Stellar Theory

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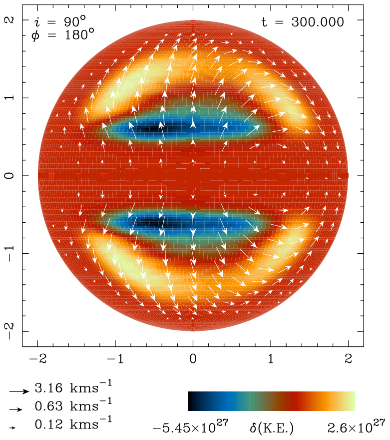
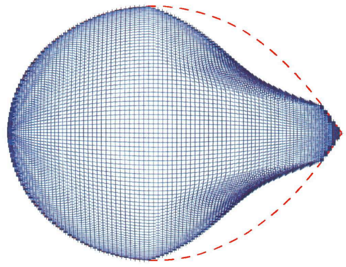
Irradiation of stars and planets



In an X-ray binary, the X-ray irradiation of the donor star can exceed the intrinsic luminosity of the donor star by several orders of magnitude, but the effect of this on the evolution of the donor star is not well-studied.

The figure to the left shows a preliminary investigation of these effects, showing the circulation currents which are driven by the irradiation. We expect that adding these currents to existing models will solve a long-standing and problematic mismatch between the X-ray binary birthrate and the millisecond pulsar birthrate.

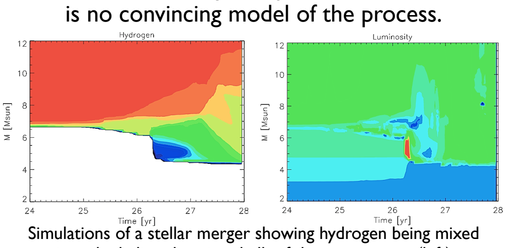
We also expect that our models can be applied to the structures of short orbital-period giant planets.



The shape of a donor star in an X-ray binary if irradiation-driven circulation currents are **not** included!

Modelling stellar mergers & common-envelope ejection

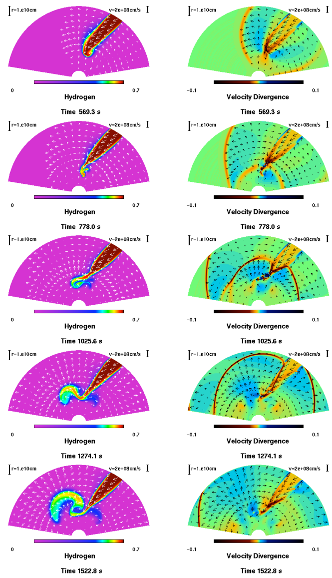
Some of the most important problems in stellar astrophysics are unsolved because of the difficulty inherent in simulating stellar hydrodynamic processes. Common-envelope ejection is vital to the formation of many compact binaries, but there is no convincing model of the process.

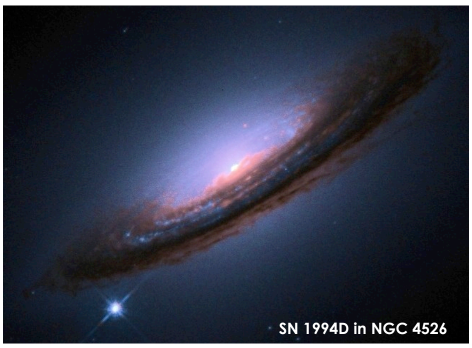


Simulations of a stellar merger showing hydrogen being mixed into the helium-burning shell of the massive star (left) causing explosive nuclear burning (right). The sudden energy input could unexpectedly unbind the massive envelope.

The famed outburst of Eta Carina (above) may well have been due to a stellar merger, as could a recent optical transient observed in M85. Stellar mergers should be more common then supernovae, but we don't understand them. Now is an ideal time to try and model such events.

Simulation of a stellar merger showing a stream of matter from the inspiralling star flowing towards the core.





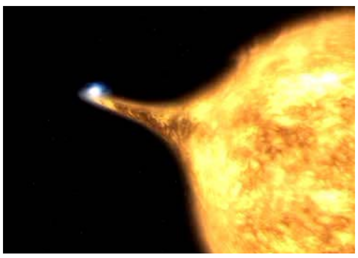
SN 1994D in NGC 4526

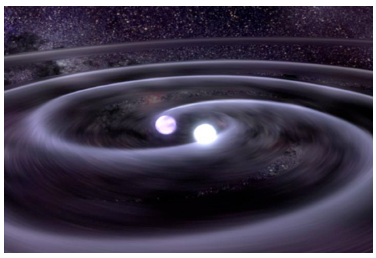
Understanding cosmic explosions

In recent years we have become aware of a wide diversity of stellar explosions. In the near future an unprecedented amount of new data should help us to finally understand the different ways in which stars end their lives. This includes the core-collapse of massive stars, thermonuclear explosions of objects the size of our moon and extreme accretion onto newly-formed black-holes.

For example, type Ia supernovae (SN Ia) are of considerable importance to astrophysics. The supernova is almost certainly caused by the destruction of a white dwarf (WD) in a thermonuclear explosion, but - amazingly - we still don't know what causes this to happen.

We want to definitively identify the progenitors, and understand why galaxies of different age and metallicity seem to produce different-looking SN Ia. These very new observational results are fascinating, and could be very important to future cosmological surveys.





Single-degenerate (left) vs double-degenerate (right) models for SN Ia progenitors (from NASA).