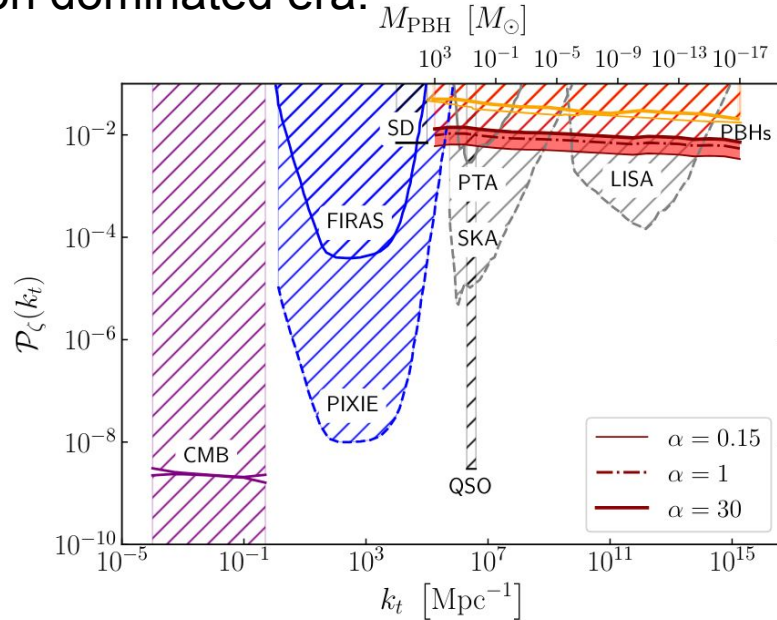
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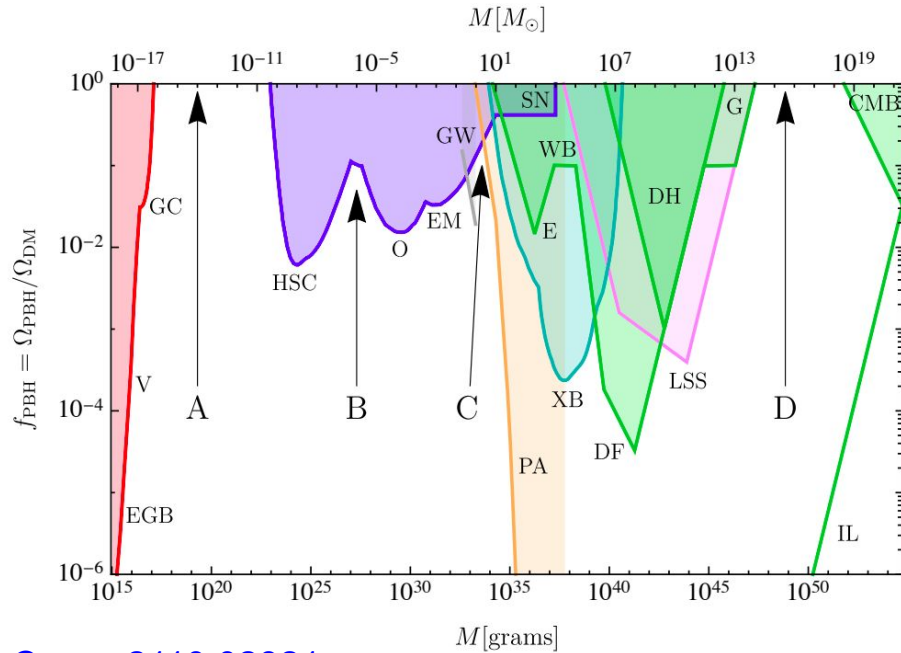
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PBH abundance constraints



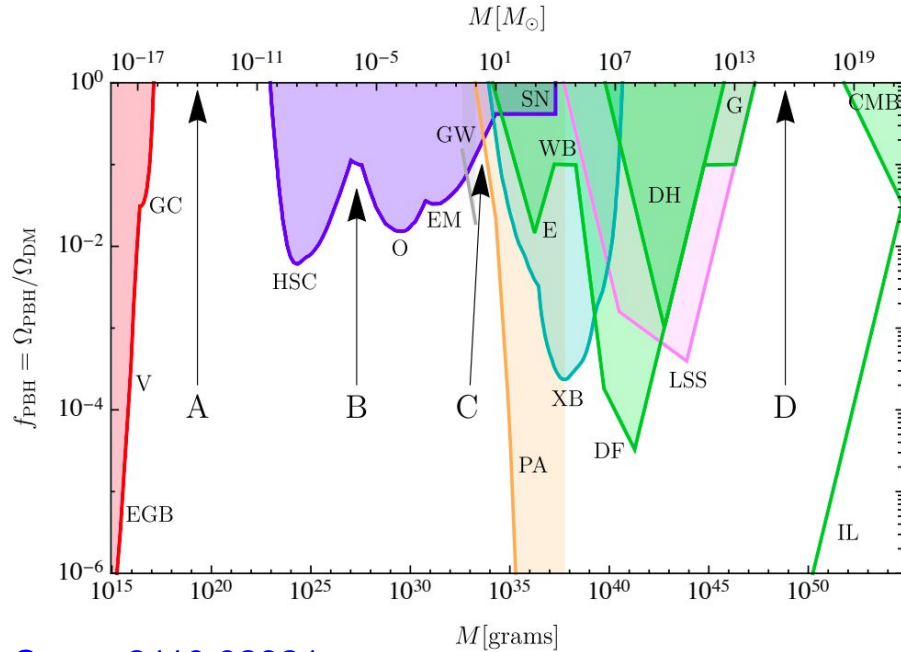
Carr+, 2110.02821

Rich phenomenology:

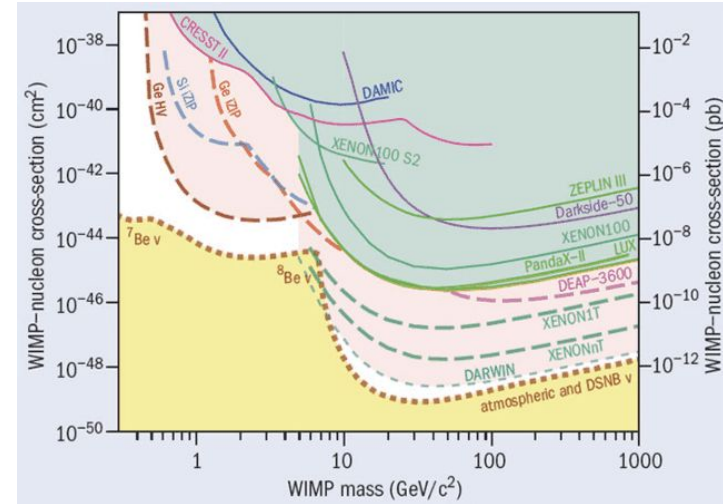
- Dynamical effects;
- Lensing effects;
- Accretion effects;
- Effects on Large Scale Structure.



PBH abundance constraints



\neq

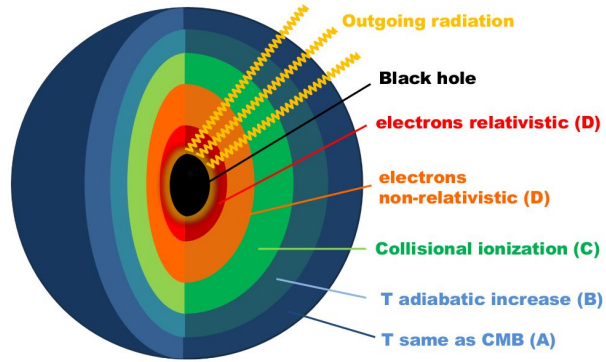


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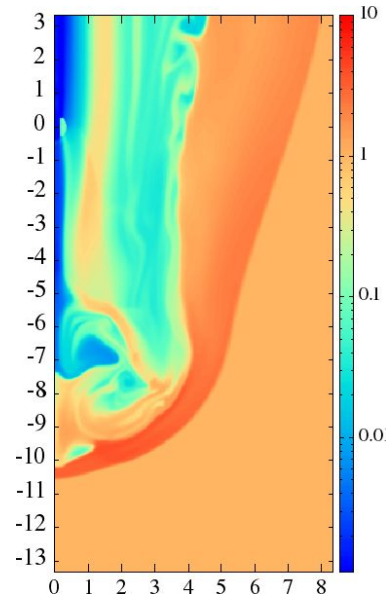
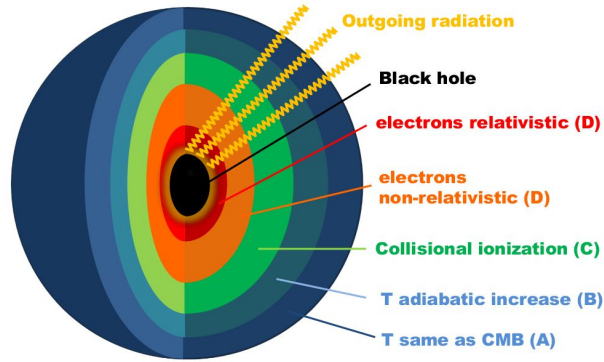


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Comparing models of BH accretion Physics



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What is the impact of outflows on PBH abundance constraints?

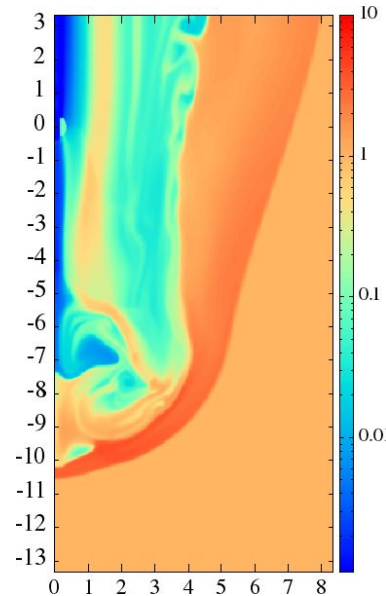
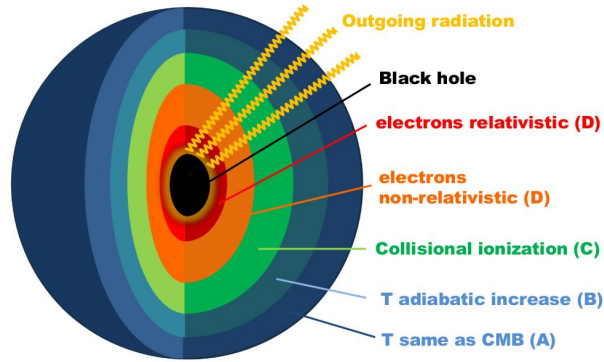
[Bosch-Ramon&Bellomo, 2004.11224](#)

[Bosch-Ramon, 2201.09601](#)

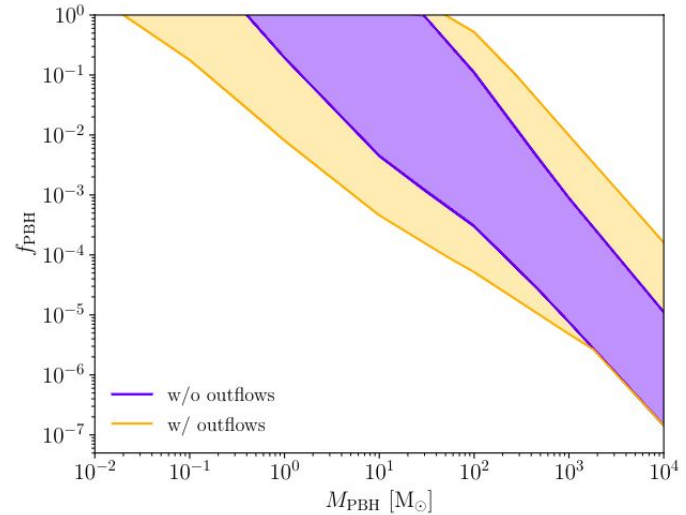


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Comparing models of BH accretion Physics



Piga, Lucca, Bellomo+, 2210.14934



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Bosch-Ramon&Bellomo, 2004.11224

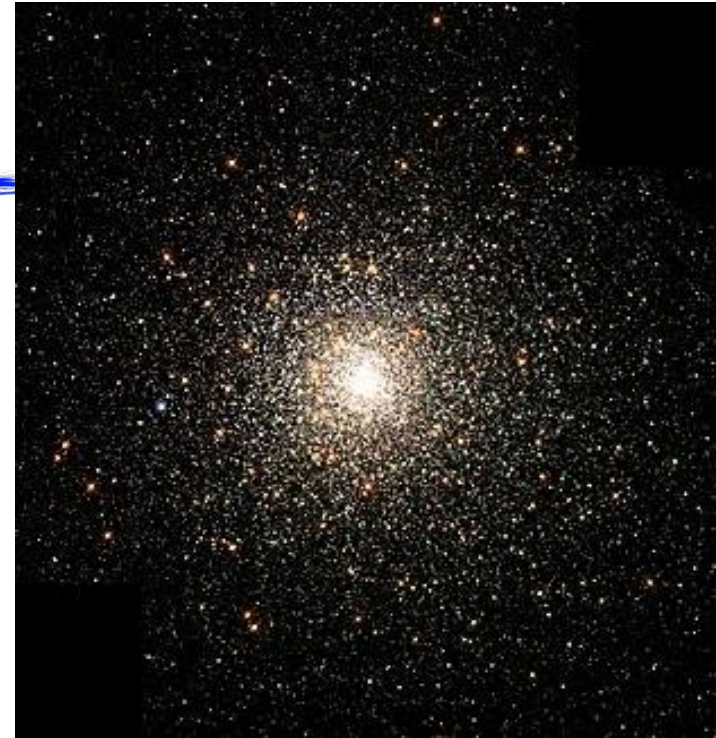
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Globular clusters

Old, almost-spherical systems with a dense core.



Vanzan+, 2405.13871

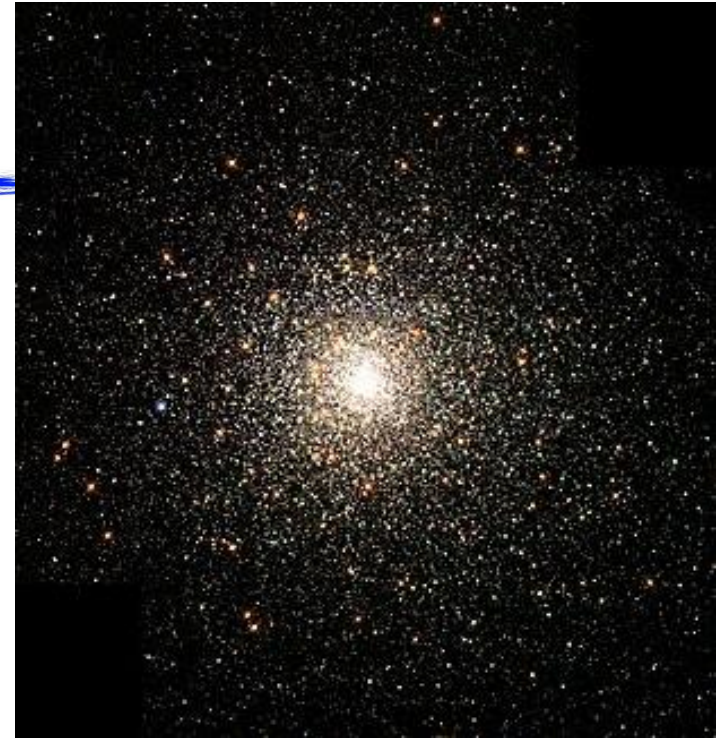


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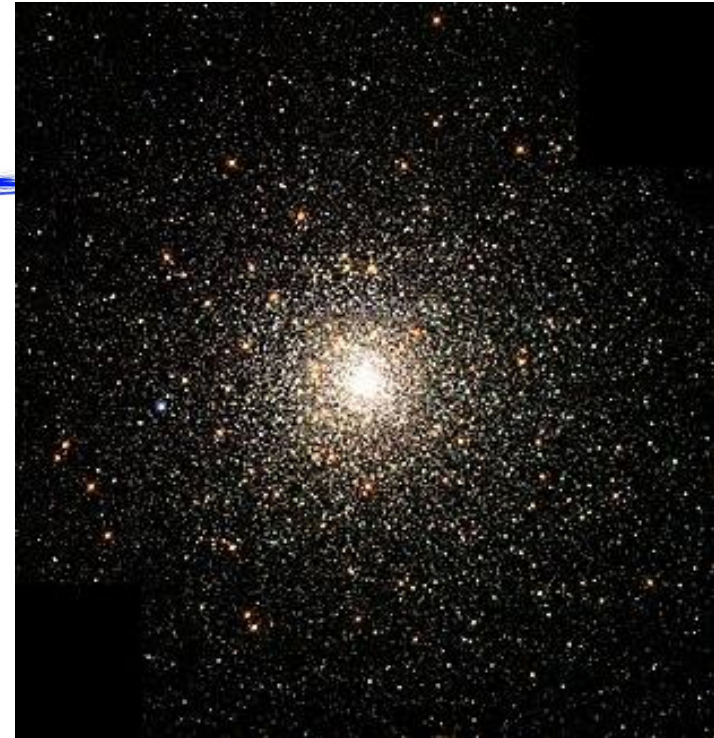
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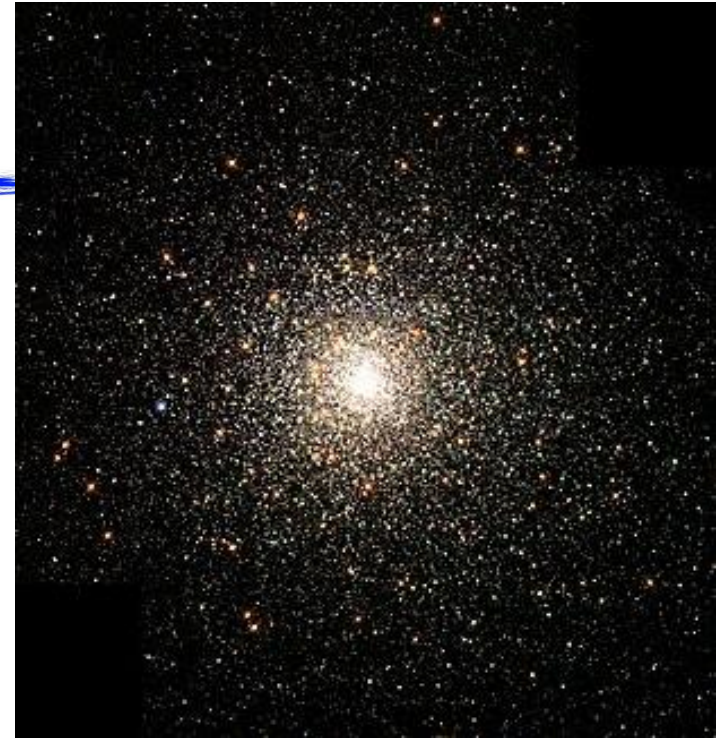
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Common objects: Milky Way hosts more than a 100 GC.



How we describe globular clusters?

Main features of a GC can be captured by describing the cluster objects via a phase space distribution:

$$f_j(r, v) \propto \rho_{0j} \left(e^{-v^2/2\sigma_j^2} e^{\Psi(r)/2\sigma_j^2} - 1 \right)$$



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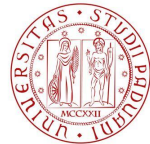
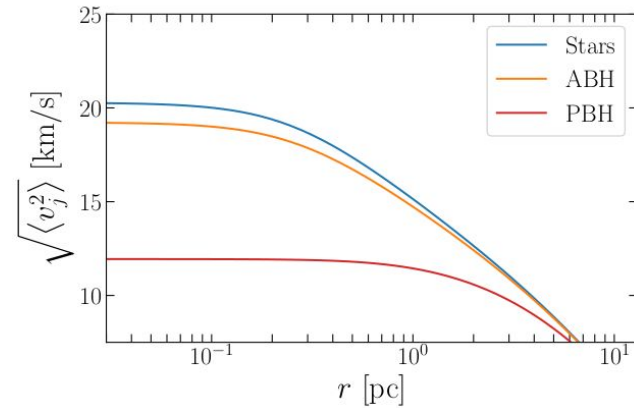
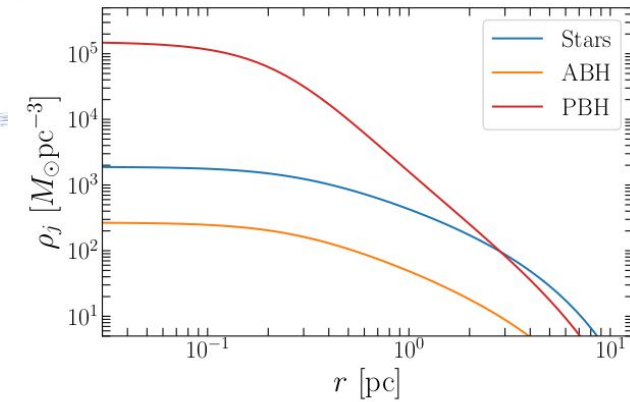
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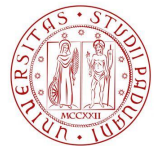
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Binary formation channels in globular clusters

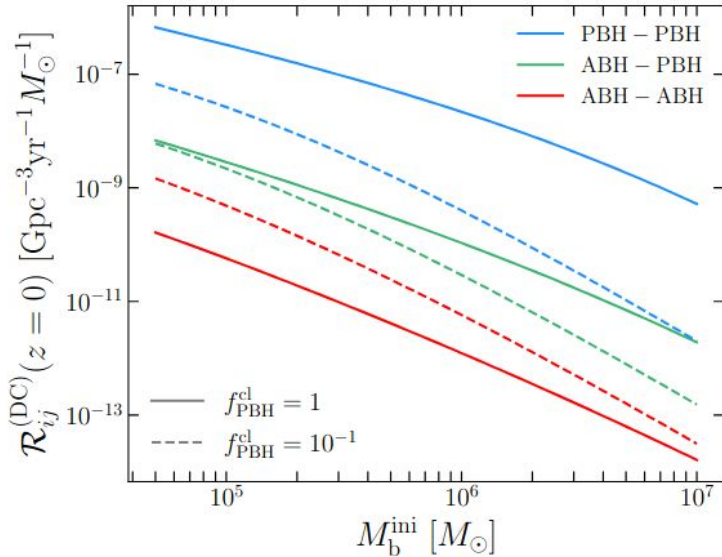
Common phenomenology: $\Gamma \propto n_{\text{BH}}^2 M^a v_{\text{rel}}^{-b}$



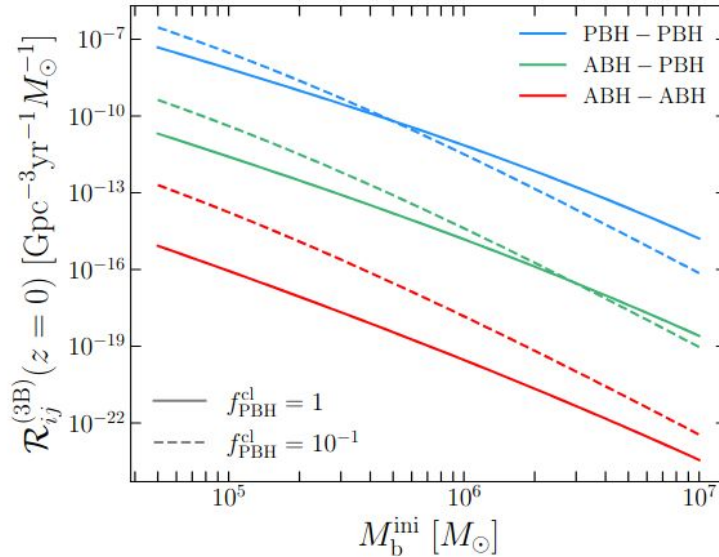
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Direct Capture



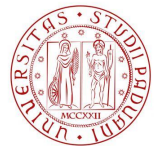
Three-body



Gravitational wave background from PBH binaries

Other formation channels:

Bellomo+, 2110.15059
Vanzan+, 2405.13871



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Gravitational wave background from PBH binaries

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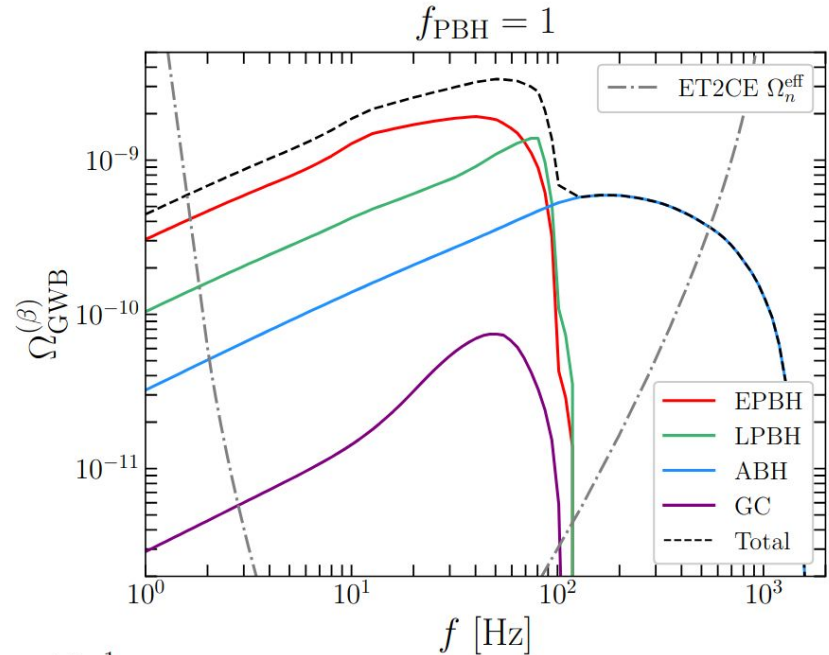


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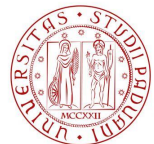
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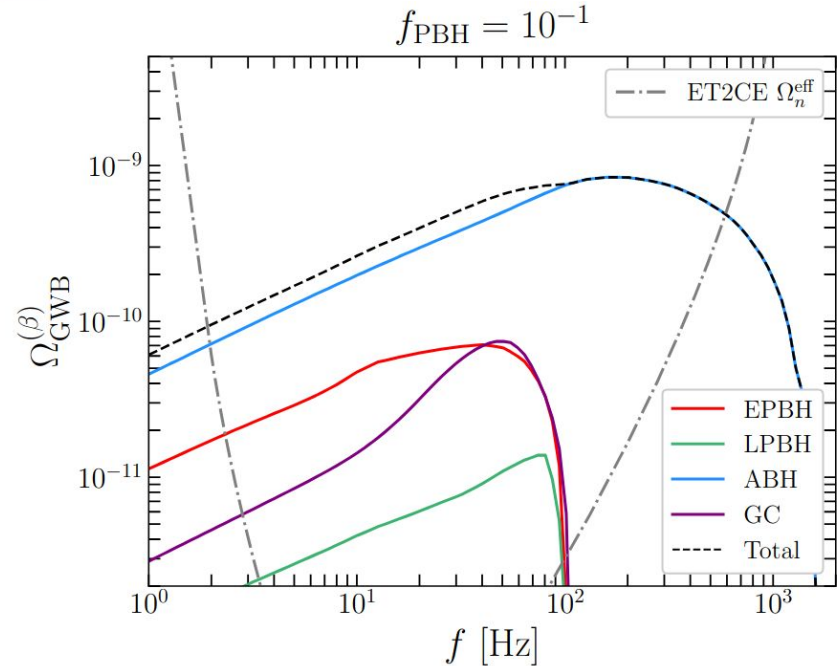


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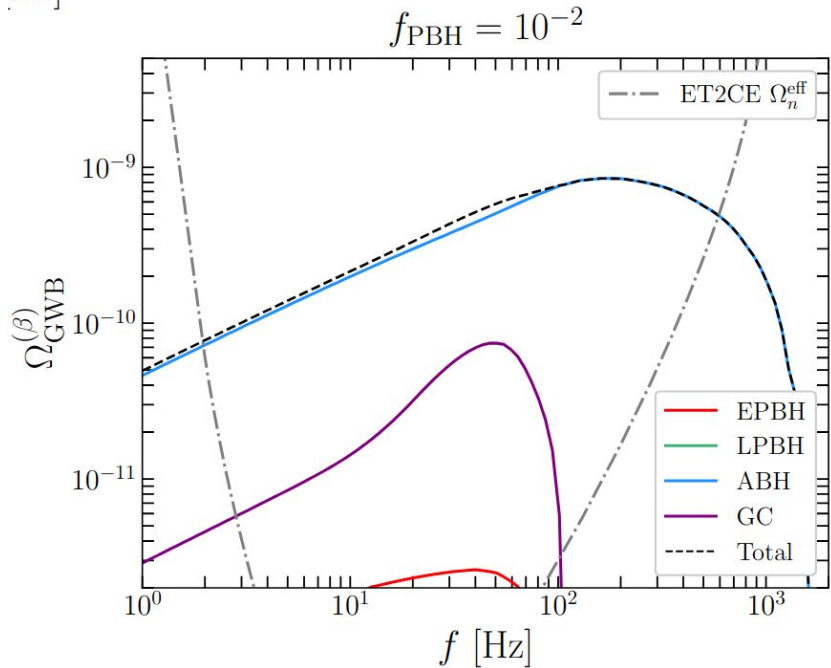
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GC channel can contribute at the 10% level, even when common PBH channels are subdominant!

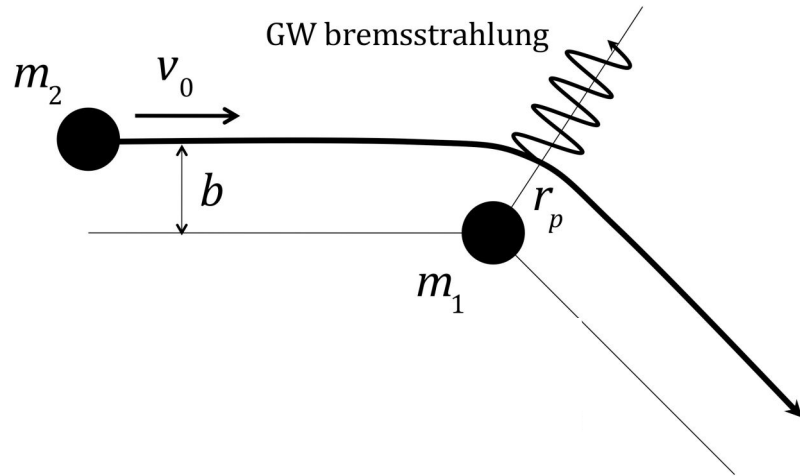


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Gravitational wave background from PBH fly-by

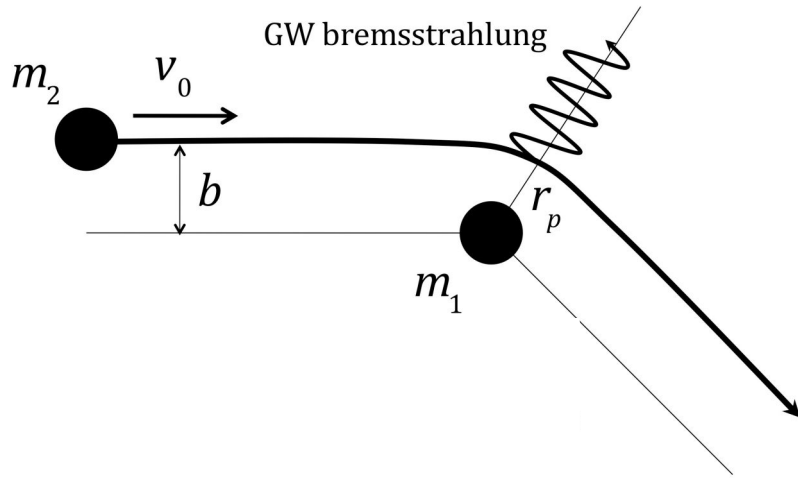


Common event...

$$\Gamma_{\text{tot}}^{(\text{HE})}(M_b^{\text{ini}} = 10^5 M_{\odot}) \simeq 10^{-5} \text{ yr}^{-1}$$



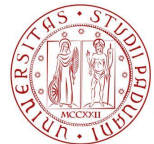
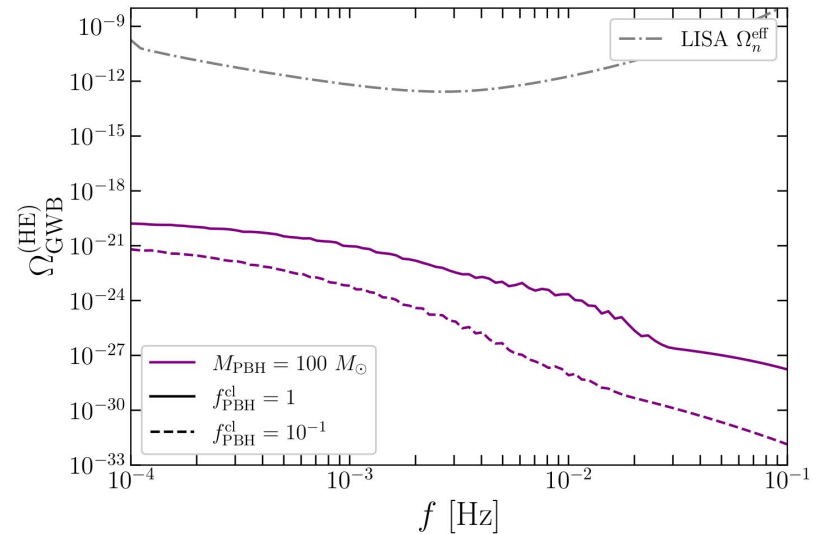
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... but weak GW emission.



Conclusions

Looking for PBHs is interesting no matter what their abundance is.



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Even if PBHs represent a subdominant component of dark matter, their presence may be detectable if they live in dense environments that boost their gravitational signatures.



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Even if PBHs represent a subdominant component of dark matter, their presence may be detectable if they live in dense environments that boost their gravitational signatures.

However, even if we detect a signature that we think that comes from PBHs from GCs, how do we prove it is what we say it is? How robust (i.e., how large is the theoretical error) are GWs population studies?

