Thin shell morphology in the circumstellar medium of massive binaries

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In massive binaries, the powerful stellar winds of the two stars collide, leading to the formation of shock-dominated environments that can be modelled only in 3D.

We investigate the morphology of the collision front between the stellar winds of binary components in two long-period binary systems, one consisting of a hydrogen rich Wolf-Rayet star (WNL) and an O-star and the other of a Luminous Blue Variable (LBV) and an O-star. Specifically, we follow the development and evolution of instabilities that form in such a shell, if it is sufficiently compressed, due to both the wind interaction and the orbital motion.

We use MPI-AMRVAC to time-integrate the equations of hydrodynamics, combined with optically thin radiative cooling, on an adaptive mesh 3D grid. Using parameters for generic binary systems, we simulate the interaction between the winds of the two stars.

The WNL + O star binary shows a typical example of an adiabatic wind collision.
The resulting shell is thick and smooth, showing no instabilities.
On the other hand, the shell created by the collision of the O star wind with the LBV wind, combined with the orbital motion of the binary components, is susceptible to thin shell instabilities, which create a highly structured morphology.
We identify the nature of the instabilities as both linear and non-linear thin-shell instabilities, with distinct differences between the leading and the trailing parts of the collision front. We also find that for binaries containing a star with a (relatively) slow wind, the global shape of the shell is determined more by the slow wind velocity and the orbital motion of the binary, than the ram pressure balance between the two winds.

The interaction between massive binary winds needs further parametric exploration, to identify the role and dynamical importance of multiple instabilities at the collision front, as shown here for an LBV + O star system.

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