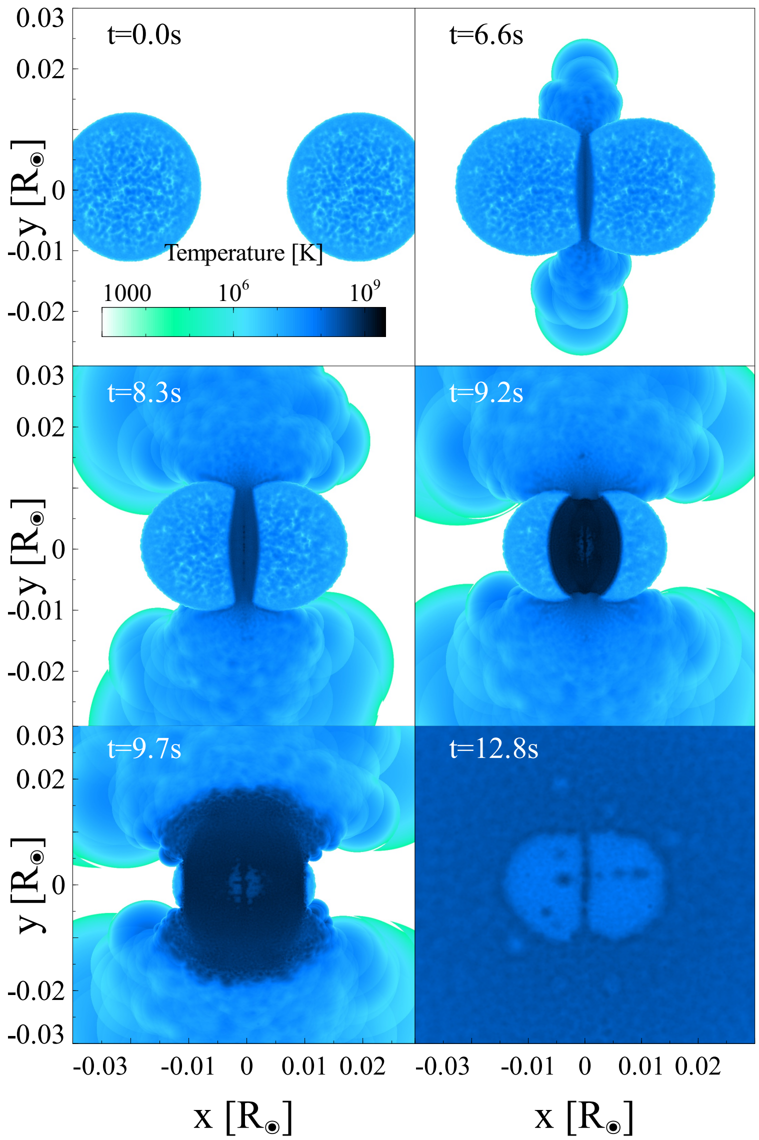
Collisions between two White Dwarfs



Collisions between two white dwarfs is an unexplored pathway for producing a new class of transients and/or Type Ia supernovae - which play a key role in astrophysics as premier distance indicators for cosmology, as direct probes of low-mass star formation rates at cosmological distances, and as significant contributors to iron-group elements in the cosmos.

White dwarf number densities in globular clusters allow enough collisions, 10 - 100 redshift ≲ 1 events per year, to be interesting. In addition recent observations of globular clusters in the nearby galaxy NGC 7457 have detected what is likely to be a Type Ia supernova remnant.

We have completed simulations of the collision between two white dwarfs with various masses at different impact angles. For impact parameters less than half the radius of the white dwarf, we find such collisions produce enough radioactive ^{56}Ni for them to be viable candidates for Type Ia supernovae or a new class of transients between Classical Novae and Type Ia supernovae.

A head-on collision is shown above. As the white dwarfs approach each other, their velocities increase to the escape speed(first panel). When the white dwarfs first make contact (second panel), shocks attempt to travel outward along the x-axis at the sound speed. The near equality of these two characteristic speeds means the shocks stall as material falls through them (third panel). The region between the two fronts achieves a nearly constant temperature and density with a non-explosive nuclear energy generation rate. This shocked region expands slowly as more material piles into it.

When the central core of each white dwarf encounters of the shocks, it raises the nuclear energy generation rate of enough material to trigger a detonation. Two curved detonation fronts form and begin to propagate (fourth panel), which releases enough energy to unbind the merged system (fifth panel), and enter homologous expansion (sixth panel). The final nucleosynthesis depends on the masses of the two white dwarfs.

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Movies:
cococubed.asu.edu/research_pages/type1a.shtml