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Binary Stars Approaching Supermassive Black Holes: Tidal Break-up, Double Stellar Disruptions and Stellar Collision

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In galactic centers, stars and binaries can be injected into low-angular-momentum orbits, resulting in close encounters with the central supermassive black hole (SMBH). We use simulations to study such encounters under a wide range of conditions. Depending on the system parameters (such as β_b, the ratio of binary tidal radius to pericenter distance r_p to the SMBH, and the compactness of the binary), such close encounters can lead to the break-up of the binary, disruptions of both stars and collision between the stars. Binary break-up produces a hyper-velocity star and a bound star around the SMBH; the peak value of the orbital binding energy depends weakly on β_b. When r_p is comparable to the stellar tidal radius, sequential disruptions of the stars occur within a time interval much shorter than the initial binary orbital period. Stellar collisions occur for a range of β_b's, with a few to 10's percent probabilities (depending on the compactness of the binary). The merger remnants are either ejected or bound to the SMBH. We suggest that stellar collisions induced by binary-SMBH encounters may produce exotic stars in galactic centers, trigger accretion flares onto the SMBH due to the mass loss, and result in bound merger remnants causing repeated partial TDEs. We also carried out hydrodynamical simulations on double stellar disruptions and stellar collisions. We explored the mass loss during the collision and calculated the fallback rate onto the SMBH, which could potentially result in light curves distinct from TDE flares.

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