Scientists model physics of stellar burning

April 15 2005

A University of California scientist at Los Alamos National Laboratory working with astronomers from around the world recently validated a computer model that predicts the rebirth and stellar burning and mixing processes of evolved stars. The discovery is a leap forward in our understanding of how stars like the sun evolve through violent outbursts during their evolution.

In research published recently in the journal *Science*, Laboratory astrophysicist Falk Herwig and his colleagues describe how Herwig's computer model was recently corroborated by radio telescope observations made at the Very Large Array (VLA) in Socorro, N.M. The radio signals collected by the VLA indicate that a star in the constellation Sagittarius known as V4334 Sgr, or Sakurai's Object, is about to re-illuminate it's planetary nebula for the second time, initiating a new phase in the spectacular evolution of this enigmatic star. This never before seen event is another step in a complex chain of events initially triggered by a nuclear burst after the star had already become a hot white dwarf.

Computer simulations of the stellar outburst made nearly 10 years ago by Herwig and others had predicted this series of physics events that would lead up to the rejuvenated planetary nebula. However, V4334 Sgr failed to follow the script as events moved many times more quickly than the simulations predicted. In 2001, Herwig proposed a new fast-evolving model, claiming the problem may be the way in which nuclear burning and rapid mixing was simulated.

Stars typically evolve into white dwarfs and die when they have used up most of their hydrogen, but about a quarter of them, like V4334 Sgr, experience a brief rebirth when their helium suddenly ignites, and the remaining hydrogen in the outer regions is drawn into the helium shell through rapid mixing, causing a massive nuclear explosion. This burst of energy will expand the dying star to gigantic proportions and lower surface temperatures and, in the process, expel prodigious amounts of carbon. V4334 Sgr has just evolved through this phase.

Herwig's new model predicts that V4334 Sgr will now become much hotter very rapidly and will then slowly repeat the stellar rebirth cycle once more, returning to its current cooler temperature in roughly two hundred years. Only then follows the final episode of reheating for a third time before V4334 Sgr eventually will become an inactive cooling white dwarf.

In addition to Herwig, who works in the Laboratory's Theoretical Division, the stellar burning team included Marcin Hajduk of the University of Manchester and Centrum Astronomii UMK; Peter A.M. van Hoof of Queen's University in Belfast and the Royal Observatory of Belgium; Florian Kerber of the European Southern Observatory in Germany; Stefan Kimeswenger of the University of Innsbruck, Austria; Don Pollacco of Queen's University in Belfast; Aneurin Evans of Keele University in Staffordshire, UK; Jose Lopez of the National Autonomous University of Mexico in Ensenada; Myfanwy Bryce of Jodrell Bank Observatory in the UK; Stewart P.S. Eyres of the University of Central Lancashire in the UK; and Albert Zijlstra and Mikako Matsuura of the University of Manchester.

Source: Los Alamos National Laboratory