X-ray flare and plateau as a tool for probing the GRB central engine

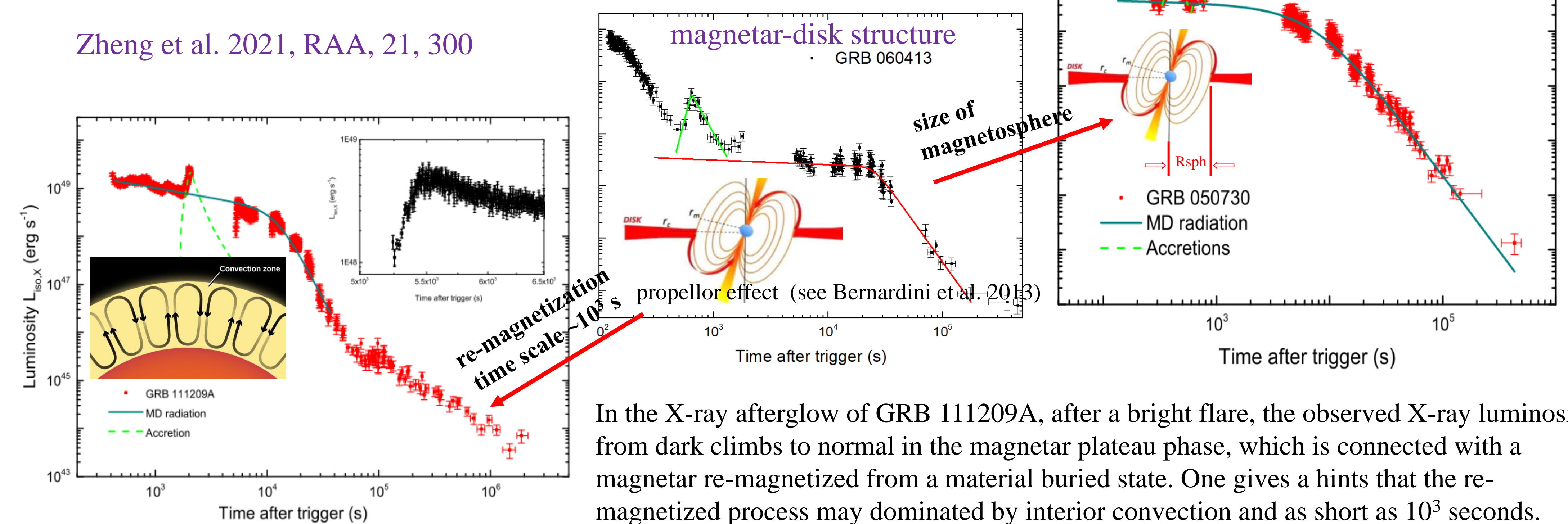**Tianci Zheng** (https://tianci-zheng.github.io/)

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Abstract: The study of the central engine of gamma-ray bursts (GRBs) can offer specific insight into extreme conditions physics. However, it's uneasy to conclude the properties of a certain GRB. Finding clues of central engine activities in the prompt and afterglow emission is a popular method. By combining the X-ray flare and plateau in the afterglow phase, we studied the magnetar's magnetosphere size and its re-magnetized process. In the afterglow of GRB 050904, possible Quasi-Periodic Oscillation (QPO) signature throughout the internal plateau and the subsequent sharp decay (slope ~ -6). One can't be readily explained by massive magnetar scenario, but favors Kerr black hole (BH) powered BZ jet scenario.

Flares rising upon the magnetar plateau gives an implication for magnetar-disk structure

There are muti-flare upon the magnetar plateau in the X-ray afterglow of GRB 050730, one favors a steady-state disk scenario. It's used to study the average mass flow rate of disk and the size of the magnetar's magnetosphere
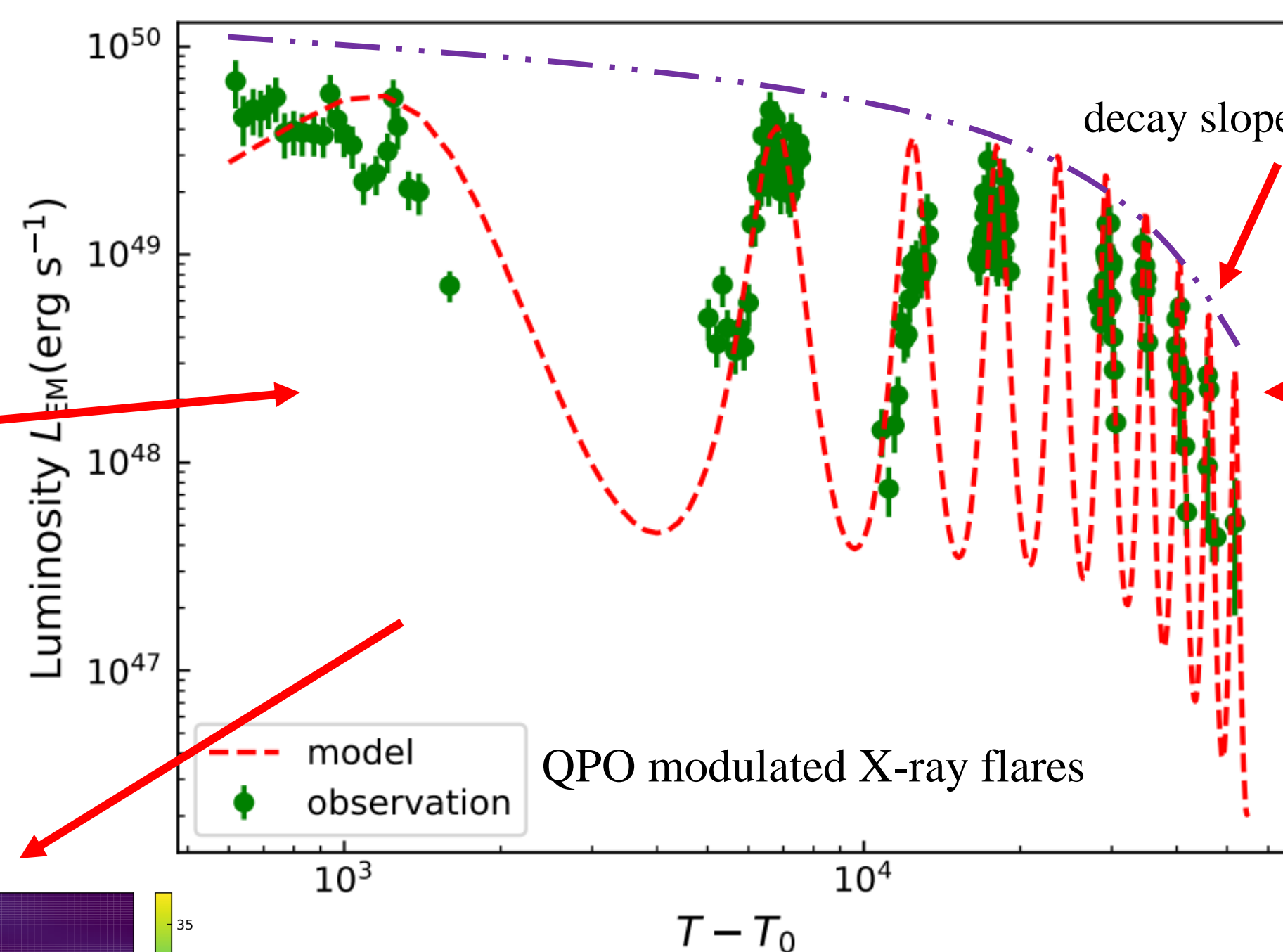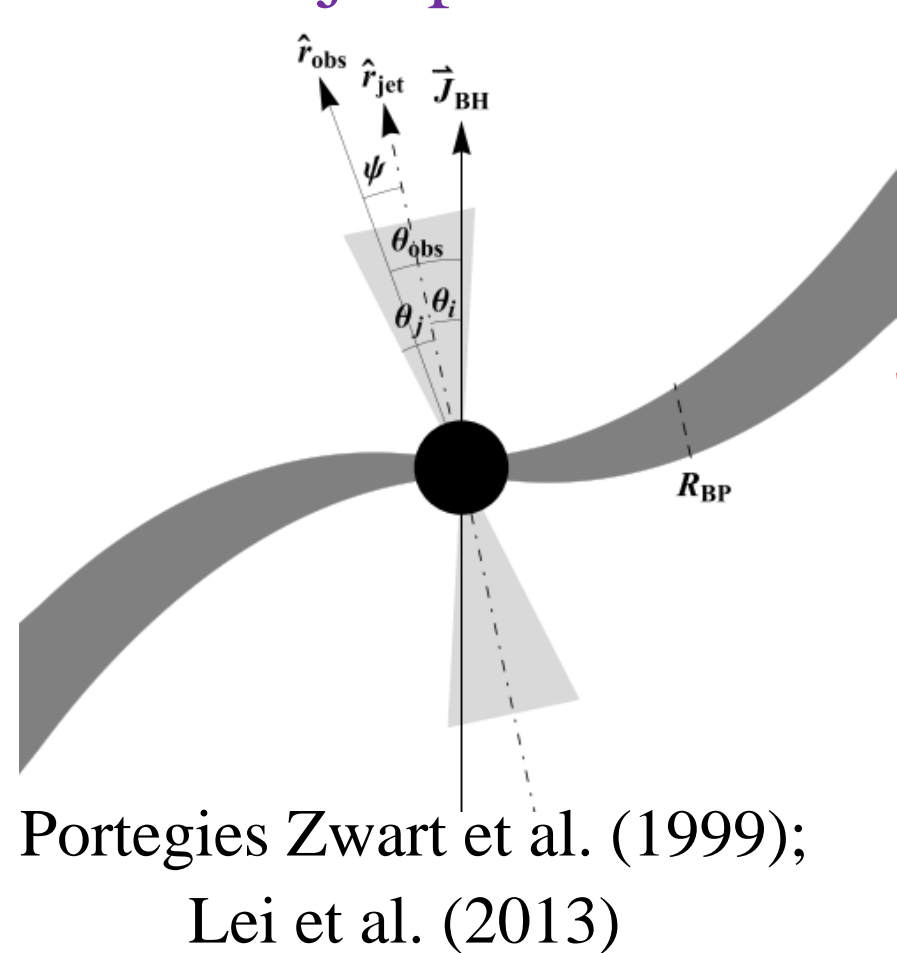
Zheng et al. 2021, RAA, 21, 300

magnetar-disk structure

GRB 060413

size of magnetosphere

propellor effect (see Bernardini et al. 2013)
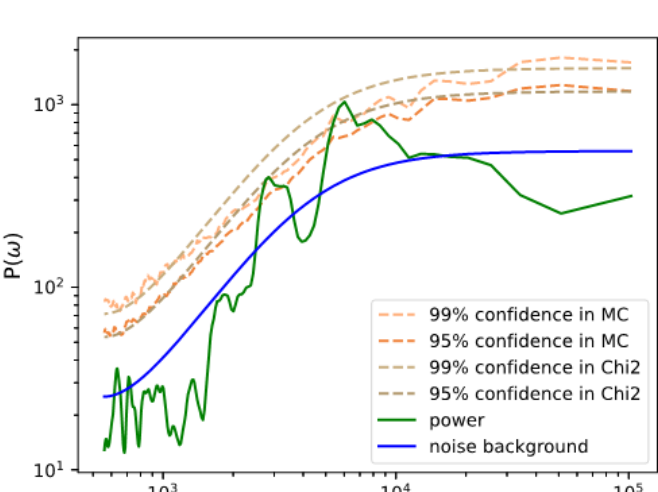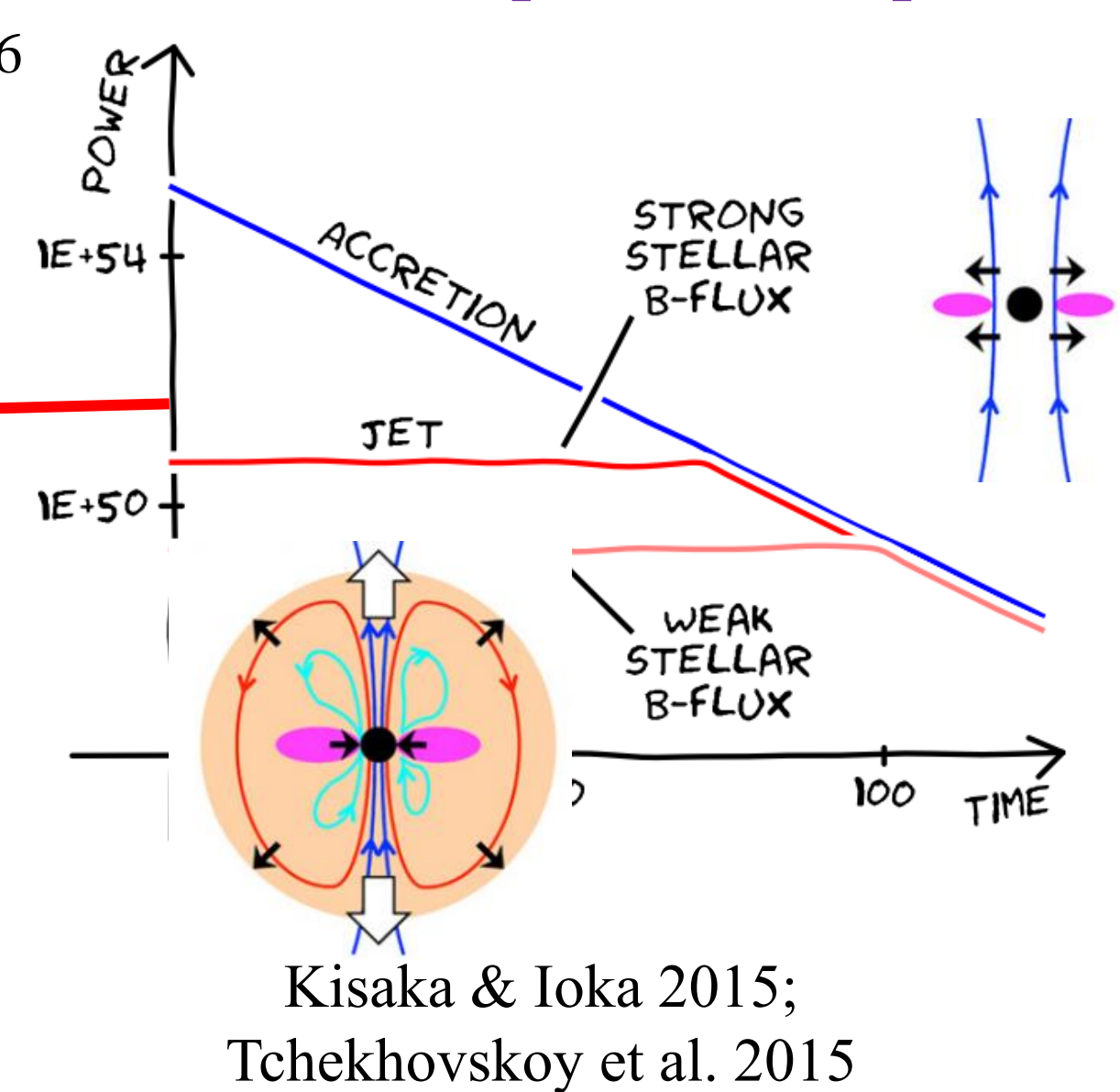
re-magnetization time scale ~10³ s

In the X-ray afterglow of GRB 111209A, after a bright flare, the observed X-ray luminosity from dark climbs to normal in the magnetar plateau phase, which is connected with a magnetar re-magnetized from a material buried state. One gives a hints that the re-magnetized process may dominated by interior convection and as short as 10^3 seconds.

The Activity of Black Hole Imprints on the Internal Plateau and the Subsequent Sharp Decay
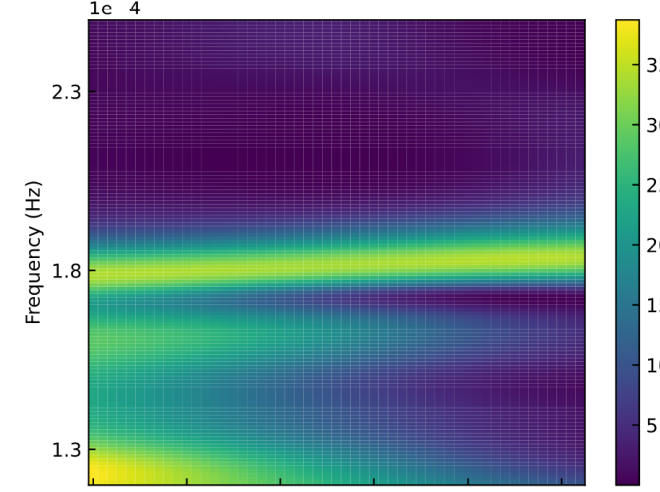
Lensing-Thirring effect induced disk and jet precession

Portegies Zwart et al. (1999);
Lei et al. (2013)

decay slope ~ -6

QPO modulated X-ray flares

- - - model
● observation

Accretion dependent BZ power

Kisaka & Ioka 2015;
Tchekhovskoy et al. 2015

Periodicity test (REDFIT, Schulz & Mudelsee 2002; WWZ, Aydin 2017)

ApJ submitted:
A. We propose that a precessing BZ jet would manifest a QPO signature on the internal plateau and the subsequent sharp decay. A good case study given by GRB 050904.
B. One potential clue for distinguishing magnetar and BH central engines: whether QPO signature is throughout the plateau and the subsequent sharp decay.

References:
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Kisaka, S. & Ioka, K. 2015, ApJL, 804, L16.
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Tchekhovskoy, A. & Giannios, D. 2015, MNRAS, 447, 327.
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