UNIVERSIDADE D
COIMBRA

Determining mass and spin of light PBHs

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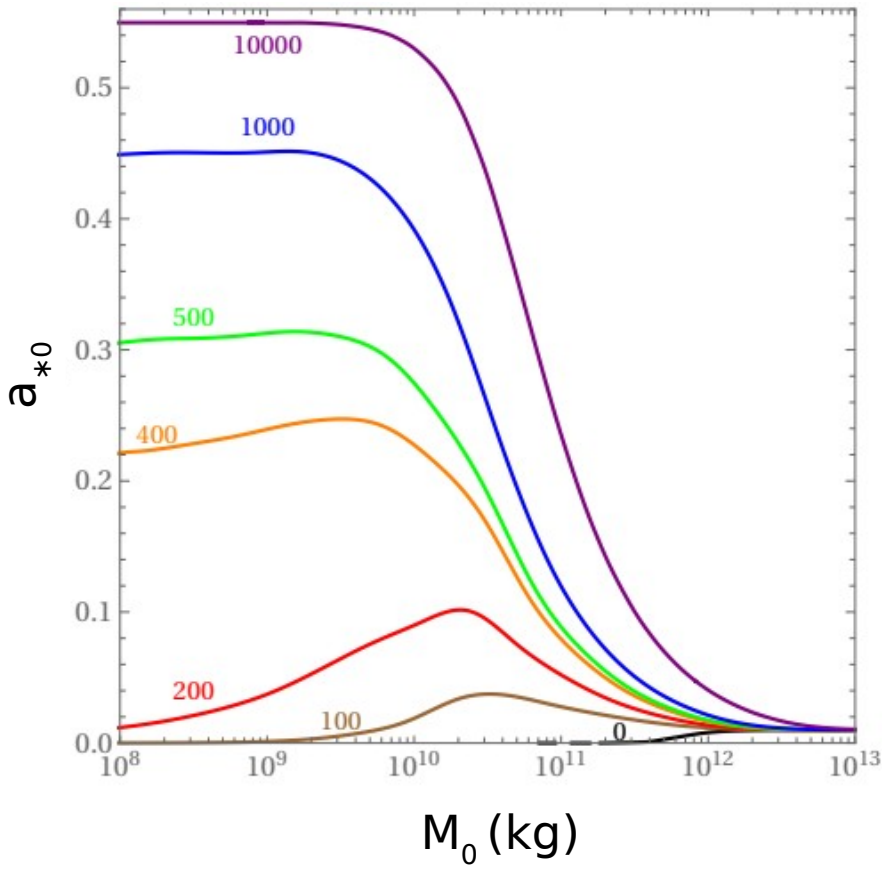
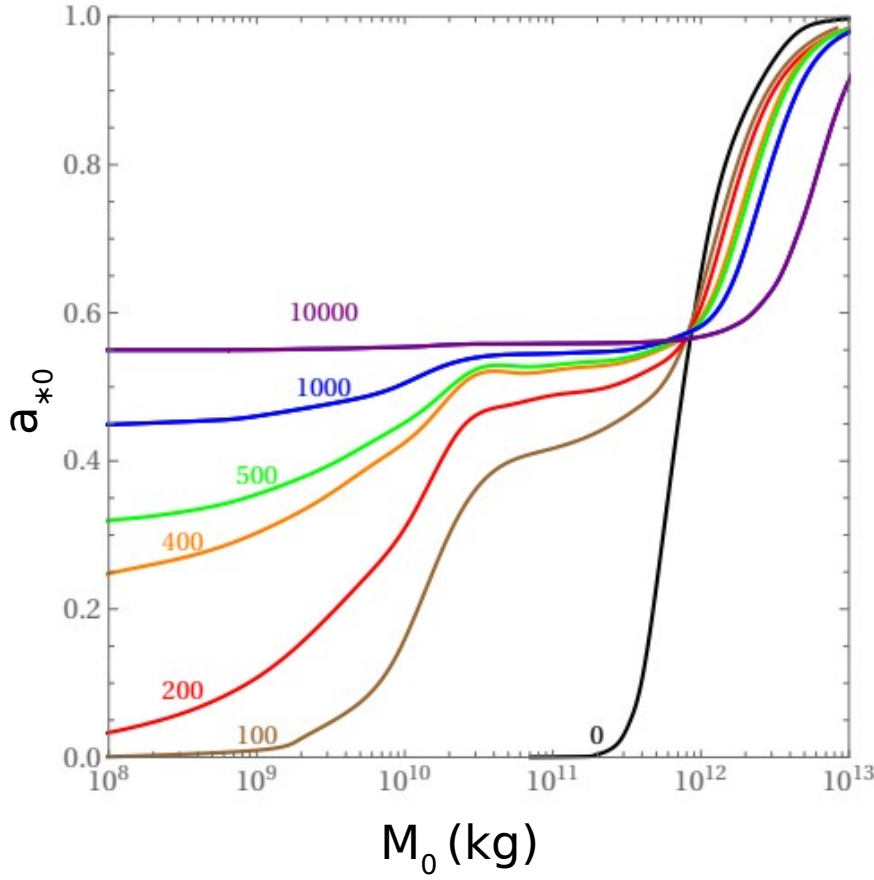
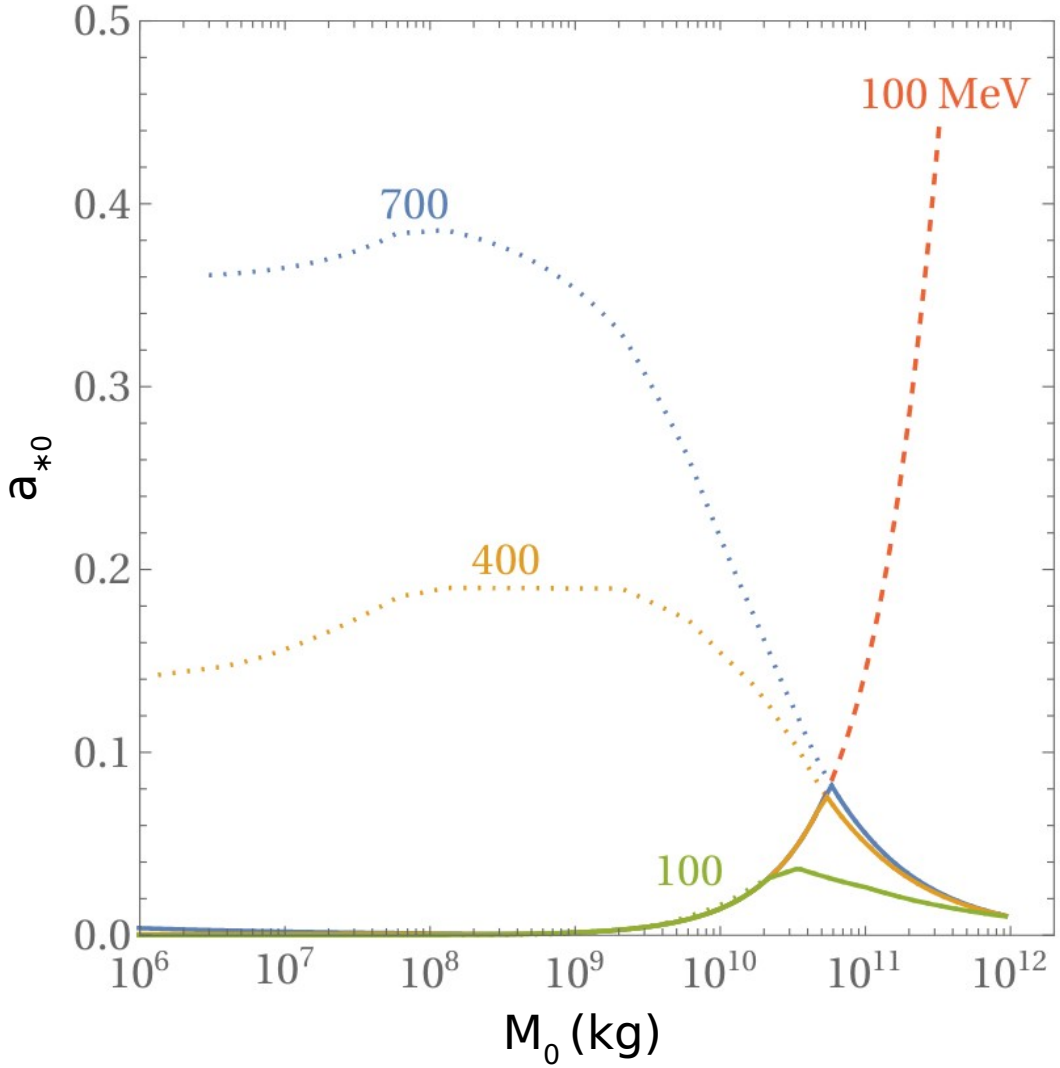
Axiverse fingerprint in PBH evaporation

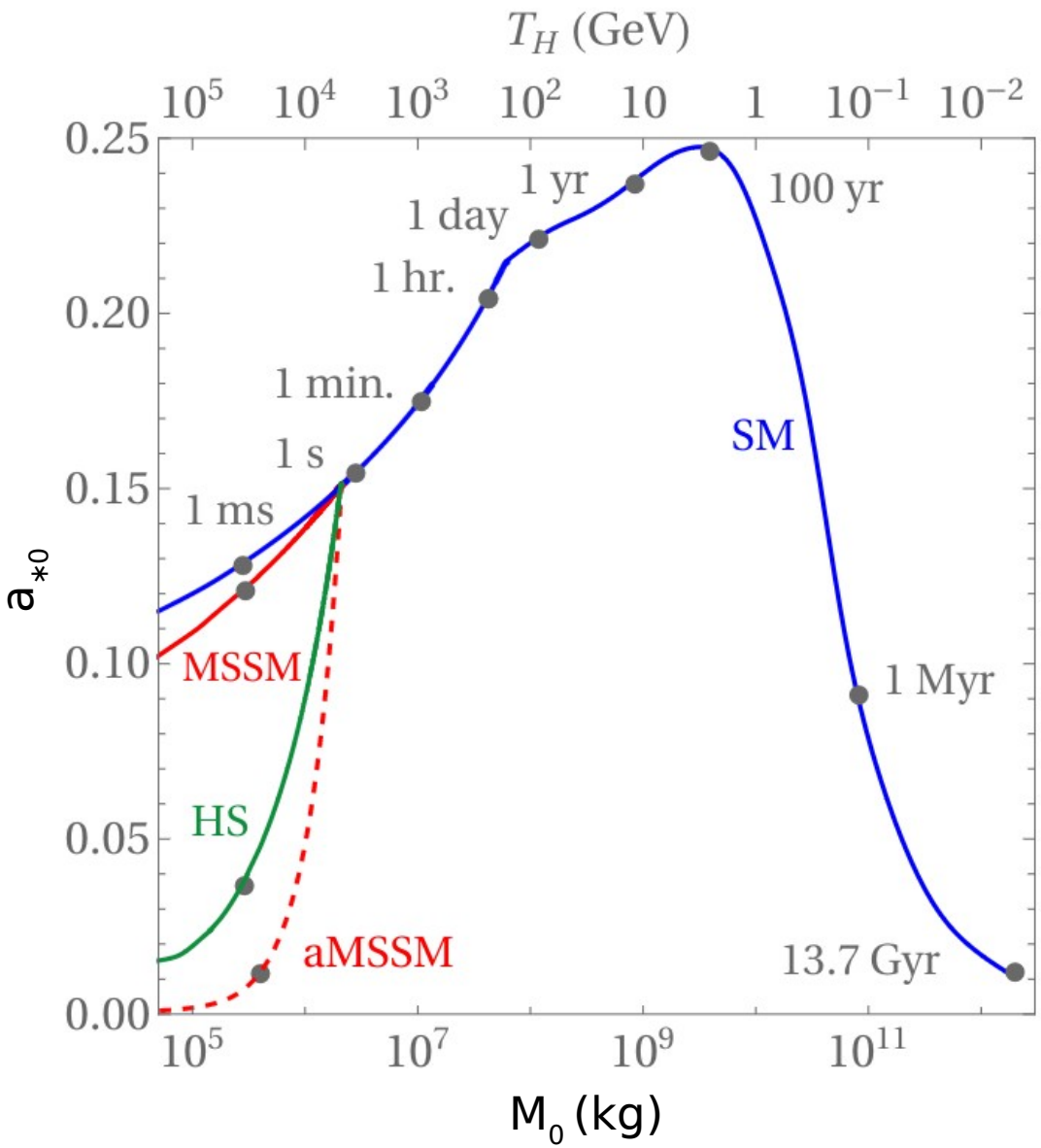




Superradiance + ALPs

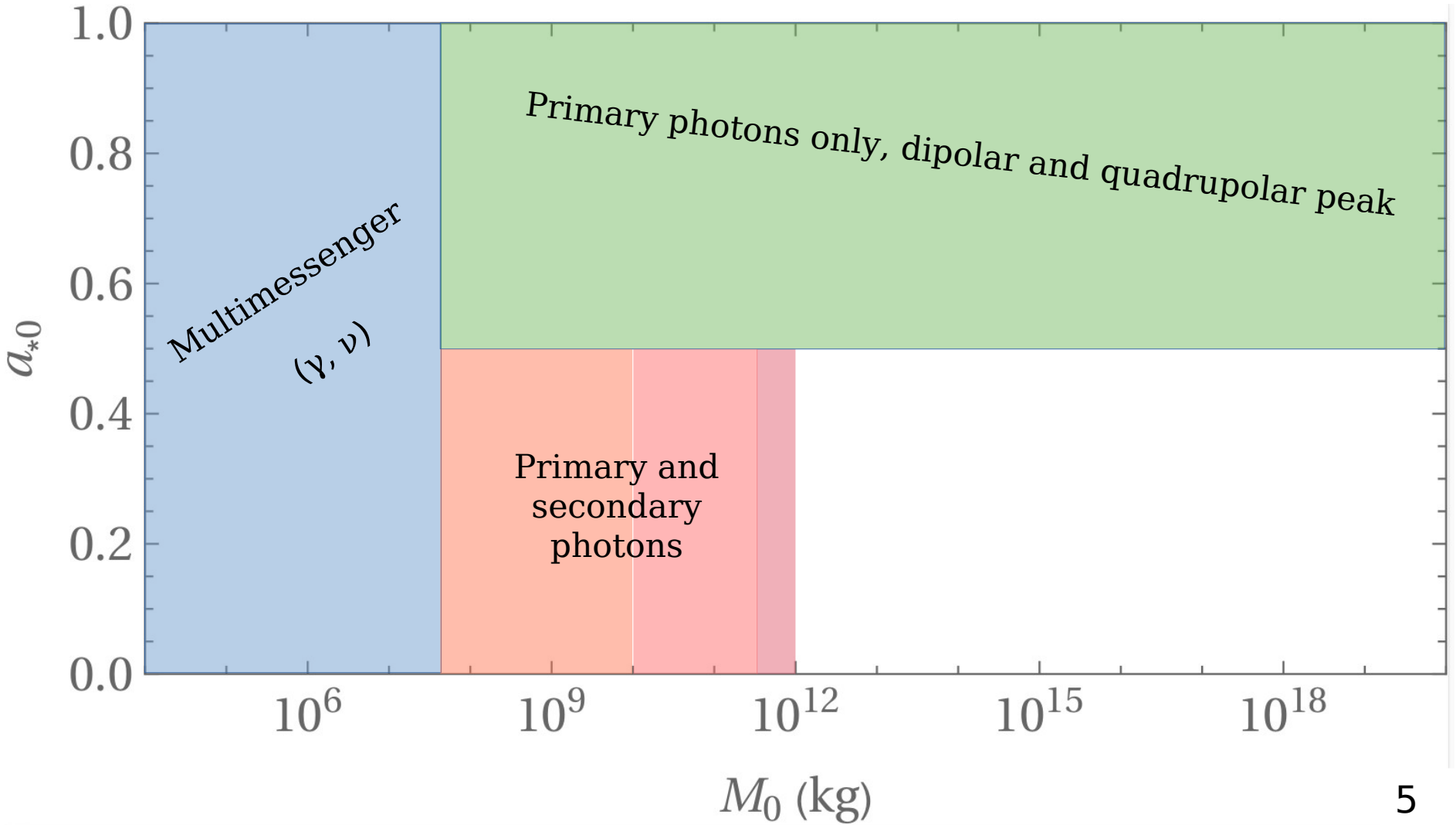


High Energy BSM

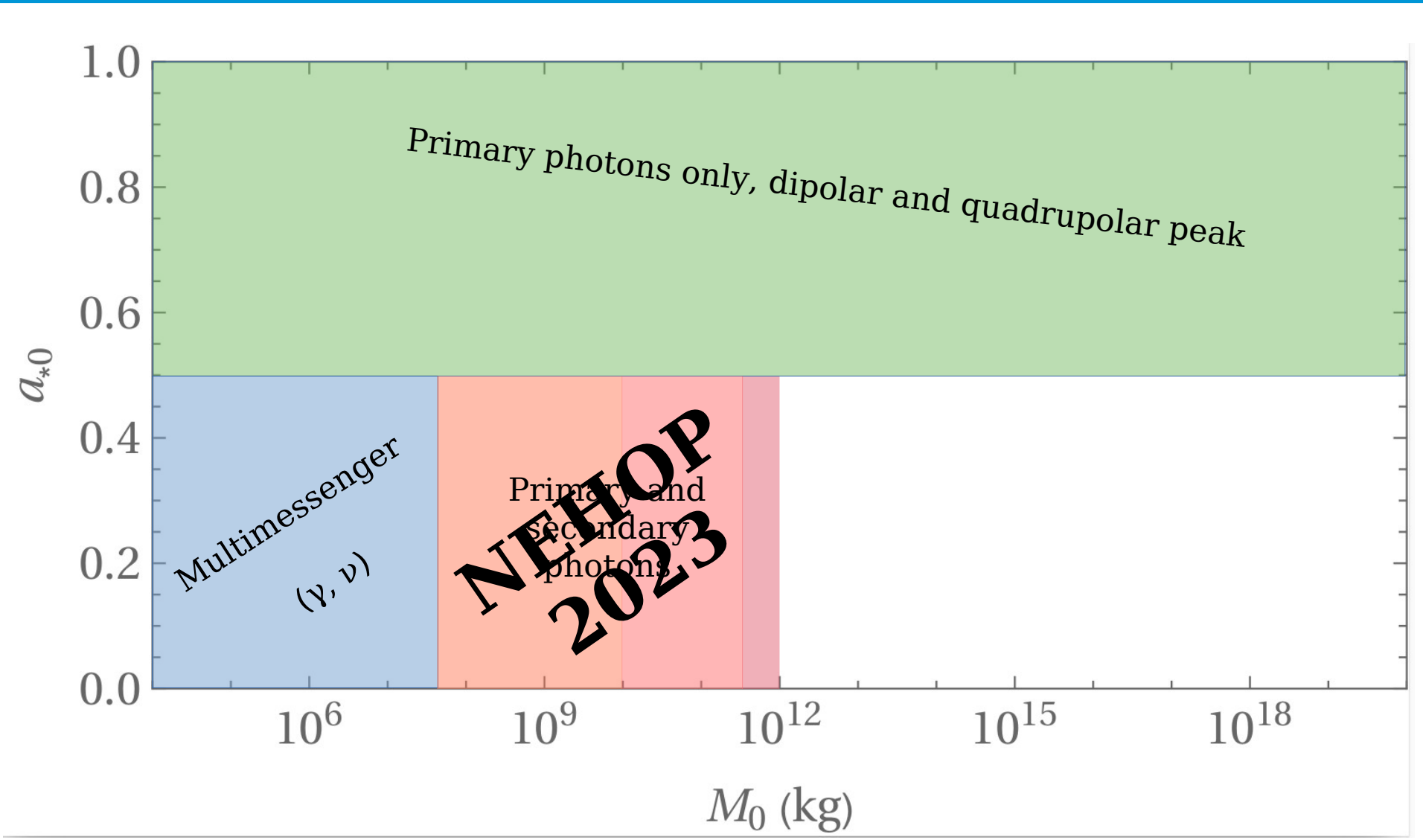


Take home message:

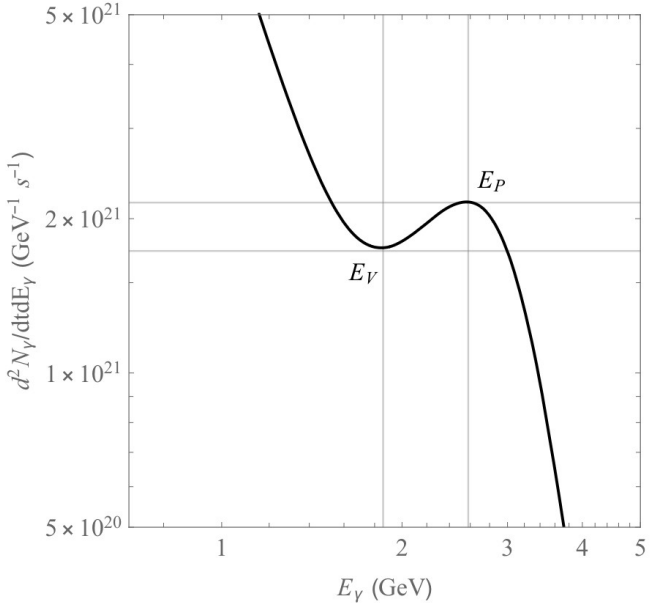
New Physics with PBHs → know the position on the plane (a ,M)

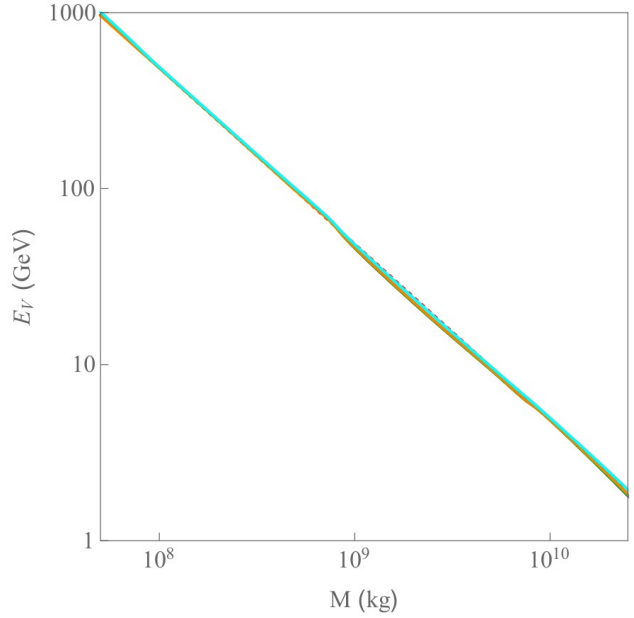


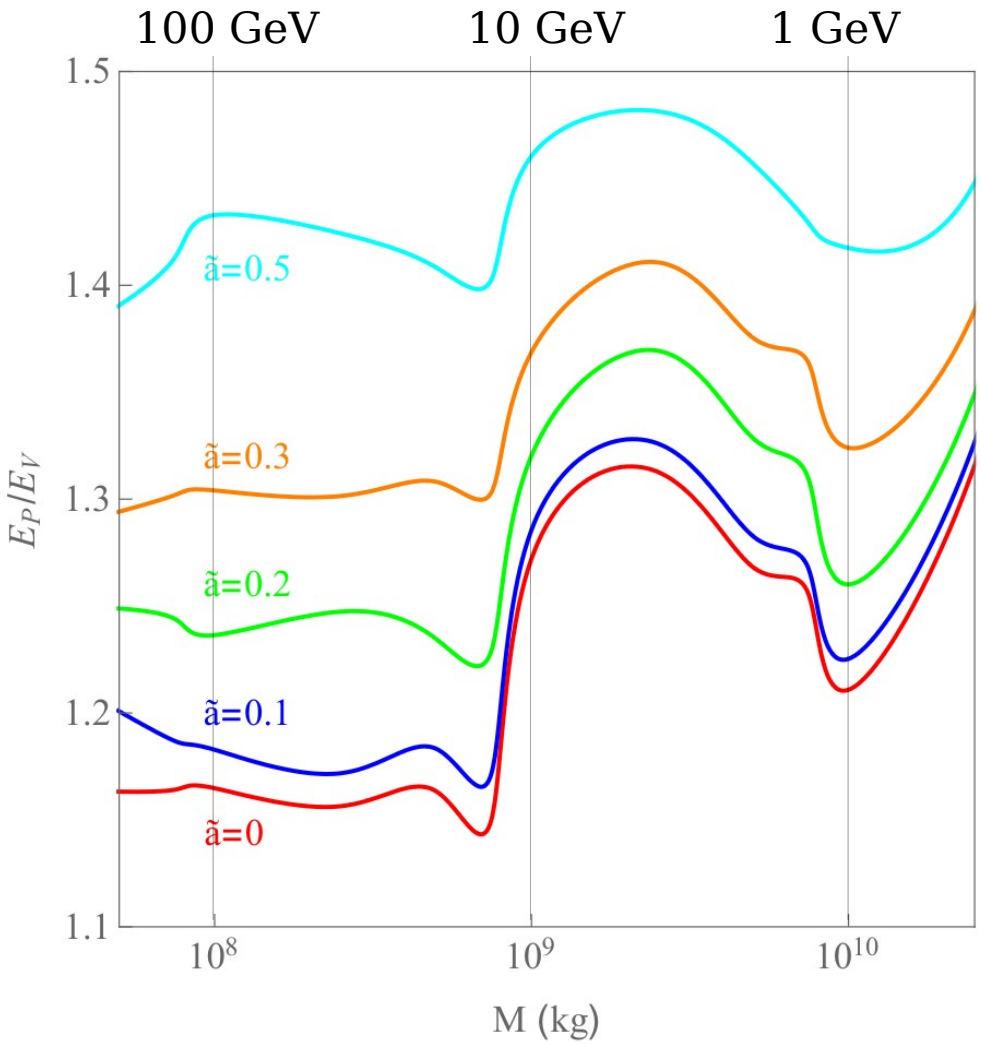
Prequel


Primary photons only, dipolar and quadrupolar peak
Multimessenger
(γ, ν)
Primary and
secondary
photons
NEHOP
2023
1.0
0.8
0.6
0.4
0.2
0.0
a_{*0}
10^6
10^9
10^{12}
10^{15}
10^{18}
M_0 (kg)

In previous episod: recap NEHOP 2023

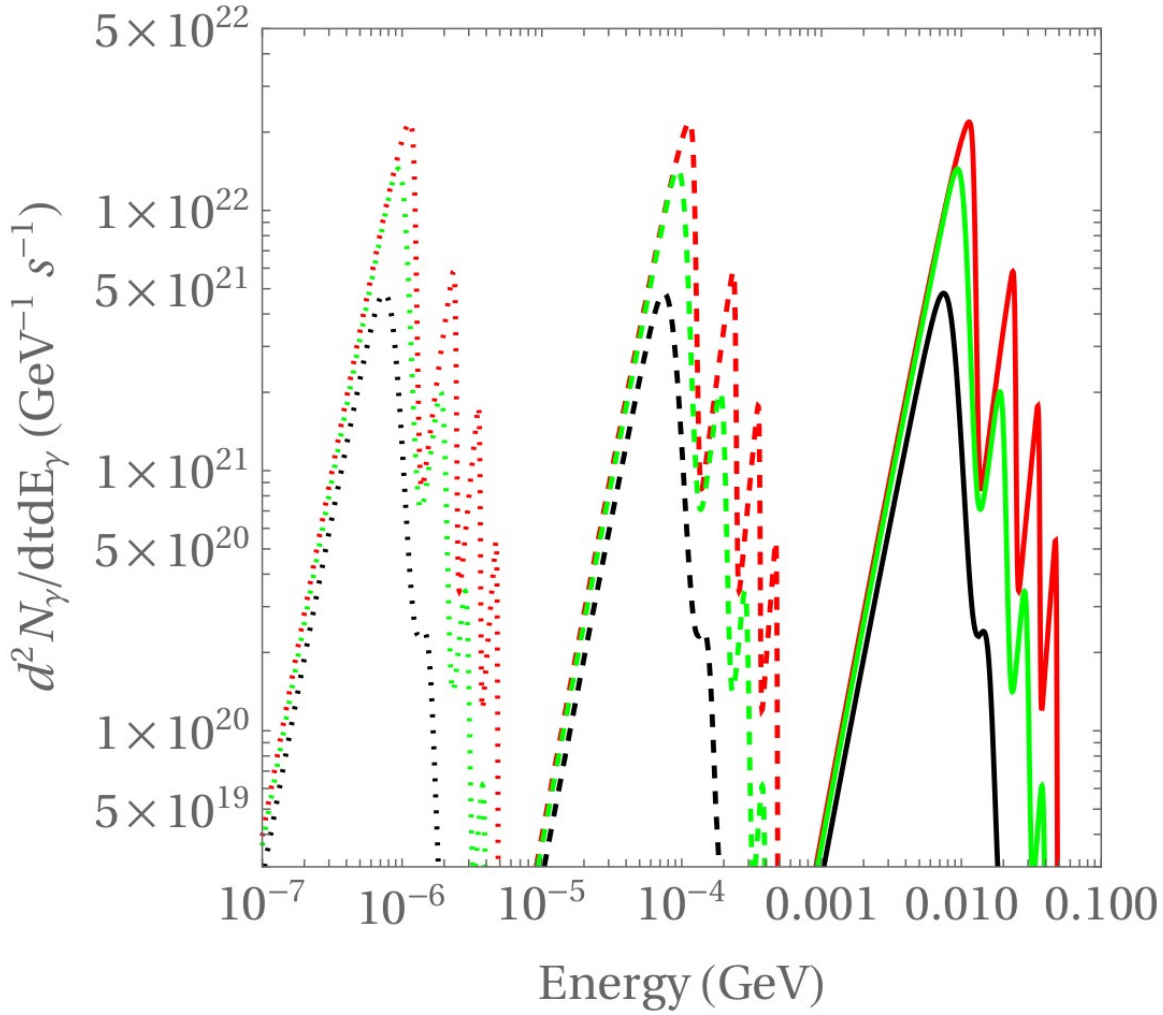




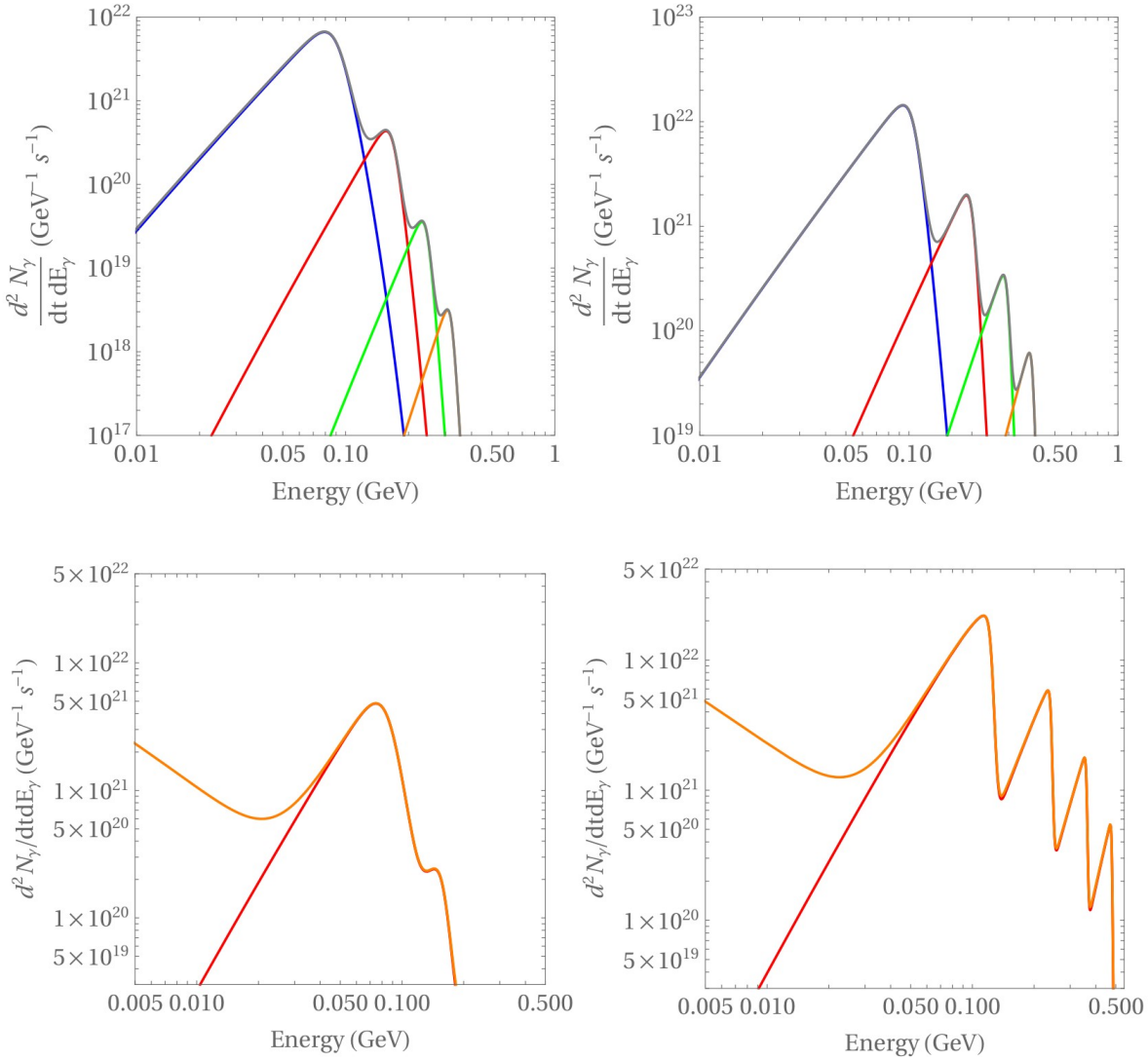


What happen increasing the spin?

$$\frac{d^2 N_{P,i}}{dt dE_i} = \frac{1}{2\pi} \sum_{l,m} \frac{\Gamma^s_{l,m}(\omega)}{e^{2\pi k/\kappa} \pm 1} \ ,$$

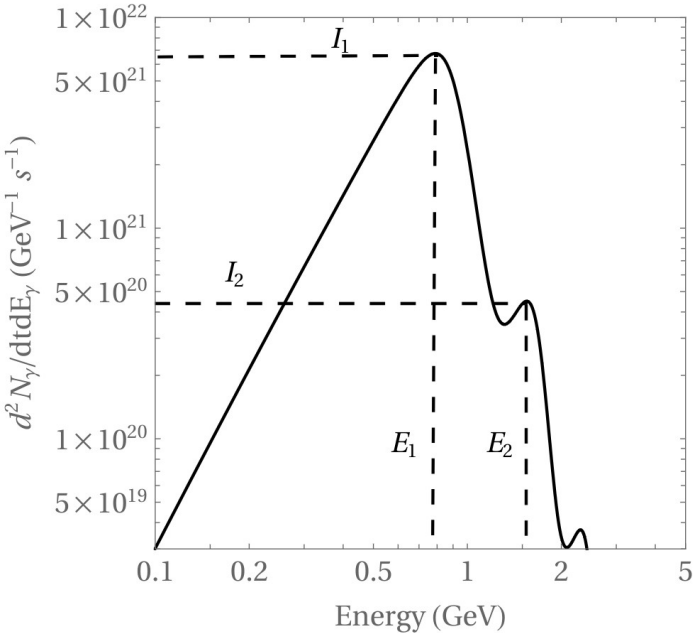


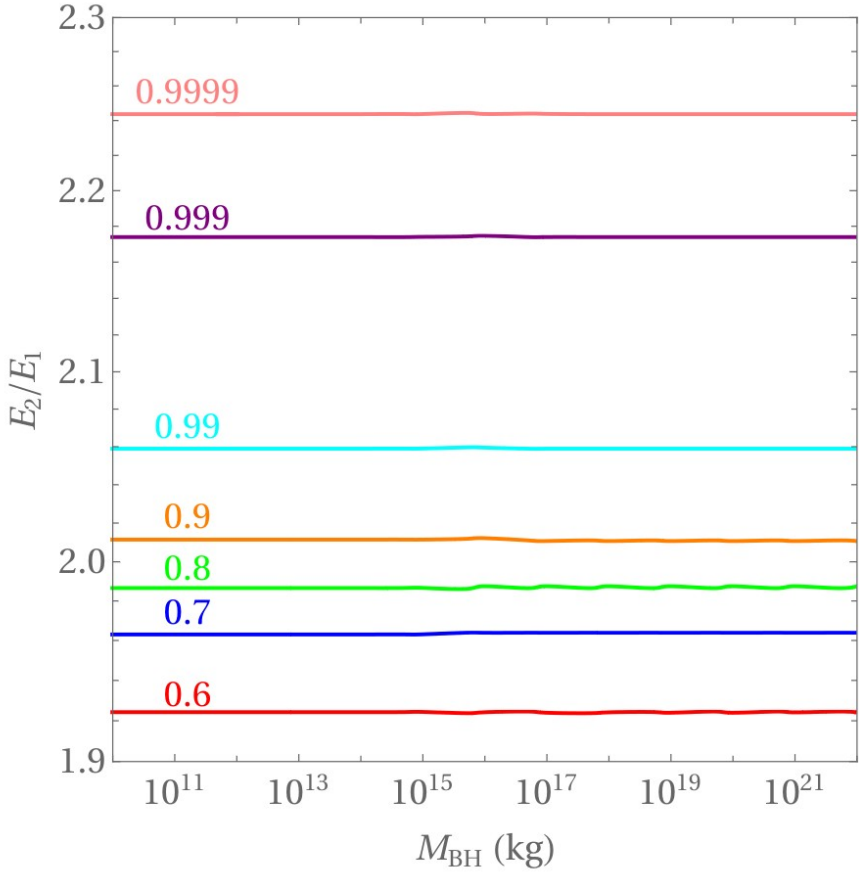
What happen increasing the spin?

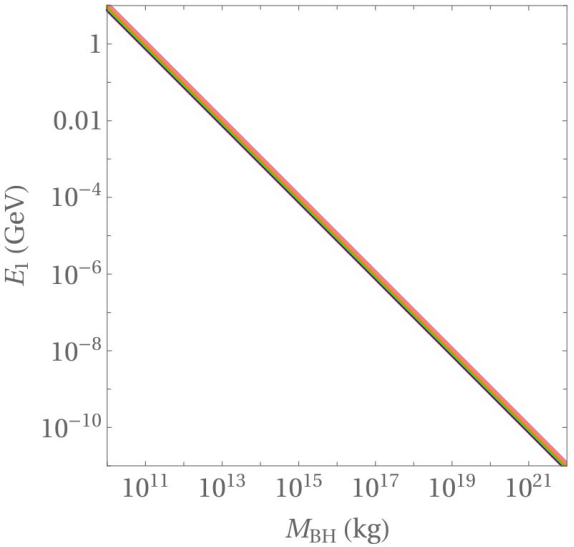


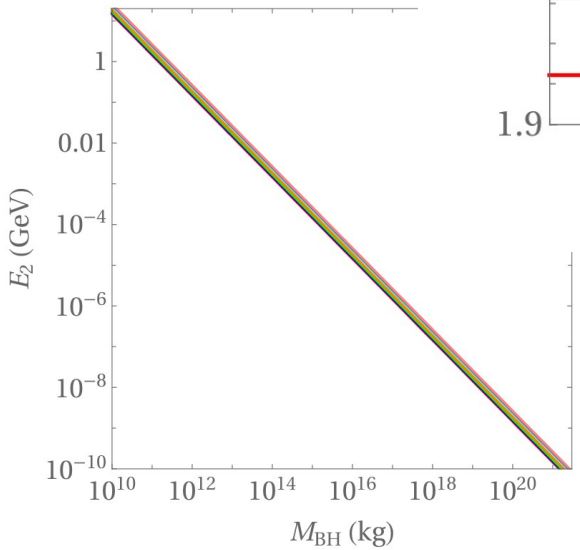
PBH with $M = 10^{12}$ kg and (left) $\tilde{a} = 0.6$ and (right) $\tilde{a} = 0.99$.

What happen increasing the spin?



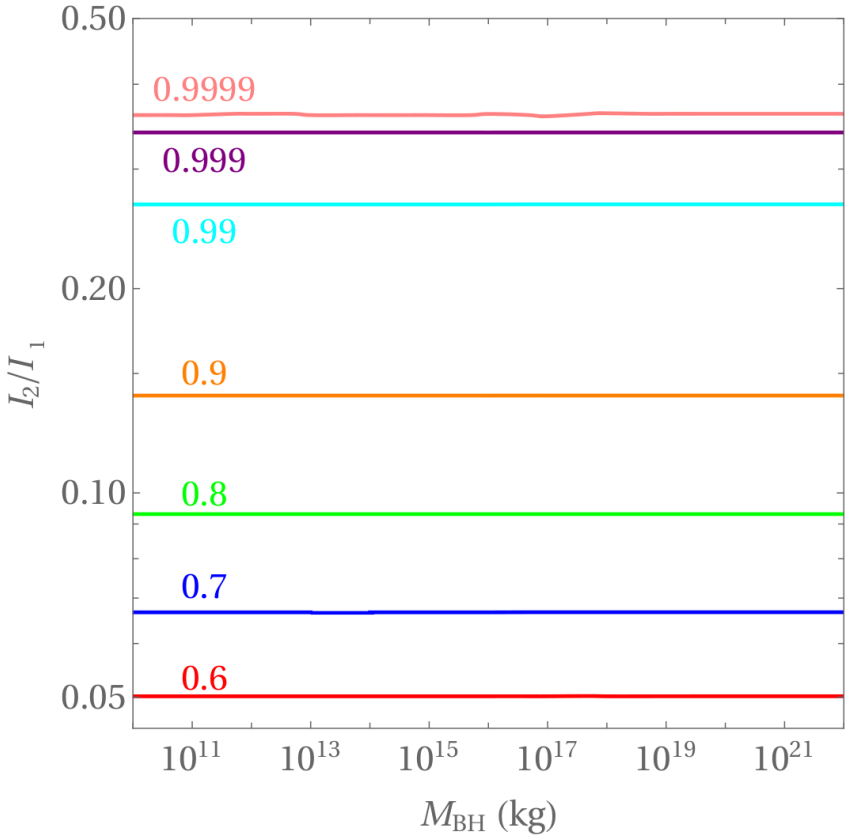






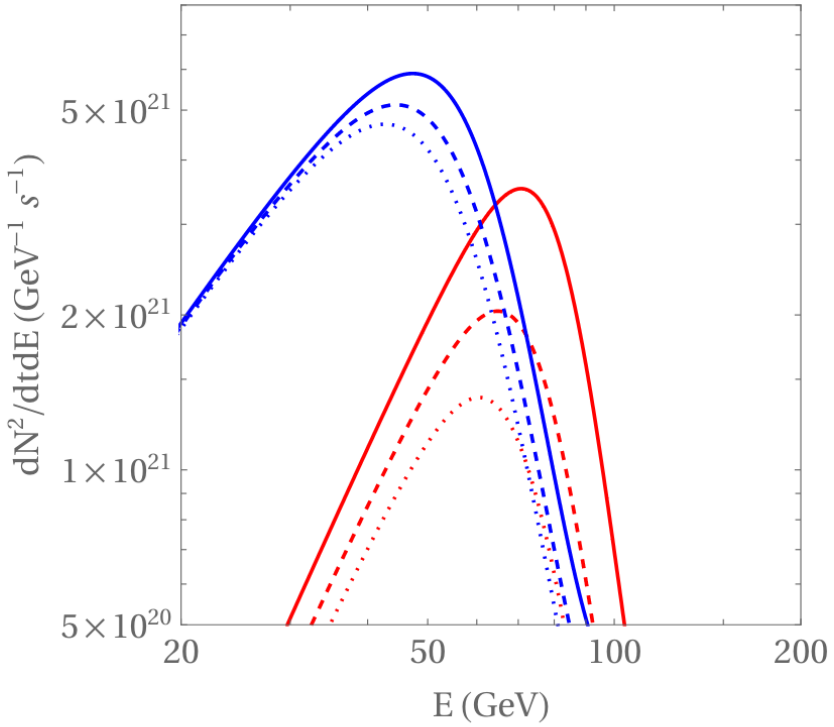
What happen increasing the spin?

$$\frac{d^2 N_{P,i}}{dt dE_i d\Omega} = \frac{1}{4\pi} \sum_{l,m} \frac{\Gamma^s_{l,m}}{e^{2\pi k/\kappa} \pm 1} (|S^{-s}_{l,m}(\theta)|^2 + |S^s_{l,m}(\theta)|^2) \ ,$$



$$\frac{\mathcal{F}_2}{\mathcal{F}_1} = \frac{I_2}{I_1} \frac{|S^1_{2,2}(\theta)|^2}{|S^1_{1,1}(\theta)|^2} \simeq \frac{I_2}{I_1} \frac{|Y^1_{2,2}(\theta)|^2}{|Y^1_{1,1}(\theta)|^2} \simeq \frac{5}{3} \frac{I_2}{I_1} \sin^2\theta \ ,$$

How to infer mass and spin?



Primary photon (red) and single neutrino (blue) Hawking emission spectra for a PBH with $M = 10^9$ kg and $\tilde{a} = 0$ (dotted), $\tilde{a} = 0.2$ (dashed) and $\tilde{a} = 0.5$ (solid).

$$E_{\gamma,\nu} \propto T_H \propto M^{-1}$$

Maximum emission rates $I_{\gamma,\nu}$ independent of the PBH mass.

The ratios between these quantities for ν and γ depend only on ã

$$\frac{E_\nu}{E_\gamma} = 0.705 - \frac{0.559\tilde{a}^2}{1+5.18\tilde{a}}\ , \qquad \frac{I_\nu}{I_\gamma} = 3.423 - \frac{31.05\tilde{a}^2}{1+7.05\tilde{a}}$$

Conclusions

- Use PBHs to investigate fundamental building blocks of Physics
    - Number of light ALPs.
    - Possible heavy ALPs.
    - High energy BSM content.
- The information is encoded in the Regge plots (M,ã).
- It is possible to investigate the (M,ã) parameter space using different methods:
    - Primary and secondary photons (low spin).
    - Dipolar and Quadrupolar photon peak (high spin).
    - Multimessenger: primary ν, γ (high temperature).

References

[1] M. Calzá, J. March-Russell & J. G. Rosa, [arXiv:2110.13602] (sub. to PRL)

[2] M. Calzá & J. G. Rosa, JHEP 12 (2022) 090

[3] M. Calzá, Phys. Rev. D 107 (2023) no.4, 044067

[4] M. Calzá, J. G. Rosa & F. Serrano, JHEP 05 (2024) 140

[5] M. Calzá, J. G. Rosa, [arXiv:2311.12930] (sub. to JHEP)

[6] M. Calzá, J. G. Rosa, [arXiv:2312.09261] (sub. to PRL)

Thanks for your attention!!!