Probing the pulsar explanation of the GeV excess using GW

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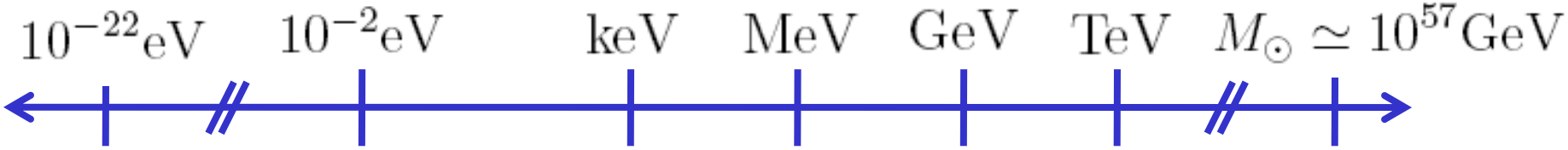
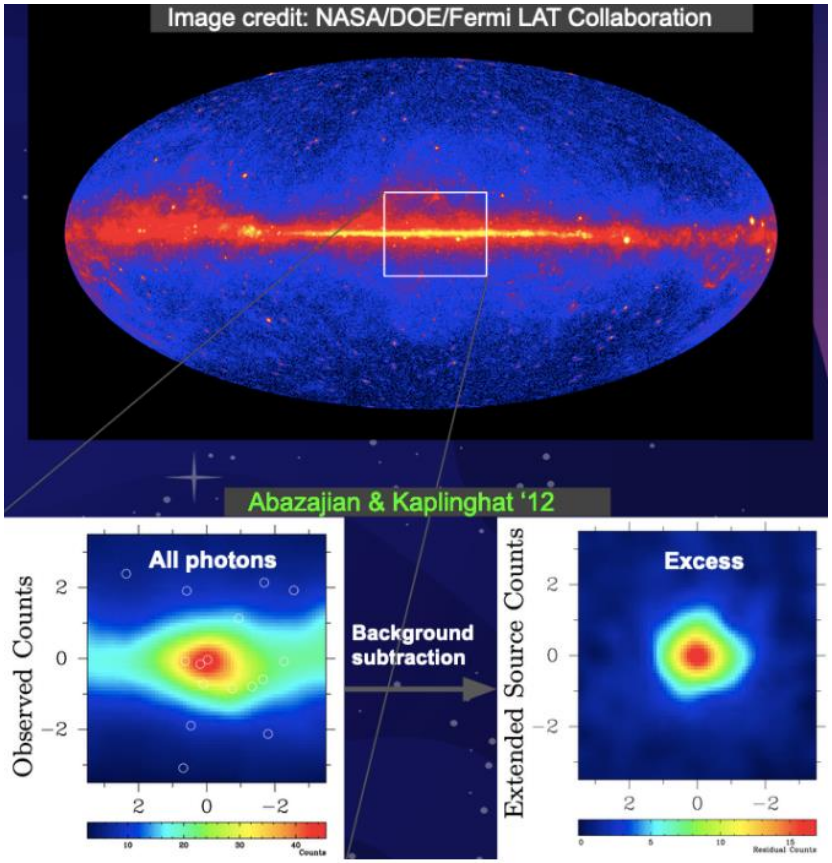
A GeV excess at the Galactic Center:

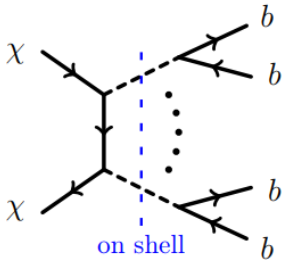


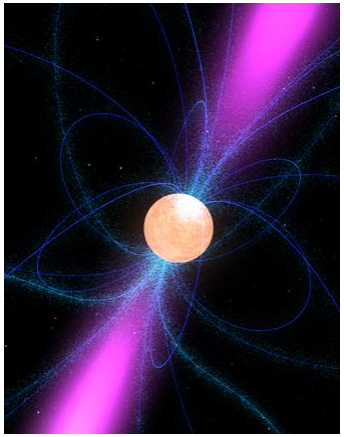


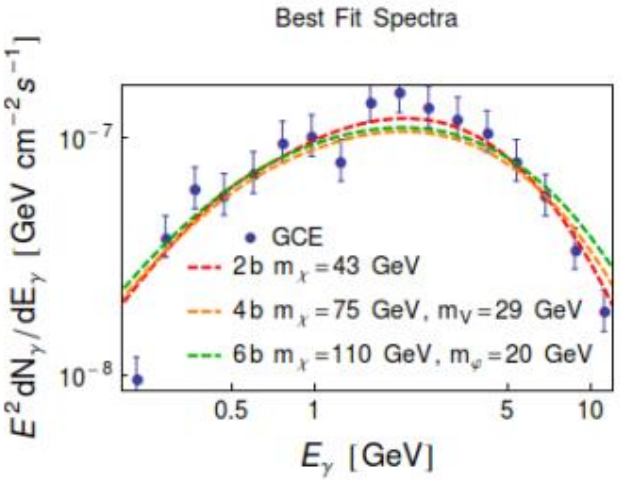
Well motivated.
Correct relic abundance.
Searched for decades.

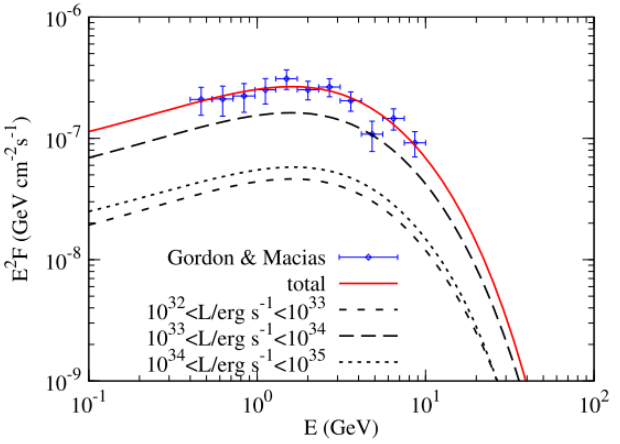
Fermi Gamma-ray Space Telescope

Two explanations:







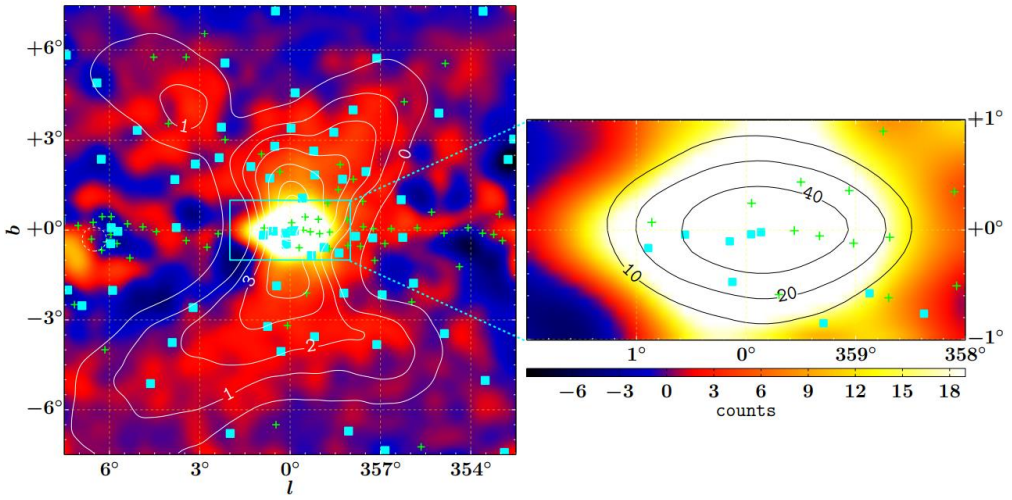


Abdullah, et. al.
Phys. Rev. D 90, 035004 (2014)

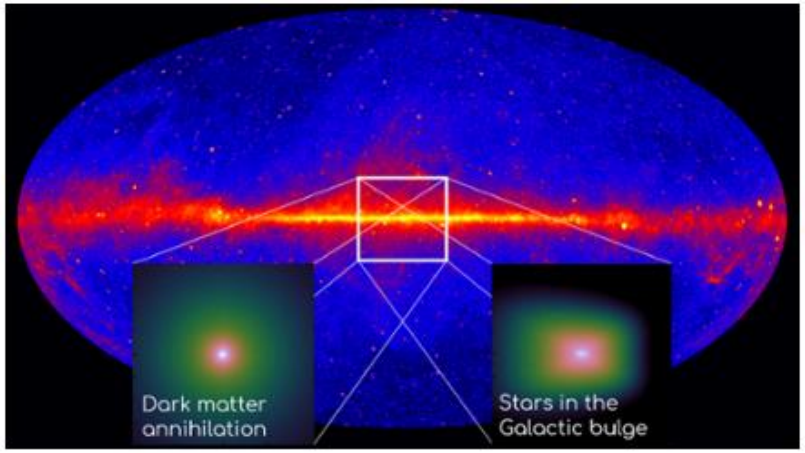
Yuan, et. al.
JHEAp 3 (2014) 1

Efforts to distinguish these two explanations:

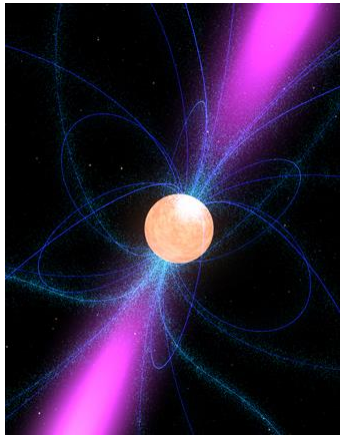
- Smoothness: Point Source v.s. Smeared Distribution

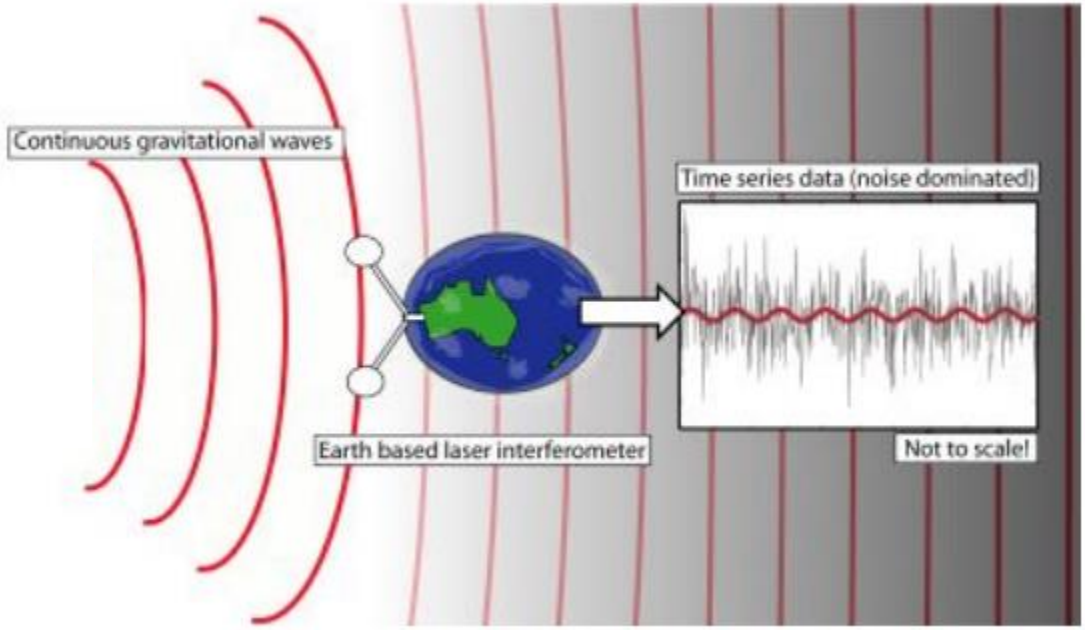


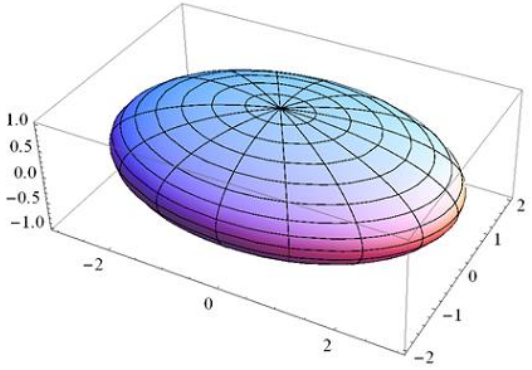
- Morphology: Spherical v.s. Bulge-like



GW channel can be useful:



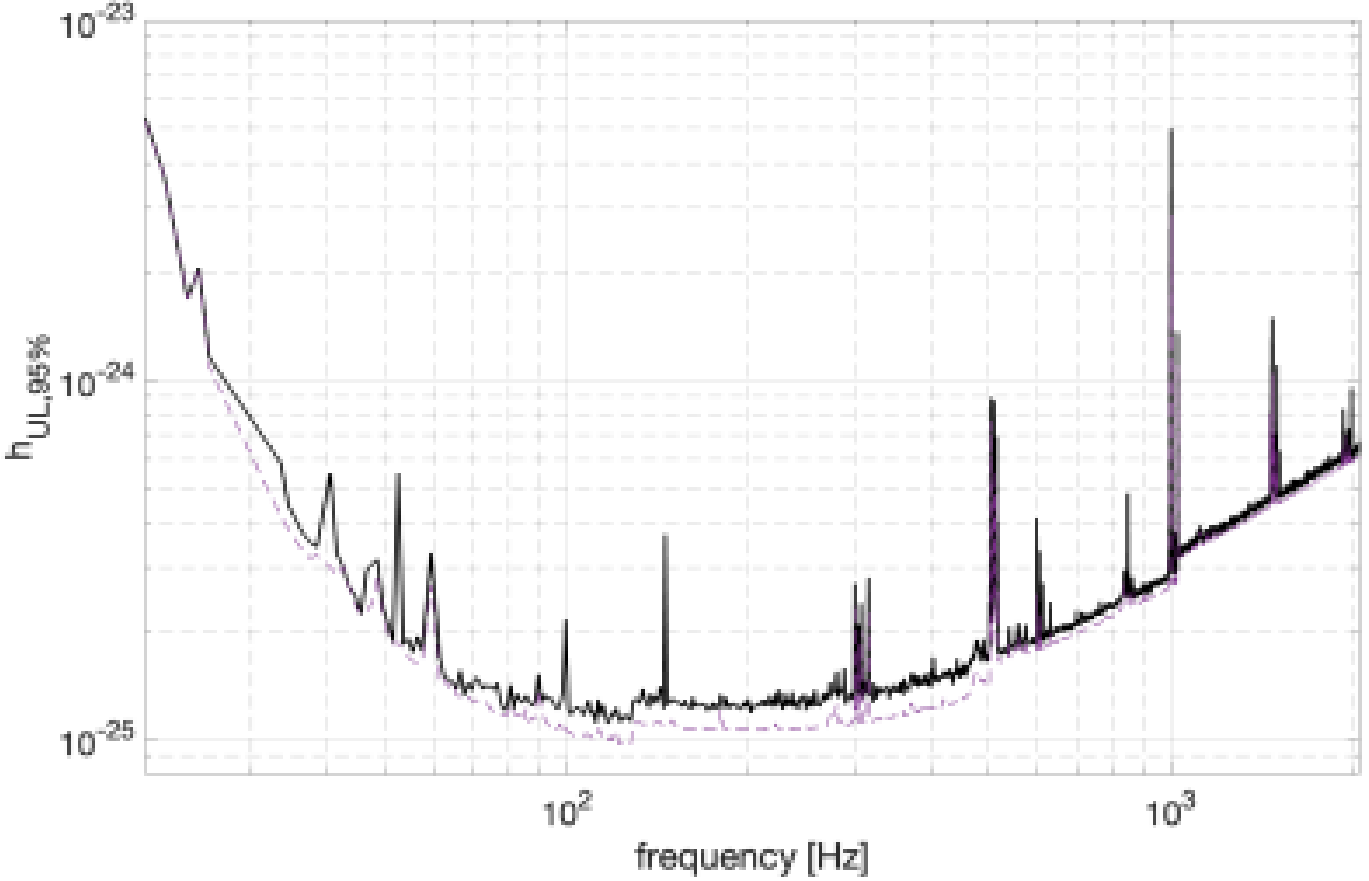




$$h_0 = \frac{16\pi^2 G}{c^4}\frac{I_{zz}\epsilon f_{rot}^2}{d}$$

WIMP DM:

The LVK collaboration
Phys. Rev. D 106, 102008

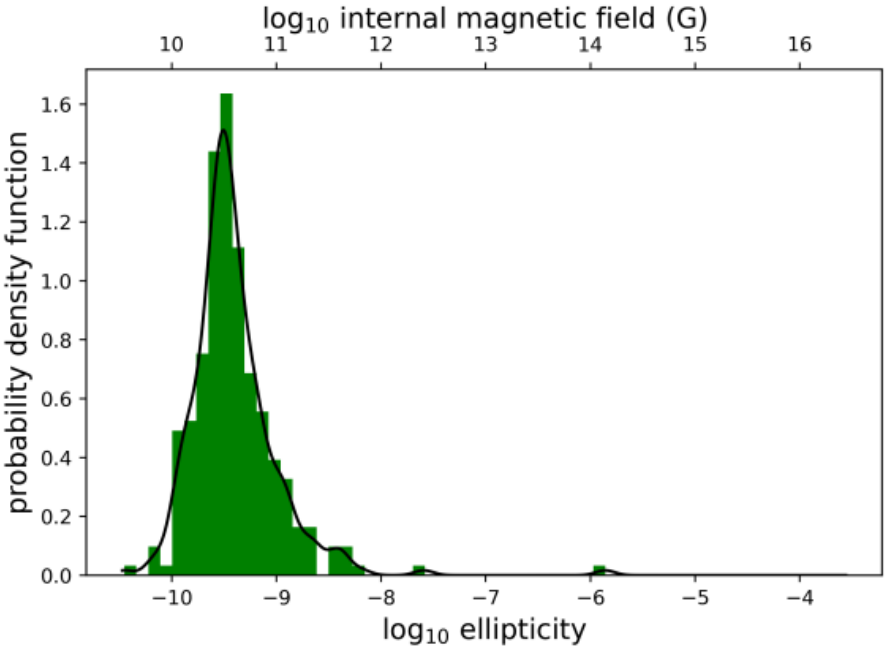


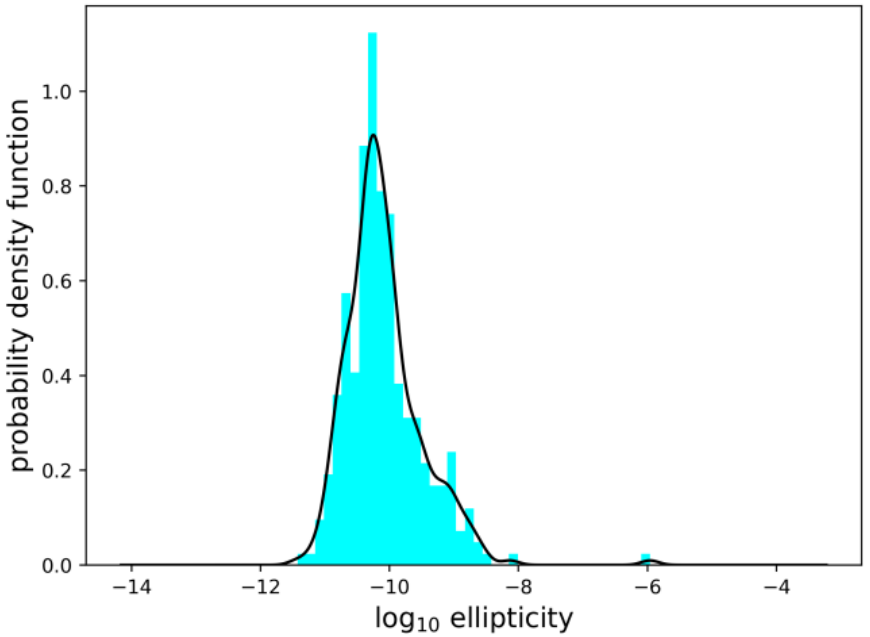
Ellipticity distribution:

$$h_0 = \frac{16\pi^2 G}{c^4}\frac{I_{zz}\epsilon f_{rot}^2}{d}$$

$$\epsilon \equiv |I_{xx} - I_{yy}|/I_{zz}$$

principal moments of inertia





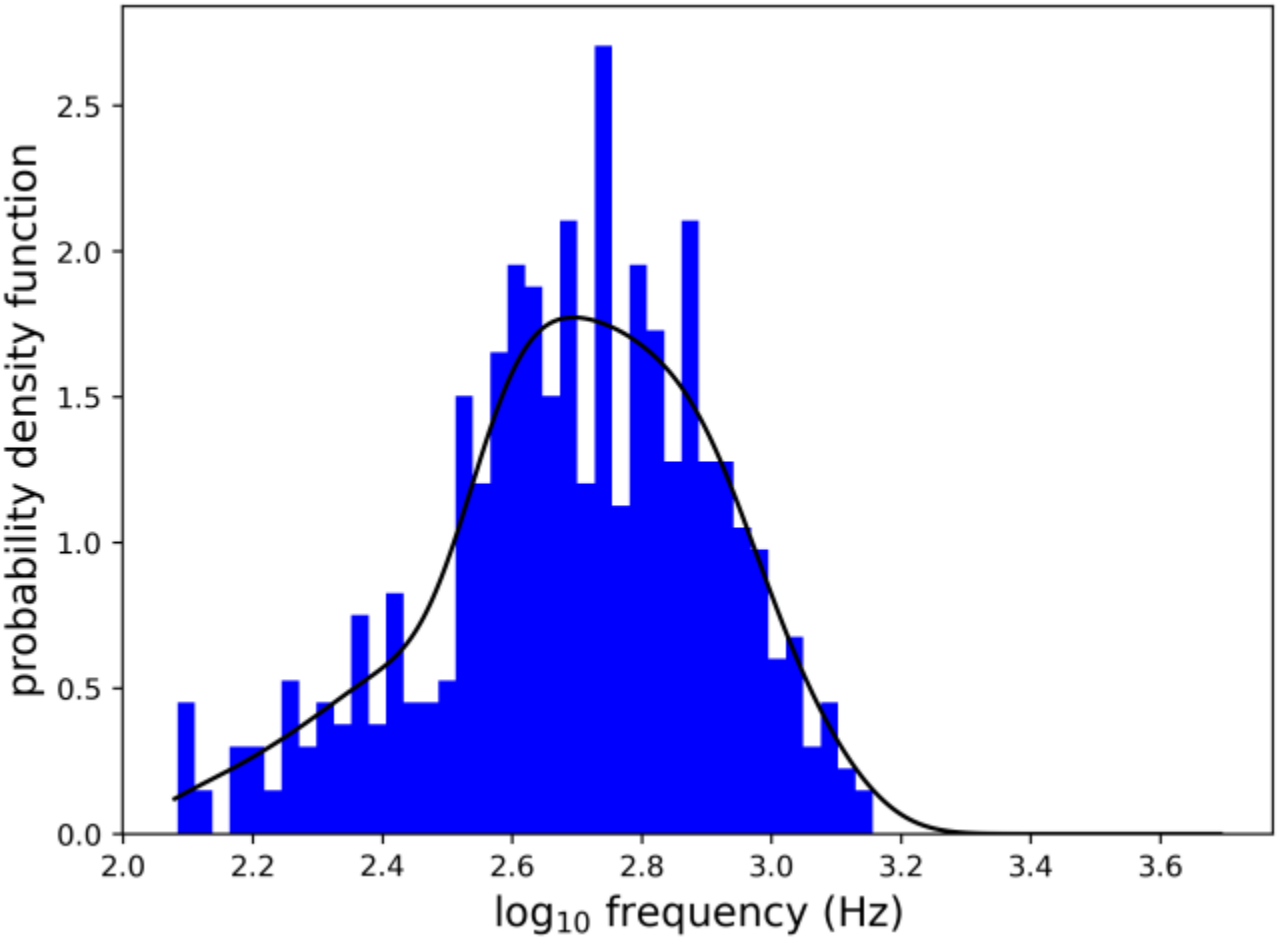
$$\epsilon \approx 10^{-8}\left(\frac{B_{int}}{10^{12}\,\mathrm{Gs}}\right)$$

$$B_{int} = 150 B_{ext}$$

GW radiation accounts for 1% rotational energy loss.

Frequency distribution:

$$h_0 = \frac{16\pi^2 G}{c^4}\frac{I_{zz}\epsilon f_{\rm rot}^2}{d}$$

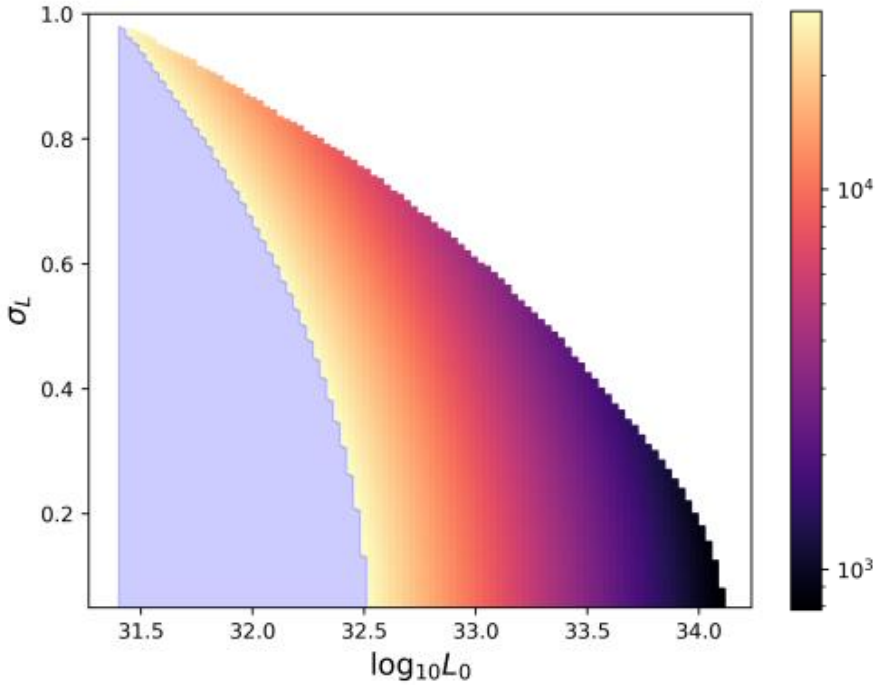


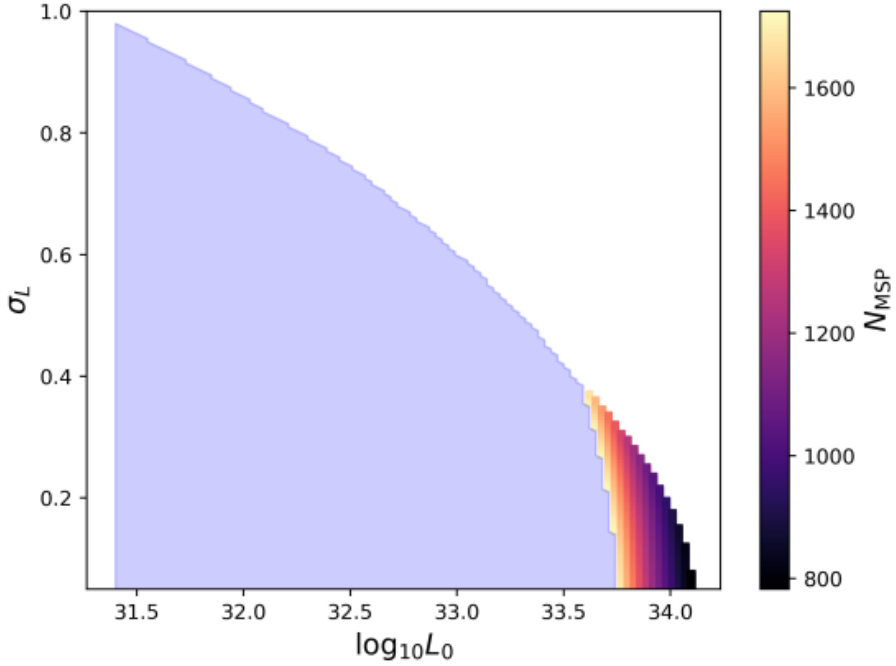
WIMP DM:

Andrew Miller, Y.Z.

Phys.Rev.Lett. 131 (2023) 8, 081401

$$\frac{dP(L)}{dL} = \frac{\log_{10} e}{\sigma_L \sqrt{2\pi} L} \exp\left(-\frac{\log_{10}^2(L/L_0)}{2\sigma_L^2}\right)$$





1% energy loss through GW

$$d = 8 \text{ kpc}$$

$$I_{zz} = 10^{38} \text{kg}\cdot\text{m}^2$$

$$B_{\rm int} = 150 B_{\rm ext};\ d = 8 \text{ kpc}$$

$$I_{zz} = 5 \times 10^{38} \text{kg}\cdot\text{m}^2$$

Conclusion:

The origin of the GeV excess at the galactic center:

dark matter or milli-second pulsars

We need a lot of these MSPs to explain the GeV excess.

GW provides a good probe to distinguish these two interpretations.

The current limits from LVK is already quite strong.
We expect more parameter space can be probed in near future.

Better sensitivity in the next LVK run.
Optimized analysis pipeline is under construction.
SGWB vs Continuous wave.