Accretion and Dynamics of Compact Objects in AGN Disks: Multimessenger Implications

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Outline

- Background
- Binary BH Merger Produces Short GRB in AGN Disk
- WD Collisions in AGN Disks
- NS Accretions in AGN Disks
- Summary and Outlook

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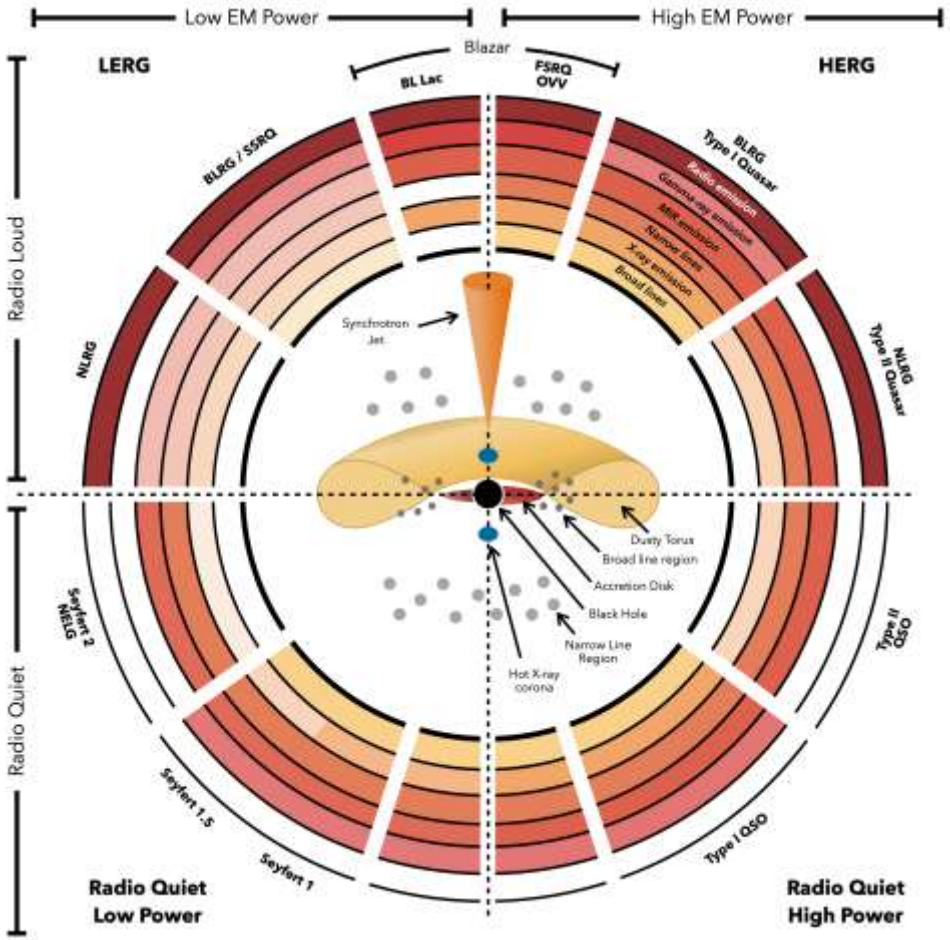
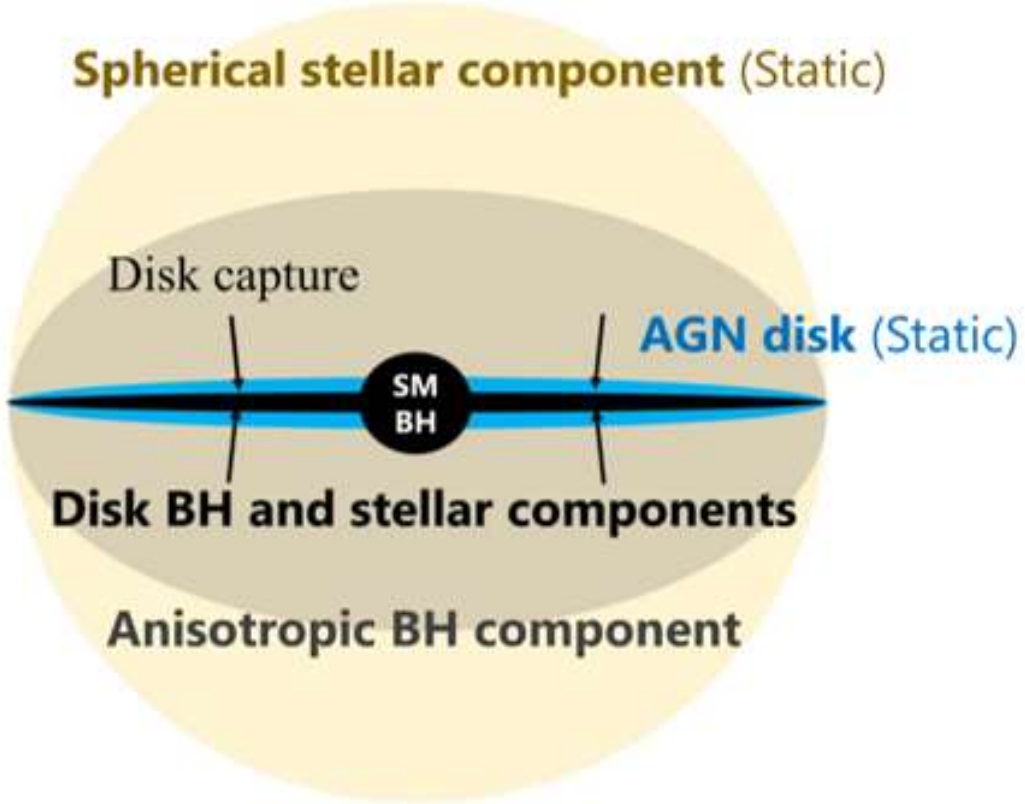
AGN Unified Model and NSC



Thorne J.E. , et al. 2022



Tagawa H., et al. 2020

- The **AGN unified model** is based on **EM** observations and typically **not** include the **compact object** component;
- **Multi-messenger** observations can reveal compact objects in AGNs.

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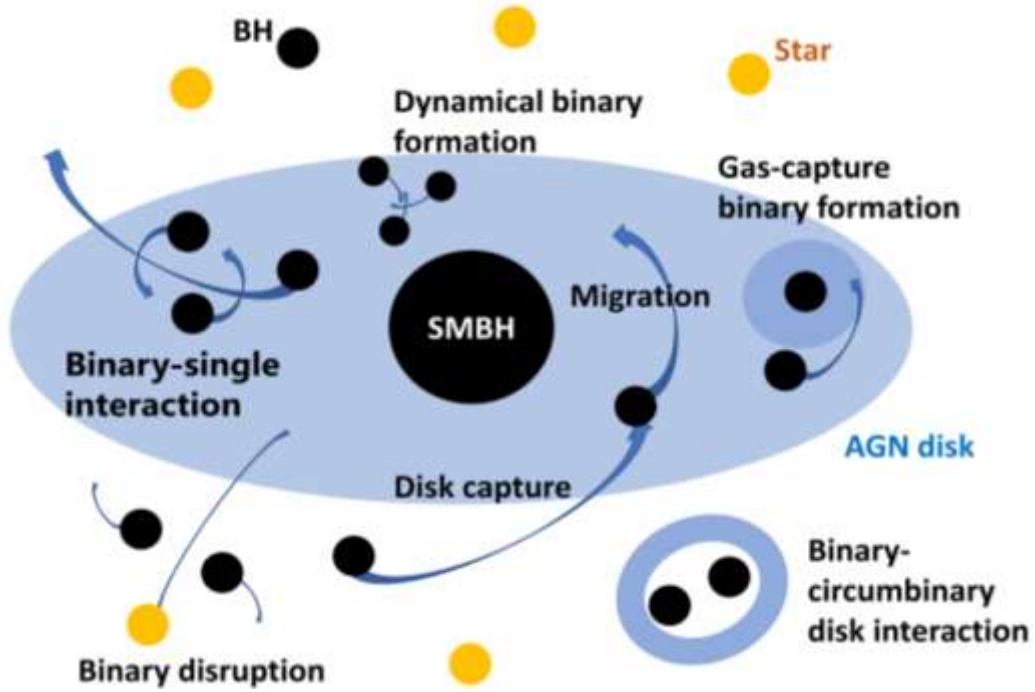

Tagawa H., Haiman Z., & Kocsis B. 2020, ApJ, 898, 25

Observational evidence/hint

GW:

- High **merger rate** *(Abbott et al. 2019).*
- Significantly **massive** than those observed in our Galaxy *(LIGO 2019)*
- **Candidate:** GW190521 *(Samsing, J. et. al. 2022)*

EM:

- **GRB** Candidate: GRB 191019 *(Lazzati et al. 2023; Levan et al. 2023)*
- Super-solar **metallicities** *(e.g. Hamann & Ferland 1999; Du & Wang 2014)*
- **QPEs** and **QPOs** *(e.g. Song, et al. 2020; Miniutti, et al. 2023)*
- **Changing-look AGNs** *(e.g. Ricci et al. 2020; Trakhtenbrot et al. 2019)*

Neutrinos:

- 79 **TeV neutrinos** from NGC 1068 *(Tagawa et al. 2023)*

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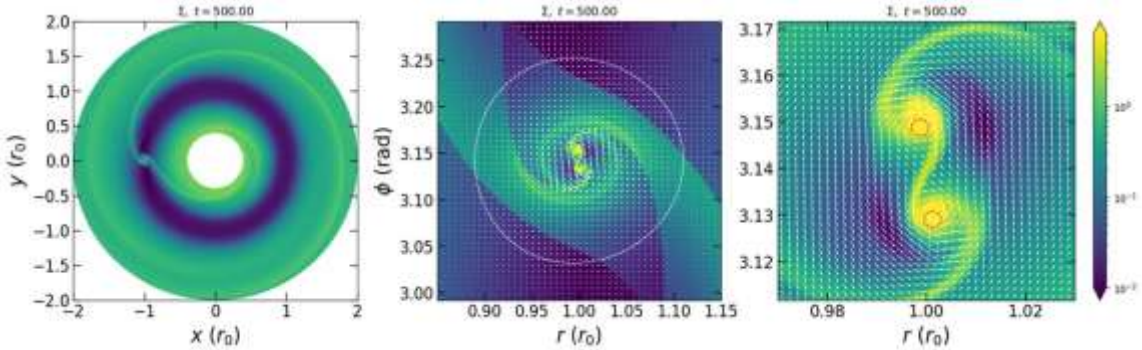
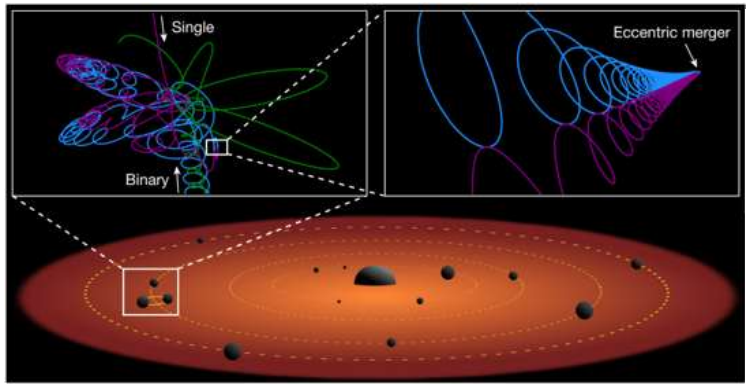
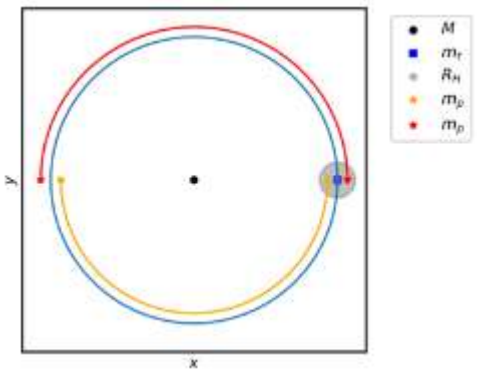
Dynamics of BHs in AGN Disks

Merger though **gas** interactions *(e.g., Li et al. 2021)*

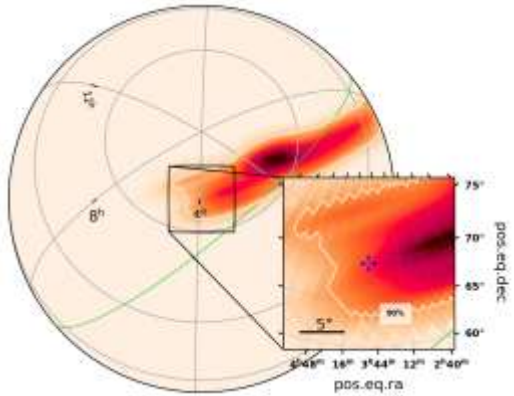


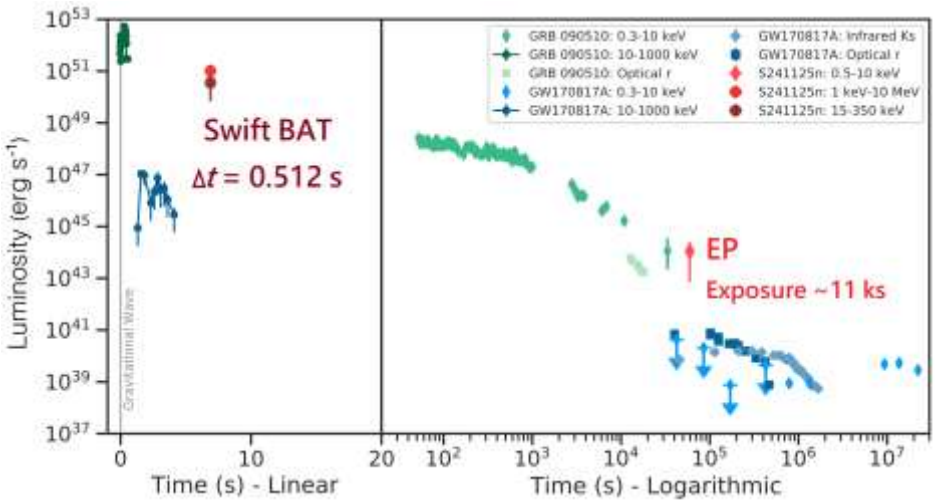
AGN disks can produce excess **eccentric** mergers through interactions with stellar-mass objects *(e.g., Samsing et al. 2022)* or the central SMBH *(Boekholt et al. 2023)*





Candidate: S241125n





Zhang, et al., ApJ (2026).

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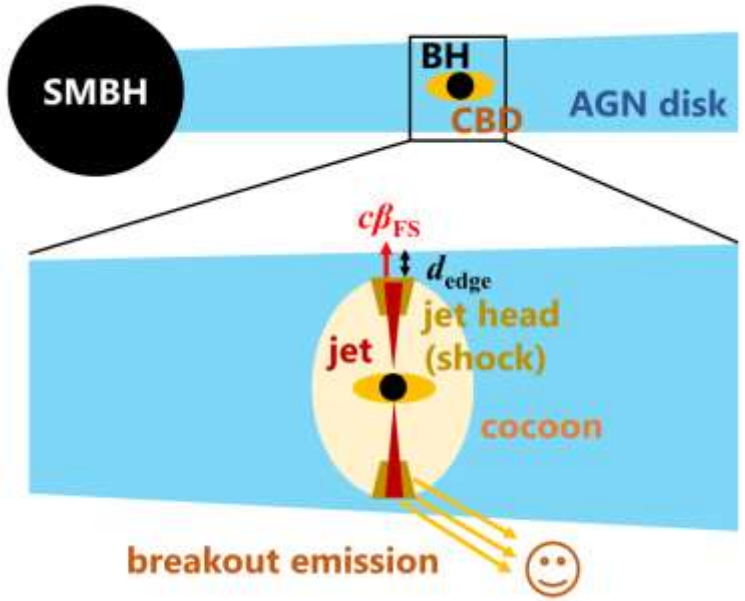
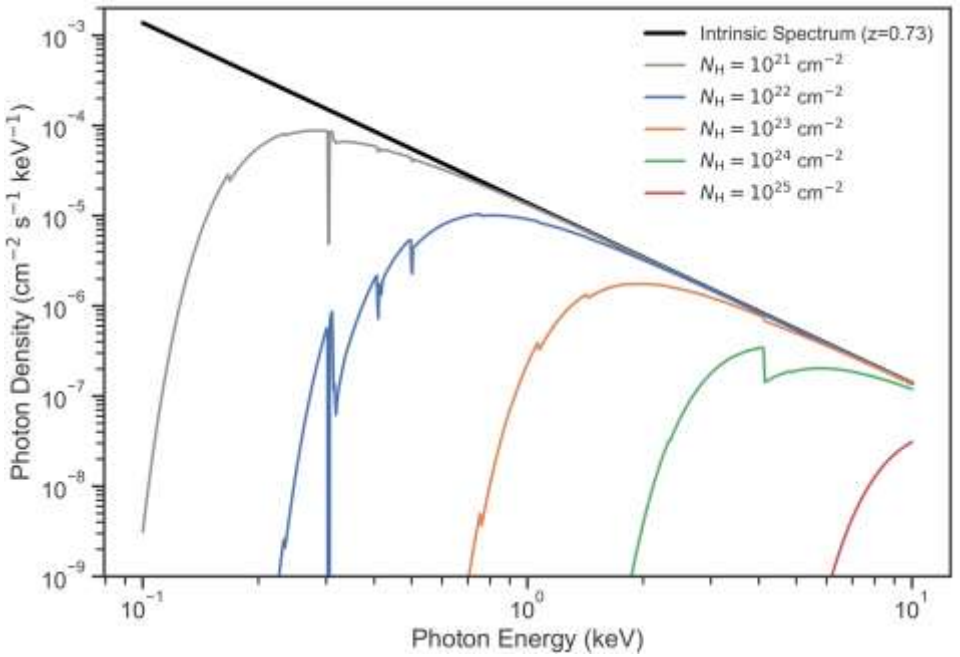
The Case of S241125n

- The **prompt's** photon index is $-2.2^{+0.6}_{-0.8}$, **softer** than the typical prompt value of ~−1.5. The **afterglow** (0.5–10 keV) shows an absorbed power-law with index $-0.43^{+0.76}_{-0.74}$, significantly **harder** than the usual afterglow value of −2.



BH accretion and jet launched in AGN disk *(Tagawa et al. 2023)*



X-ray absorption effects on a power-law spectrum *(Zhang, et. al., ApJ. 2026)*

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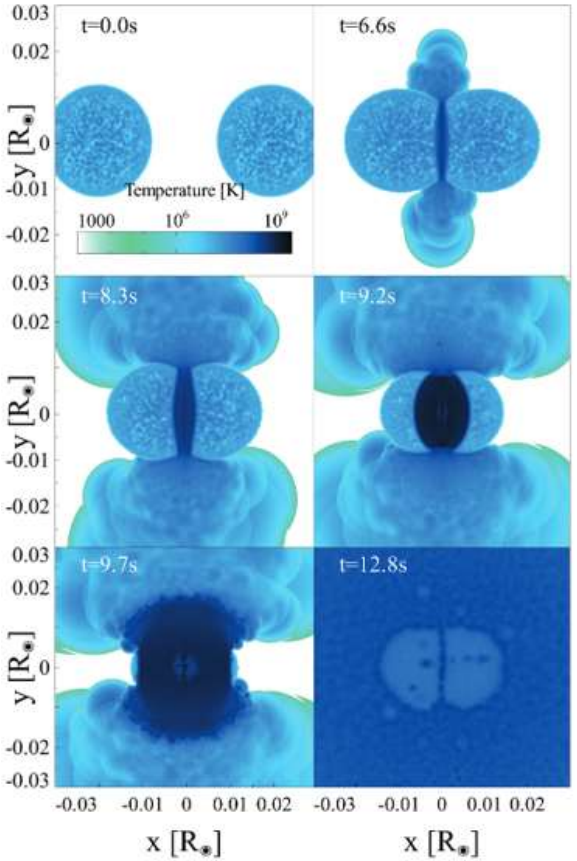
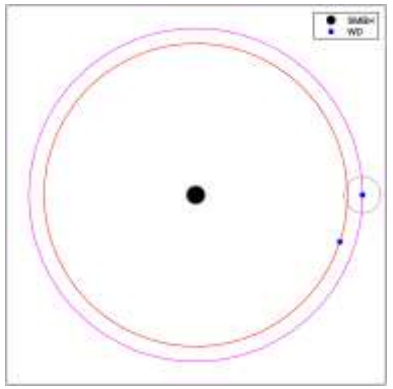
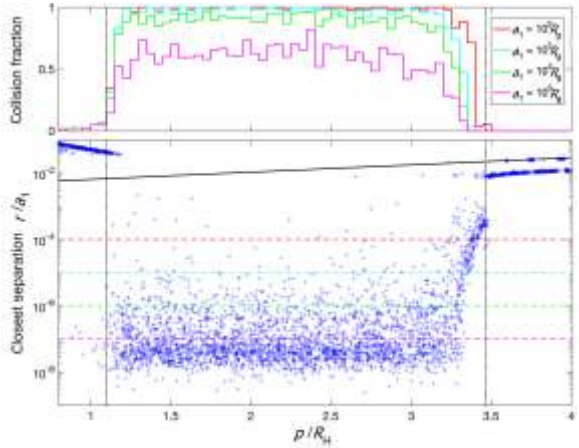
WD Collisions in AGN Disks

WD–WD Collision and Thermonuclear Explosions (*Raskin et al. 2009*)

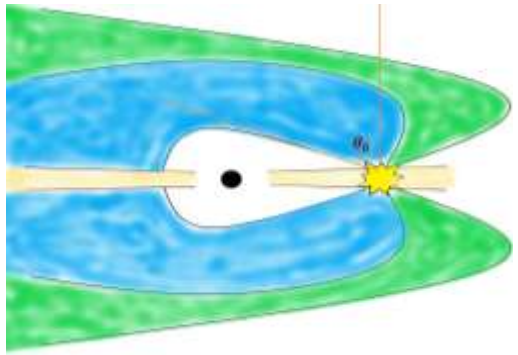


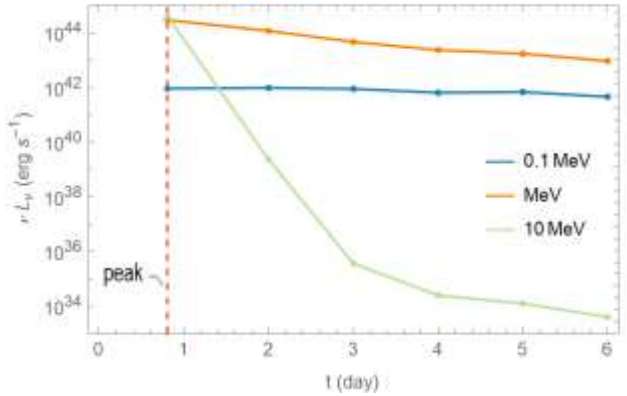




WDs Close Encounters in AGN Disks

Luo, et al. (2023).
Zhang, et al. (2023).





- WD–WD **collisions** occur efficiently in AGN disks through close encounters and trigger **thermonuclear explosions**.
- The enormous **kinetic energy** released in AGN disks can generate significant **MeV** radiation.

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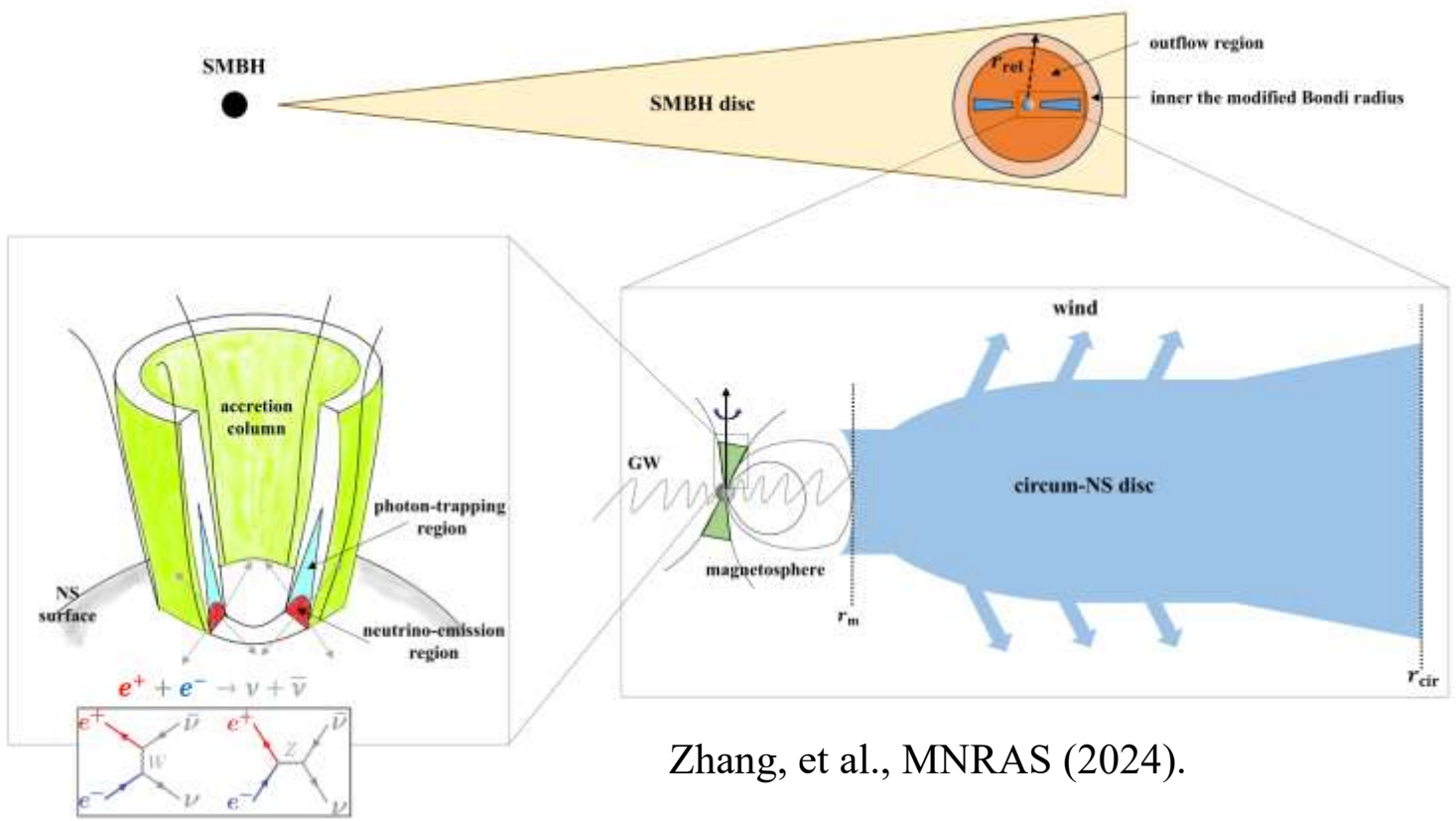
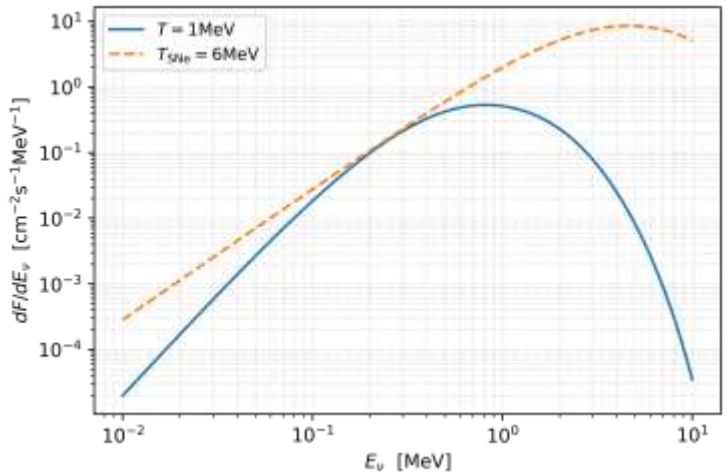
NS Accretion in AGN Disks

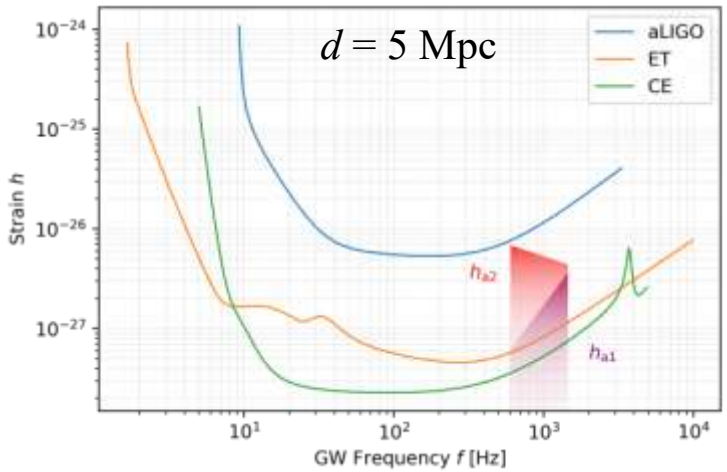


Zhang, et al., MNRAS (2024).

Diffuse Neutrino Background



GW from NS "Mountains"



- **Neutrino** and **GW** emissions carry away **energy** and **angular momentum** from accretion, weakening the **feedback** on the AGN disk. This results in an exceptionally **high** NS **accretion rate**, making it less likely that binary NS **mergers** originate from AGN disks.

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Summary and Outlook

By studying the **accretion** and **dynamics** of **various** compact objects in AGN disks, their respective fates and the resulting multi-wavelength and multi-messenger signals are investigated. *Probe the Role of Compact Objects in AGNs Through Multi-messenger Approaches* has much room for exploration:

- How these **objects** and various **explosive events** in AGN disks influence the AGN **disk structure?**
- How stellar objects **connect** between the central **SMBH** and **larger scales** of AGNs? What are the roles of stellar objects in the **growth of SMBHs**?
- **Observational searches** for more stellar objects in AGN disks, pushing into the **population-level** regime, and further applications to **cosmological tests**.

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Thanks!
SMBH

Outline

- Content

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