LENSES-THIRRING
PRECESSION DURING
TIDAL DISRUPTION
EVENTS

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Tidal Disruption Events (TDEs)

Star wanders too close to a SMBH (Rees 1988) torn apart by its tidal field

\[ r_t \approx 0.47 \text{ au} \left( \frac{M_6}{m_*} \right)^{1/3} x_* \]

Impact parameter \( \beta = \frac{r_t}{r_p} \gtrsim 1 \) disruption

\[ t_{\text{min}} \approx 41 M_6^{1/2} m_*^{-1} x_*^{3/2} \tau \]

\[ \dot{M}_{fb} = \dot{M}_p \left( \frac{t}{t_{\text{min}}} \right)^{-5/3} \]
Tidal Disruption Events (TDEs)

- Very bright flares, super-Eddington in the early phase
- Last weeks
- Luminosities declining with $t^{-5/3}$

Quasi-periodicity in the light curve of the event $t_p \approx 2.7$ days

Could it be the disc rigid precession causing the jet precession? (Stone & Loeb 2012, Lei et al. 2013, Shen & Mazner 2014)
Accretion disc

Stellar debris orbits circularize at \( r_c \approx 2r_t \) and form an accretion disc (Bonnerot et al. 2015)

\[
    r_{\text{out}} = 94M_6^{-2/3}
\]

\[
    r_{\text{in}} = r_{\text{isco}}
\]

Black hole spin

Narrow disc (radiation pressure dominated)
Accretion disc

Super-Eddington ($\dot{m} = \dot{M}/\dot{M}_{\text{Edd}} \gtrsim 1$) accretion in the early phase, the disc is hot and then it is expected to be thick.

$$\frac{H}{R} = \frac{3}{2} (2\pi)^{1/2} \eta^{-1} \dot{m} r^{-1} f(r) K(r)^{-1}$$

$$\dot{m} = r/r_{\text{in}}$$

$$\dot{m}_{\text{fb}} = \dot{m}_p (t/t_{\text{min}})^{-5/3}$$
Warp

Stellar orbit inclined with respect to the black hole equatorial plane coupling between the disc and the black hole angular momenta.

Lense-Thirring effect \( \Omega_{LT} \approx \frac{2GJ_h}{c^2(R^3)} \)

Warp propagation in the bending wave regime since the disc is thick

\( H/R \gtrsim \alpha \)

Propagation with half the sound speed

\( t_w = \frac{2}{\Omega} \left( \frac{H}{R} \right)^{-1} \)
Rigid precession

\[ a = 0.7 \, M = 10^7 \, M_\odot \]

\[ a = 0.9 \, M = 10^6 \, M_\odot \]
Precession period

Precession frequency depends on SMBH mass and spin.

\[
\Omega_p = \frac{\int_{R_{in}}^{R_{out}} \Omega_{LT}(R) L(R) 2\pi R dR}{\int_{R_{in}}^{R_{out}} L(R) 2\pi R dR}
\]

Franchini et al. (2015) (submitted)
Alignment

After some time the precession stops, meaning that the disc angular momentum is aligned with respect to the SMBH spin (no longer coupling).

\[ t_{\text{thin}} \propto \alpha^{-3/5} \]

\[ t_{\text{align}} \propto \alpha^{-1} \]
Conclusions and outlook

• Calculate the precession period so that it can be linked with the SMBH spin value

• Study the alignment process

• Apply this model in the case of QPOs in LMXBs.

• 3D SPH (Smoothed Particle Hydrodynamics) simulation with the aim to study the wave propagation inside the disc more deeply
THANK YOU!