

16th Patras Workshop on Axions, WIMPs and WISPs
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Probing axion-like particle radiation
from primordial black holes

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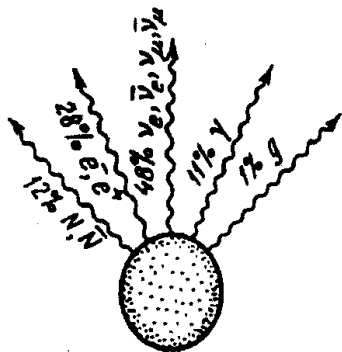
Università degli Studi di Bari "Aldo Moro"



Based on a work in progress in collaboration with A. Mirizzi, D. Montanino and F. Capozzi

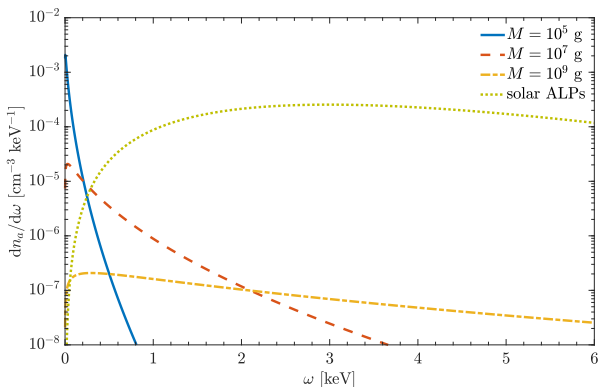
ALPs from primordial black holes

- Primordial black holes formed by collapse of density fluctuations in the Early Universe¹
- Early matter domination is possible
- Subsequent radiation is produced by Hawking evaporation of PBHs (before BBN)
- Possible non-thermal ALP production mechanism



¹Zel'dovich and Novikov 1967; Hawking 1971; Carr and Hawking 1974

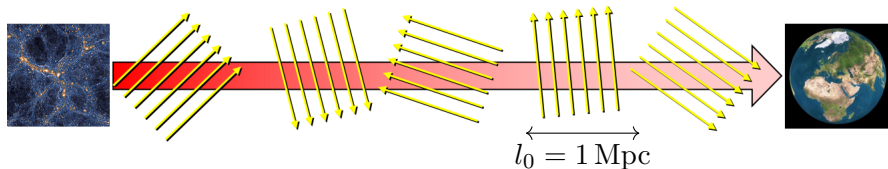
Hawking ALP spectra



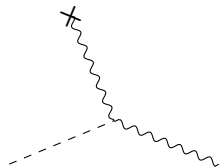
- 1–10 keV range: soft X-ray frequencies
- Independent of initial PBH fraction
- Longer tails for high M (monochromatic²)

²Other PBH mass spectra reviewed in Carr et al. 2020 [2002.12778]

ALP-photon conversions in primordial magnetic fields

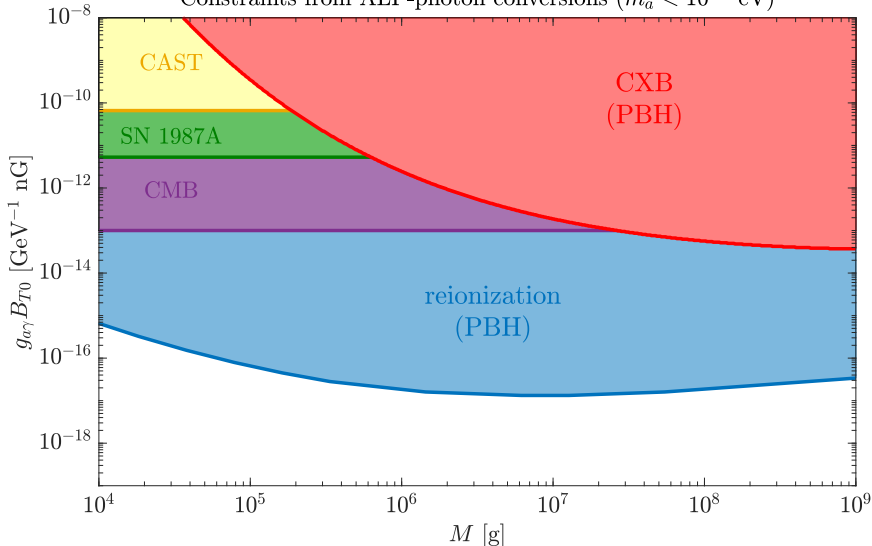


- ALP-photon mixing is possible in external magnetic fields thanks to $g_{a\gamma}$ coupling³
- Conversions inject high energy photons in the Universe contributing to
 - The present-day X-ray background
 - Reionization of the intergalactic medium (measured by optical depth τ)



³Raffelt and Stodolsky 1988

Constraints from ALP-photon conversions ($m_a < 10^{-9}$ eV)



Bounds from CAST [1705.02290], SN 1987A [1410.3747] and CMB [0905.4865]

reported assuming $B_0 = 1$ nG

Conclusions

- PBH domination is a very possible occurrence in the Early Universe
- Several observable signatures if PBHs emit axion-like particles
- Also studied: contribution to dark radiation, decay of massive ALPs
- Stringent constraints on ALP-photon mixing in this scenario
- Further developments: include gravitons (e.g. from spinning PBHs) and graviton-photon conversions in the picture



Thank you for your attention!