Unraveling the late phases of common envelope evolution in binary stellar systems with 3D MHD simulations

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Common envelope evolution is a phase in the life of binary stellar systems during which one of the components, a giant star, expands and initiates a dynamically unstable mass transfer onto its more compact companion, causing the latter to be swallowed up. This process is a key step in the formation of various observed tight binary systems, such as cataclysmic variables, X-ray binaries, or type Ia supernova progenitors. In addition, common envelope evolution is at the origin of a significant fraction of gravitational wave progenitors.

Despite being arguably one of the most crucial major processes in binary star evolution, common envelope evolution is also the least-well-constrained and more generally one of the most important unsolved challenge in stellar evolution. Despite being numerically challenging and subject to major uncertainties, 3D-hydrodynamic simulations have provided a comprehensive understanding of the initial phase consisting of the rapid inspiral of the two cores inside the shared envelope. However, because of the wide range of temporal and spatial scales that need to be resolved and the associated high numerical cost, such simulations are often halted soon after the end of this first phase, when the inspiral of the two cores has slowed considerably.

In this talk, I will present recent results from the first 3D-magnetohydrodynamic simulations focusing on the late phases of common envelope evolution by means of an original setup mimicking the preceding rapid inspiral, with the adaptive mesh refinement code Athena++. I will discuss the impact of mass and angular momentum accretion on the orbital contraction timescale of the binary, and the short-term variability of accretion and its remarkable similarity with that in circumbinary disks (Gagnier & Pejcha 2023). Finally, I will discuss the mechanisms behind magnetic energy amplification, and the impact of magnetic fields on binary separation evolution and angular momentum transport (Gagnier & Pejcha 2024).