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Tidal Stream Circularization by Schwarzschild Black Holes

MICHAEL KESDEN, JUAN SERVIN, Univ of Texas, Dallas — A star that wanders within the tidal radius $r_t \simeq R_\star(M_\bullet/M_\star)^{1/3}$ of a supermassive black hole (SMBH) will be torn apart by the tidal field of the SMBH. Approximately 50% of the tidal debris will become gravitationally bound to the black hole and evolve into a tidal stream with a distribution of specific binding energies of width $\Delta\epsilon \simeq GM_\bullet R_\star/r_t^2$. This tidal stream must dissipate substantial energy [increasing its specific binding energy to $E_c \simeq (\Delta\epsilon/4)(M_\bullet/M_\star)^{1/3}$] if it is to form a quasi-circular accretion disk at the circularization radius $r_c \simeq 2r_t$ from which gas can be accreted onto the SMBH, powering a luminous tidal disruption event (TDE). This energy dissipation may occur in an inelastic collision when the stream intersects with itself. The timing and efficiency of energy dissipation at this collision point depends crucially on the kinematics of the tidal stream including relativistic apsidal precession. We calculate the energy dissipated at the collision point as a function of SMBH mass and stellar penetration factor $\beta = r_t/r_p$ and the resulting delays to disk circularization.

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