Accretion-Induced Collapse of White Dwarf

When the mass of an accreting white dwarf grows towards the Chandrasekhar limit, the white dwarf eventually becomes unstable and destroys itself as a Type Ia supernova. In some cases, a white dwarf may not explode as a Type Ia supernova but instead undergoes a process known as an accretion-induced collapse (吸積導致塌縮) to form a rapidly rotating neutron star. Accretion-induced collapse can occur for accreting oxygen-neon-magnesium white dwarfs or from the merger of carbon-oxygen white dwarfs. The occurrence rate for accretion-induced collapse is expected to be less than one percent of the occurrence rate of Type Ia supernova. No accretion-induced collapse event has yet been directly observed.

During an accretion-induced collapse event, a white dwarf collapses into a rapidly rotating neutron star. The ejected mass from such an event is expected to be small (less than 0.1 solar masses) and travelling at high velocity (up to about 10 percent speed of light). As such, the amount of emitted radiation will be orders of magnitude less than a typical supernova. Furthermore, the expected duration of observable optical radiation being emitted from such an event is expected to last for only a day or so.

As the white dwarf collapses, conservation of angular momentum and amplification of the magnetic field leads to the creation of a rapidly spinning magnetar. A magnetar is a type of neutron star with an exceptionally strong magnetic field. The spin-down of the newly formed magnetar powers a pulsar wind nebula which injects energy in the form of magnetic fields and relativistic particles into the ejecta surrounding it. Because the spin-down energy of the magnetar is so much greater than the initial kinetic energy of the ejecta, it is the spin-down energy that determines the ejecta speed. As the ejecta expand outwards, the low-density pulsar wind nebula pushing up against the high-density ejecta can lead to the development of Rayleigh-Taylor instabilities. The ejecta plough through the interstellar medium and will begin to decelerate after it has swept up a mass comparable to its own.

Reference:

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