Radio bounds on the mixed dark matter scenarios of primordial black holes and WIMPs

Kadota (HIAS-UCAS) & HT, JCAP Vol.2022, 08, id.004

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高赤方偏移21cm線観測によるダークマターモデルの検証

FY2022学術変革シンポジウム（3/7 - 3/9, 2023）

Probe the physics of Dark Matter through radio telescopes

- Synchrotron emission of the Milky Way

  Dominant signal in the radio frequency range

  → Mixed Dark Matter scenario of WIMPs and Primordial Black Holes

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  (Today Topic)

- Redshifted 21cm fluctuations

  Small scale structure formation in high redshifts

  → Axion Dark Matter, PBHs, Warm Dark Matter etc

  (On-going)

Mixed Dark-Matter Scenario of WIMPs and PBHs

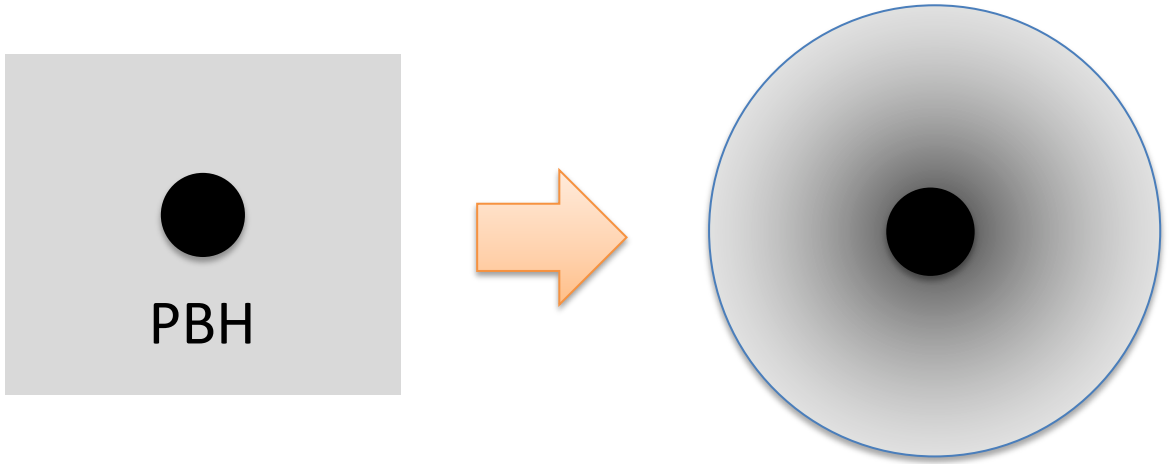
PBH abundance

$$\Omega_{\rm PBH} = f_{\rm PBH}\Omega_{\rm DM}$$

WIMP abundance

$$\Omega_{\rm WIMP} = (1 - f_{\rm PBH})\Omega_{\rm DM}$$

WIMP particles accrete onto PBH and WIMP halo form around PBH



Density profile

$$\rho(r) \propto r^{-4/9}$$

Annihilation rate: $\Gamma \propto n^2_{\rm WIMP}$

PBH enhance the WIMP annihilation

Daughter charged particles of WIMP annihilation

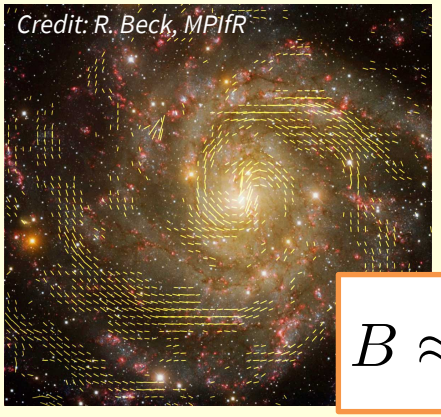
hadronic channel

$$\chi\chi \to bb^{-}$$

leptonic channel

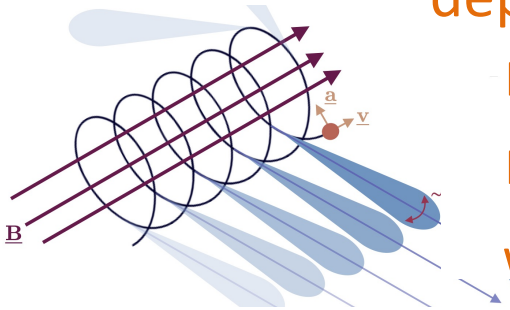
$$\chi\chi \to e^{+}e^{-}$$

Magnetic fields in galaxy



$B \approx 5\ \mu\mathrm{Gauss}$

Synchrotron emission



Synchrotron emission depending on

PBH mass: M_{PBH}

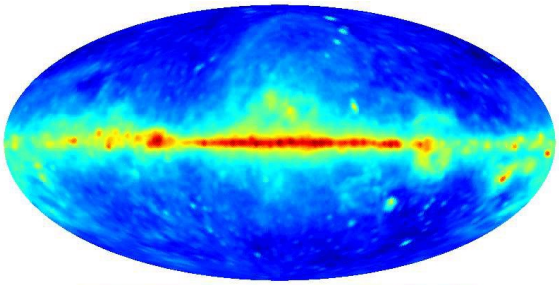
PBH DM fraction: f_{PBH}

WIMP mass: M_{χ}

WIMP annihilation rate : $\langle \sigma v \rangle$

Comparison

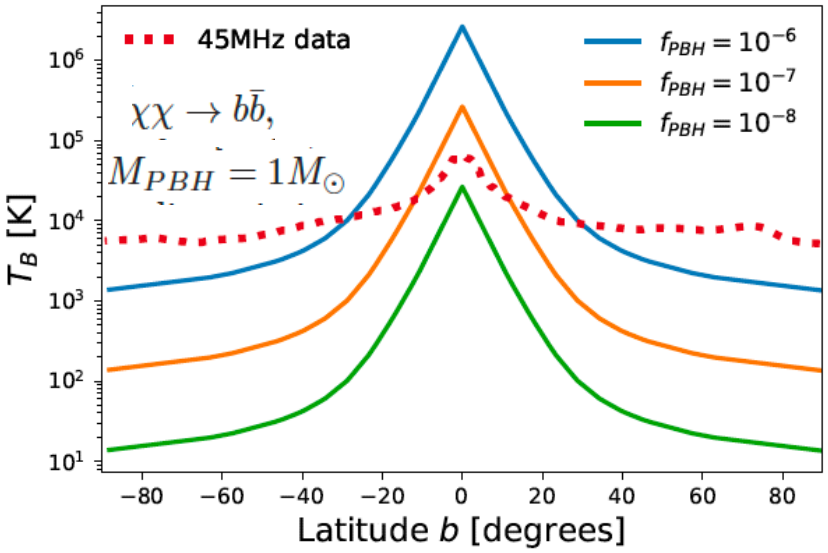
Milky Way in radio observation



Zhang et al. 2009

Prediction

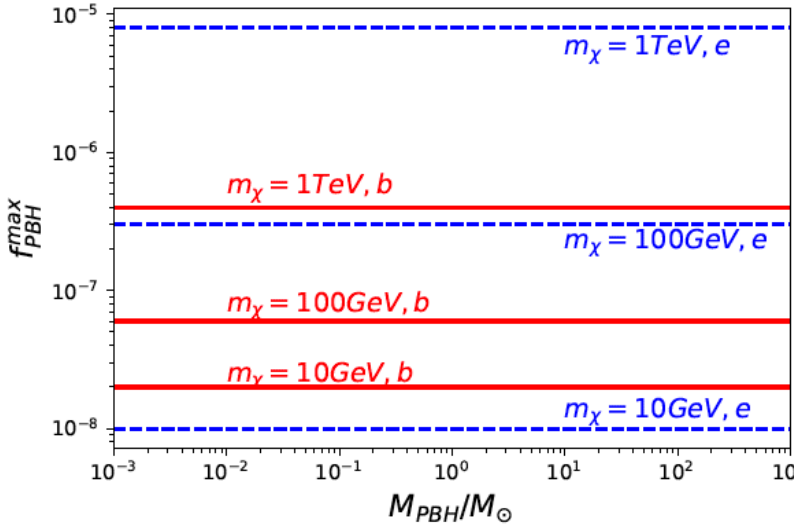
Milky Way synchrotron emission in Mixed DM of WIMPs and PBHs



Constraint

PBH DM mass fraction

b: baryonic, e: leptonic channnels



Summary

- *The upper bound of PBH fraction is of order 10^{-8} — 10^{-5}*

The PBH contribution to the total DM abundance is negligible when the other component of dark matter is composed of the conventional electroweak scale WIMPs.