

# A New Bound on Primordial Black Hole Abundance Using Interaction with Dust Tori in Active Galactic Nuclei

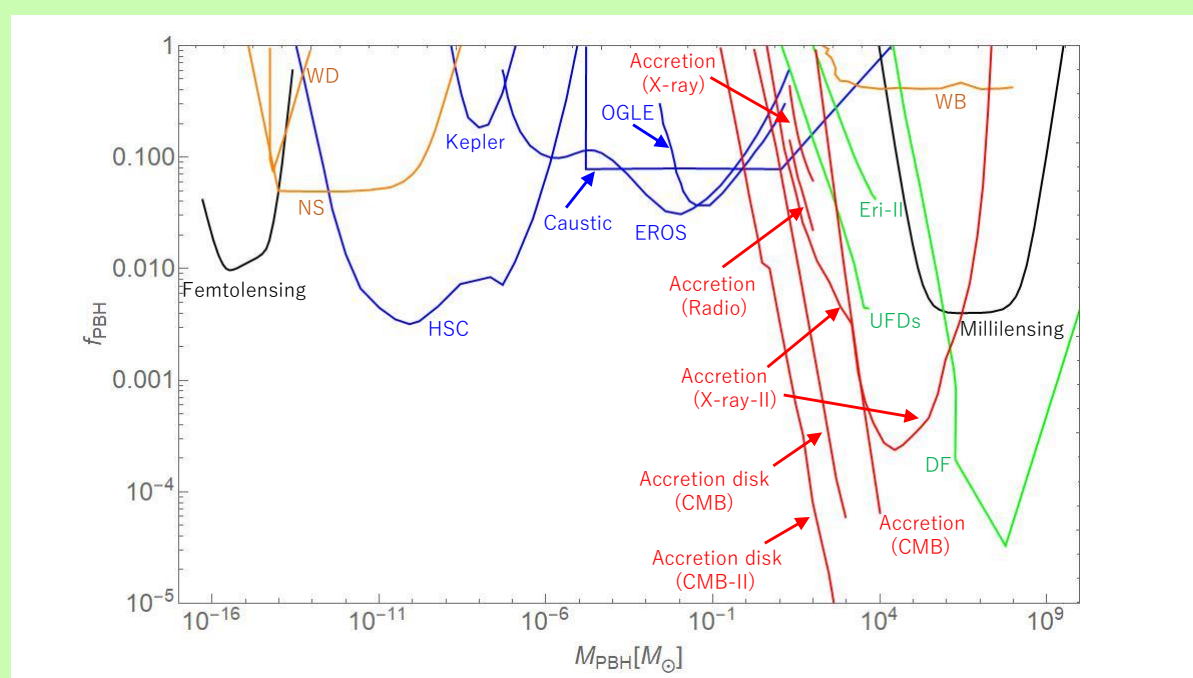
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## 1. Introduction

### Primordial Black Holes (PBHs)

- It is formed in the early universe and one of the candidates of **Dark Matter** (DM).
- PBHs with mass of  $\sim 10 M_{\odot}$  are the candidate of gravitational wave source detected by LIGO.

Abundance constraints given to PBHs



- **Gas accretion process** onto the PBHs is effective in the mass range of  $\sim 10^{-1} M_{\odot}$  or more.

## 2. Method

### Accretion onto a PBH

- Gas accretion rate onto a floating PBH is given by Bondi-Hoyle-Lyttleton accretion rate.

$$\dot{M} = \pi r_B^2 \tilde{v} \rho_{\text{gas}} = \frac{4\pi G^2 M_{\text{PBH}}^2 n_{\text{gas}} \mu m_p}{(v^2 + c_s^2)^{3/2}}$$

→ **Gas & DM dense** region is proffered.

### Dust torus in AGN

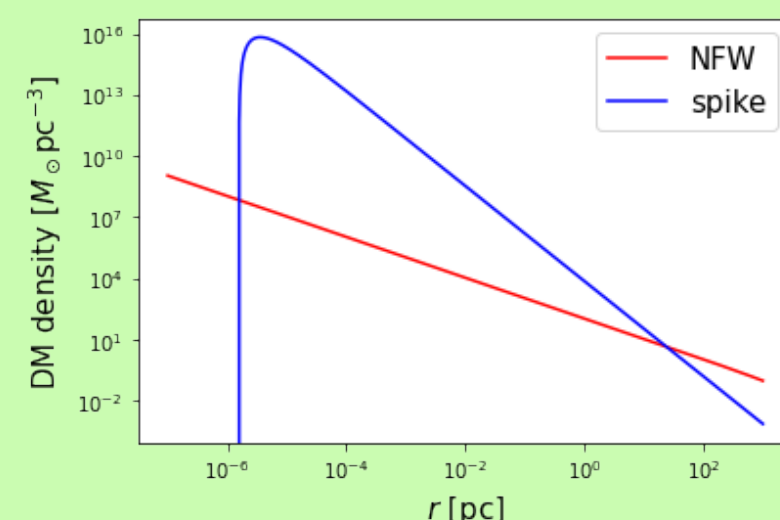
- Gas dense  $\sim 10^3 \text{ cm}^{-3}$  region near the galactic center.
  - ex. NGC1068
    - Outer radius :  $r_{\text{out}} = 20 \text{ pc}$
    - Height :  $h = 1.1 \text{ pc}$
    - Gas number density :  $n_{\text{gas}} = 6.1 \times 10^3 \text{ cm}^{-3}$

- PBH radiation shouldn't completely ionize the gas.
  - Comparison of the **heating** (radiation) and the **cooling** of the ambient gas.

### Heating rate by PBHs in the AGN torus

$$\dot{Q}_{\text{heating}} = \int_0^{\infty} d\dot{M} \int_0^{\infty} dv L_{\text{PBH}} \frac{\rho_{\text{DM}}}{M_{\text{PBH}}} \frac{df_r}{dv} \delta[\dot{M}(v) - \dot{M}]$$

- $\rho_{\text{DM}}$  : DM density distribution
  - NFW profile and spike profile



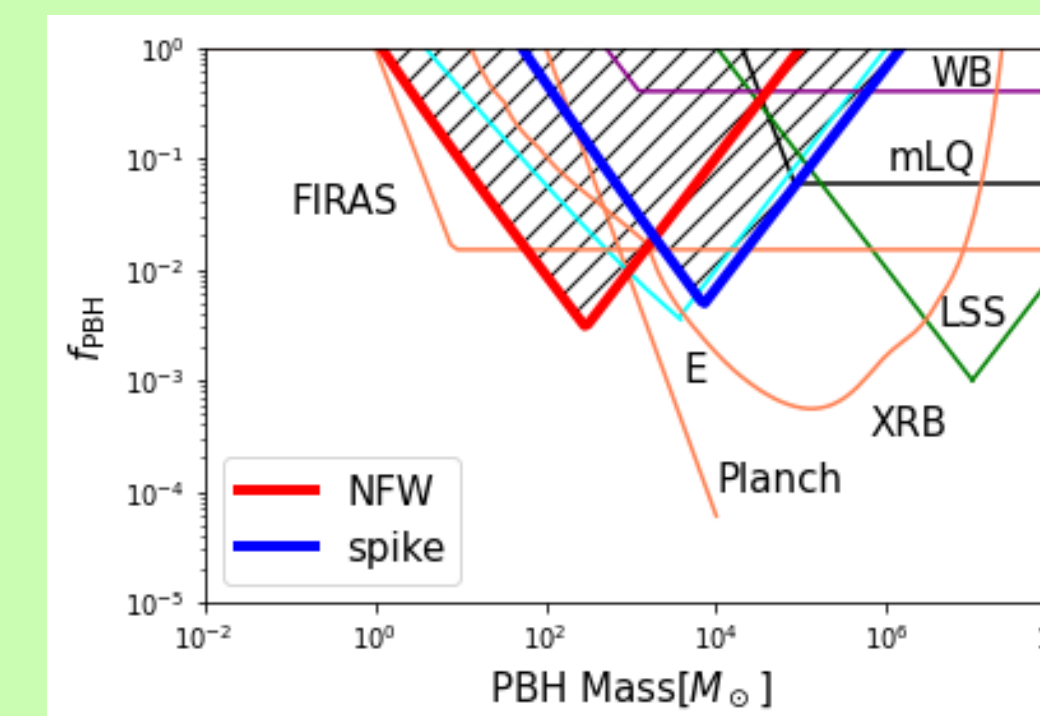
- $\frac{df_r}{dv}$  : Velocity distribution of PBHs
  - Maxwell distribution
  - Typical velocity.
    - NFW :  $\sim 1 \text{ km/s}$ , spike :  $\sim 10 \text{ km/s}$

### Cooling rate of the gas in AGN torus

- Cooling rate  $\dot{Q}_{\text{cooling}}$  is derived from cooling function of the ISM gas which is well studied and has less uncertainty.

$$f_{\text{PBH}} \leq f_{\text{UL}} = \frac{\dot{Q}_{\text{cooling}}}{\dot{Q}_{\text{heating}}}$$

## 3. Result



- Our independent constraint is **consistent with other studies**.
- PBHs are unlikely as DM, but they are allowed as the origin of gravitational wave.

## 4. Outlook

- Dust torus in AGN is plausible region for PBH constraint.
  - We plan to obtain further constraint by using other AGNs.