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The near-pericenter self-intersection of the debris stream in TDEs by a misaligned Kerr black hole

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In TDEs, the stream-stream collision is an important way to dissipate orbital energy in the process of circularizing the debris stream. For non-rotating black holes (BHs), due to the apsidal precession the stream intersects with itself near the its orbital apocenter after a single winding. However, for rotating BHs, the out-of-plane precession arising from the Lense-Thirring effect may prevent the above apocenter intersection, and the stream will instead continue to fall back to pericenter and may self intersect near the pericenter.

We perform local 3-D hydrodynamic simulations of the stream self-intersections near pericenter with Athena++, with the BH' s gravity included. The stream components that intersect at the pericenter have a width difference and a vertical offset, thus a large fraction of the stream can avoid the collision. For a BH mass of $10^6 M_\odot$ and a orbital penetration factor of 3 and in the case of offset collision where only 14% of the stream collides, we find that 0.5% of the stream kinetic energy is dissipated. After the collision, the stream experiences a lateral expansion, which makes its width to increase with radius more quickly than the case without a pericenter intersection. Our results suggest that for Kerr-BH TDEs which people once thought to have a delayed circularization, the stream intersection at the pericenter is likely to promote collisions in subsequent orbits and accelerate the disc formation.

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