Theory and observations of two stars undergoing strong interaction

Stars, especially massive ones, are commonly found in binary systems with such low separations that the stars are close enough to interact with each other through tidal forces and phases of mass transfer. Binary interactions shape the evolution of numerous stellar systems, producing a variety of exotic stellar objects as well as various transients arising from accretion or stellar evolution. This thesis aims to investigate different types of stellar interactions to constrain new and existing models.
For the first part of this work, we conducted a thorough analysis of the observations of the peculiar cataclysmic variable OGLE-BLG504.12.201843, which exhibits year-long outbursts recurring on average every 973 days. We show that these peculiar outbursts come from an unstable accretion disc, potentially classifying this object as an extreme dwarf nova, which challenges the current knowledge of similar systems.
Secondly, we explore a new scenario in which binary interaction can drive asymmetric winds in red supergiant stars. By performing 3D hydrodynamics simulations of a companion repeatedly grazing the outer envelope of a red supergiant, we show that this scenario allows the formation of dust-driven winds carrying a total of $0.185\,M_{\odot}$ and ends with the two stars entering common envelope evolution.
Finally, we investigate the impact of previous phases of mass transfer on the outcome of common envelope evolution in the case of progenitor systems of double neutron star binaries. We carried out 3D hydrodynamics simulations of common envelope evolution that took into account the effect of mass transfer on the stellar structure of the donor, which shows that the inspiral phase is hastened, the ejected envelope is more asymmetrical, and the amount of ejected mass is reduced.

Keywords: binary stars, stellar evolution, cataclysmic variables, red supergiants, hydrodynamics, photometry, spectroscopy