On the gamma-ray detectability of the Galactic isolated stellar-mass BH magnetosphere

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My previous paper　Movies of simu.

Abstract: We have investigate the detectability of Galactic isolated stellar-mass BHs during ISM accretion through GeV-sub TeV gamma-rays from their magnetospheres. We have concluded that ~10-100 objects in Fermi-LAT, H.E.S.S., and CTA are expected. Future detections will put some constraints on the BH spin, on the proper motion velocity.

(1) IBH magnetosphere formation during ISM accretion

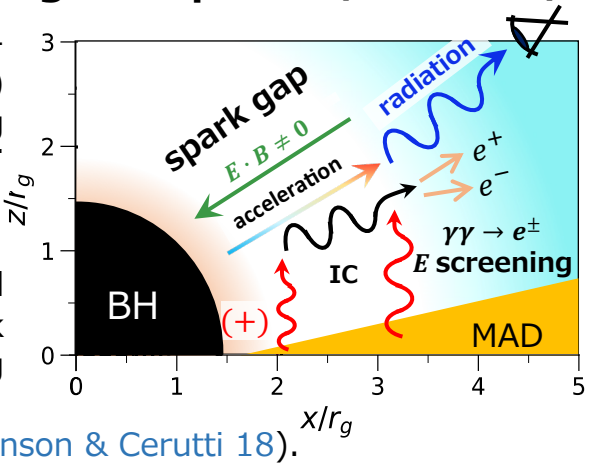
- Governing fraction of $\sim 10^8$ stellar-mass BHs in the Galaxy would be **isolated stellar-mass BHs (IBHs).**
- IBHs in the Galactic plane accrete interstellar medium (ISM) via the **Bondi-Hoyle-Littleton (BHL) accretion**.
- Efficient magnetic flux accumulation onto IBHs
  → accretion flow near IBHs become magnetically-saturated state **(MAD)** (Kaaz+23; Kwan+23).

Magnetospheres at IBH-MADs' innermost region.

(2) 1D GRPIC simulation of stellar-mass BH magnetosphere (Kin et al.24)

The longitudinal E-field (i.e. **spark gap**) would emerge during the charge-starved state of the magneto-sphere.

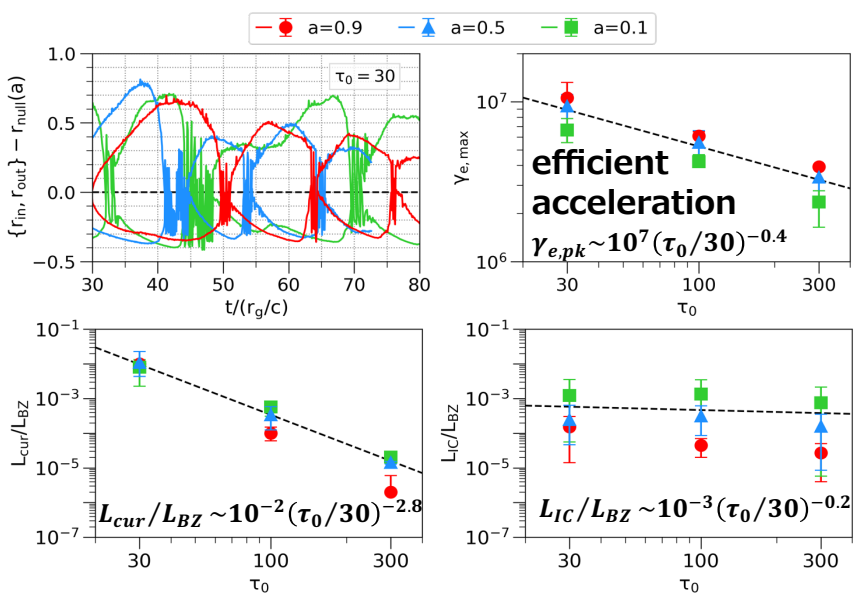
We have conducted analysis on the spark gap dynamics using 1D GRPIC simulation code Zeltron (cf. Levinson & Cerutti 18).



<We solve:>
- propagations of $e^\pm$ **particles, high-energy photons**
- E_r time-evolution
- interaction w/ MAD optical photons (**IC,** $\gamma\gamma\to e^\pm$)

<Parameters>
- $M=10M_\odot$, B^r at BH horizon $=2\pi\times10^7$G, $\epsilon_{s,min}=10^{-6}$
- fiducial optical depth: $\tau_0\equiv n_\gamma\sigma_T r_g=30,100,300$
- BH spin : $a=0.9$ (preliminary: $0.1,0.5$)

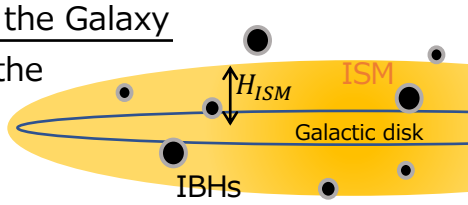
<Results>
quasi-periodic E_r opening, (almost) a independent.

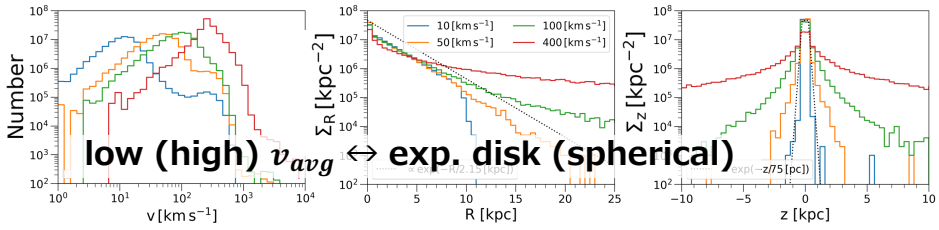


(3) Detectability estimation: model (Kin+ in prep.)

① Dynamical calculation of IBHs in the Galaxy

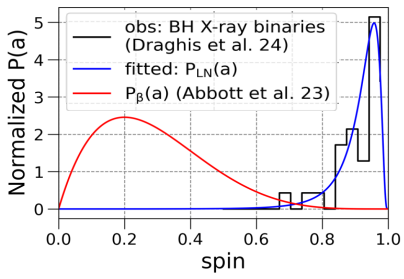
Following Tsuna+18, we calculate the **position, velocity** of each IBH.
<Parameter: SN kick velocity>
$v_{avg}=\{10,50,100,400\}$ km s^{-1}





② Calculating gamma-ray flux

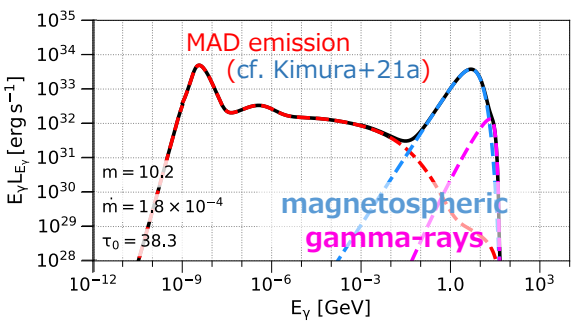
- mass/spin for each IBH:
  $dN/dM\propto M^{-3.5}$ (Abbott+23)
  $P(a)$: 2 models based on obs.
- $\dot{M}=4\pi(GM)^2m_pn_{ISM}/(c_s^2+v_{BH})^{3/2}$
  $\simeq10^{15}$g s^{-1} $\dot{m}_{(\equiv \dot{M}/\dot{M}_{Edd})}\sim10^{-3}$
- $B=\phi\sqrt{\dot{M}c}/2\pi r_g^2\simeq10^7$G
- $L_{BZ}=\kappa\pi a^2B^2r_gc/4\simeq10^{37}\kappa_{0.053}$ erg s^{-1}

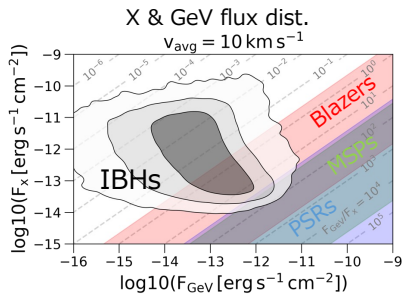


※ for $M_{10M_\odot}, n_{ISM,10^2cm^{-3}}, v_{BH,10km\ s^{-1}}, a_{0.9}$

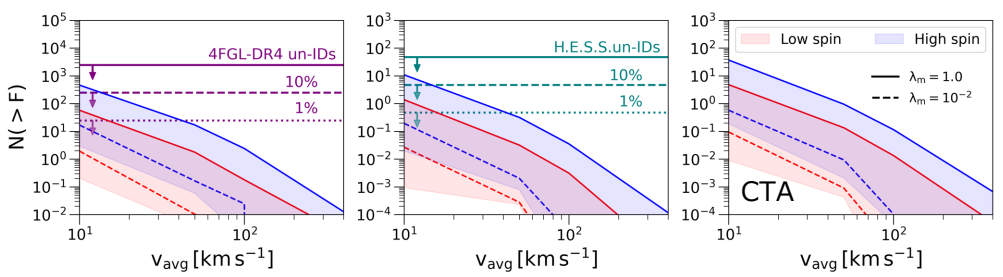
- acceleration/radiation efficiency: empirical relation in simu.(➡)
  $\tau_0\approx\left(L_s/\pi R^2\epsilon_s m_ec^3\right)\sigma_T r_g\simeq38\,\dot{m}_{-3}^{9/14}M_1^{5/14}$

(4) Detectability estimation: result

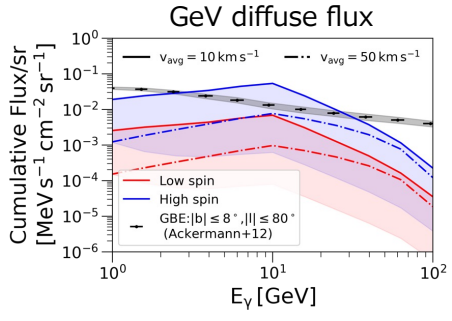




- multiwavelength detection: opt-X-GeV-sub TeV
- 10-100 detections at most ($\lesssim$ 10% of un-IDs)
- low spin/relative high v_{avg} preferred?



Comparison w/ GeV diffuse flux



Future works:
- application to AGN TeV flare
- spatial dist. of gap
- correlation to disk
  ➡ 2D simu. of BH magnetosphere