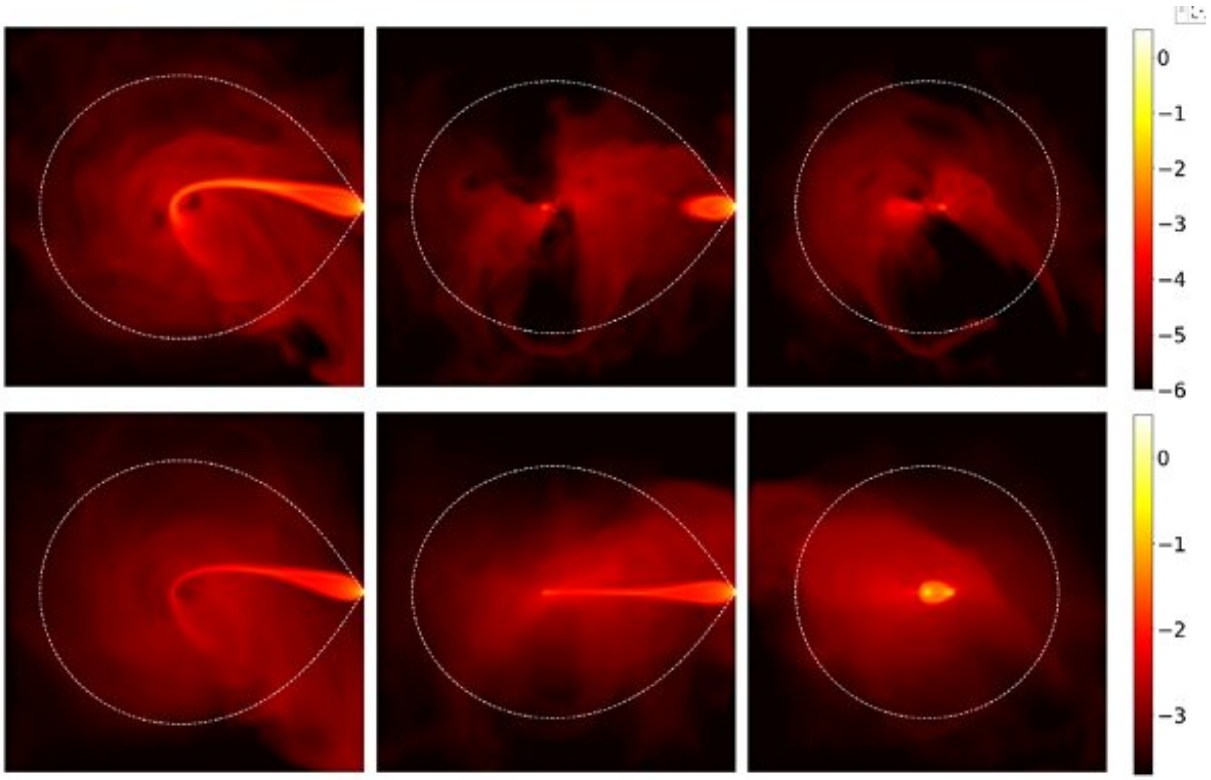
3-D simulation helps revealing accretion process in progenitor of tycho's supernova

January 4 2021, by Li Yuan



Images of density at the final time of the simulation run for B = 5.44×103G. Credit: JIAO Chengliang

Dr. JIAO Chengliang from Yunnan Observatories of the Chinese Academy of Sciences, collaborating with Prof. XUE Li's group from Xiamen University, performed three-dimensional (3-D) simulations of

the accretion flow in the progenitor of Tycho's supernova, which helps identifying the physical properties of the accretion process.

The study was published in *Monthly Notices of the Royal Astronomical Society* on Nov. 27.

Type Ia supernovae (SNe Ia) plays an important role in astrophysics, especially in cosmology and galactic chemical evolution. SNe Ia can be triggered by a carbon-oxygen white dwarf (CO WD) accreting sufficient material from a non-degenerate companion star, i.e. the single-degenerate (SD) model.

Tycho's supernova (SN) is a famous SN. Recent observations of its remnant suggests that the SN ejecta should have evolved in a bubble blown by a latitude-dependent wind, yet how this wind is formed is still not very clear.

The researchers studied the wind structure in different situations. They found that when the magnetic field in the accreted material was negligible, outflowing wind was concentrated near the equatorial plane. When the magnetic field had energy equipartition with internal energy, polar wind was comparable with the equatorial wind.

A carefully chosen magnetic field between the above two cases can roughly reproduce the latitude-dependent wind required to form the peculiar periphery of Tycho's SN remnant. This magnetic field may contain the tangled magnetic field in the accreted material obtained from the surface of the companion star, as well as contributions from the WD.

The study reveals the importance of magnetic field in the progenitor of Tycho's SN. It also provides a new source of mass-loss, other than the mass-loss caused by hydrogen and helium flashes on the WD surface, which are often considered in binary evolution researches.

The mass-loss ratio is extremely large (above 90 percent) in the simulation, yet it is consistent with researches in accretion physics, and this outflow only lasts for a limited time before the SN explosion, so it does not handicap the mass accumulation of the WD much.

More information: Li Xue et al. Three-dimensional simulations of accretion flow in the progenitor of Tycho's supernova, *Monthly Notices of the Royal Astronomical Society* (2020). DOI: 10.1093/mnras/staa3696

Provided by Chinese Academy of Sciences