THE EVOLUTION OF TIDAL TAILS IN THE AFTERMATH OF
WHITE DWARF MERGERS

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Thermonuclear supernova outbursts, or also known as Type Ia Supernovae (SN Ia), are one of the most energetic events in the Universe. However, although it is known that these outbursts are originated from the explosion of carbon-oxygen white dwarf (CO WD), the nature of the progenitor system and how it evolves to a thermonuclear detonation remains still uncertain. We ran five simulations with a Smoothed Particle Hydrodynamics (SPH) code and followed the chemical and hydrodynamical evolution of the merger. We chose two white dwarfs of different mass and composition. One of them was made of pure He and the other of carbon and oxygen, being the total mass of the system lower than Chandrasekhar mass limit, in order to analyse if sub-Chandrasekhar systems may result in a SN Ia. We studied systems of 0.2+0.6, 0.3+0.6, 0.4+0.6 and 0.3+1.0 solar masses. The 0.3+0.6 case was computed with higher resolution (HR case). We also payed special attention to the formation and evolution of the tidal stream, because it the first time that a fragmentation in the tidal tail has been found.

Figure 1. Time evolution of the density (upper panels) and temperature (lower panels) for the coalescence of 0.3+0.6 (HR) solar masses. The left panels show the equatorial plane whereas the right ones show the polar plane.

During the initial phase of the merging process, the less massive white dwarf is tidally deformed by the gravitational force of the more massive one until it overflows its Roche Lobe. Its material is subsequently accreted onto the primary star, and due to angular momentum conservation forms an accretion disk around it. After some time, the secondary star is completely disrupted and falls towards the primary white dwarf forming a tidal stream.

The final configuration of the remnant consists of a central compact object, which rotates as a rigid body, surrounded by a hot rapidly rotating corona, where the nuclear reactions take place, and a keplerian disk around it, all surrounded by debris that came out from the disk.

Figure 2. Time evolution of the position and velocity field of the tidal stream of simulation 0.3+0.6 (HR) where the number of neighbors of each particle has been rendered. For sake of comparison, the osculating circle is included.

The tidal tail starts to expand until the velocity of the particles becomes tangent to itself, stopping the expansion. During this period, the tidal stream is fragmented in small clumps, starting in the tail and propagating through it. This fragmentation has been seen in all simulations.

Figure 3. Maximum temperature achieved in the hot corona of each simulation as a function of time. The simulations 0.2+0.6, 0.3+0.6, 0.4+0.6, 0.3+1.0 and 0.3+0.6 (HR) are represented in blue, red, yellow, purple and green, respectively.

At the beginning of the simulations, the maximum temperature oscillates, corresponding to the spiralling phase of the merger. Then, mass transfer starts and the temperature increases due to the compression of helium accreted. When the secondary star is disrupted, the accreted mass rate is reduced and therefore, the temperature of the corona decreases until a stable state is reached. The maximum temperature is higher for those cases of larger difference between star masses.