Rare White dwarf stars with carbon atmospheres

Date de mise en ligne : jeudi 1er novembre 2007
A team of astronomers, including a researcher from Paris Observatory, have discovered white dwarf stars with nearly pure carbon atmospheres. The composition of the stars does not fit into any currently known class of white dwarf stars, so their evolution remains a mystery. These results have just been published in the Nov. 22 issue of Nature.

The stars were discovered among 10 000 new white dwarf stars found in the Sloan Digital Sky Survey (SDSS). The team has identified eight carbon-dominated atmosphere white dwarf stars among about 200 DQ stars checked in the Sloan data so far.

The great mystery is why these carbon-atmosphere stars are found only between about 18 000 degrees and 23 000 degrees Kelvin, in effective temperature. These stars are too hot to be explained by the standard convective dredge-up scenario, so there must be another explanation, Dufour said. Dufour and Liebert say they these stars might have evolved from a star like the unique, much hotter star called H1504+65 that Pennsylvania State University astronomer John A. Nousek, Liebert and others reported in 1986. If so, carbon-atmosphere stars represent a previously unknown sequence of stellar evolution.

H1504+65 is a very massive star of 200 000 degrees Kelvin effective temperature. This star is thought to have violently expelled all its hydrogen and all but a very small trace of its helium, leaving an essentially bare stellar nucleus with a surface of 50 percent carbon and 50 percent oxygen.

Figure 1 : Vue d'artiste de la surface de l'étoile H1504+65, qui se serait débarassé de son enveloppe d'hydrogène et d'hélium, laissant un noyau stellaire essentiellement nu. Ce serait, après refroidissement, une étoile du même type que celles qui viennent d'être découvertes. (Crédit illustration : M.S. Sliwinski et L. I. Sliwinska de Lunarismaar, Copyright photo par Sliwinski, M.S. et Sliwinska, L.I.)
We think that when a star like H1504+65 cools, it eventually becomes like the pure-carbon stars, Dufour said. As the massive star cools, gravity separates carbon, oxygen and trace helium. Above 25 000 degrees Kelvin, the trace helium rises to the top, forming a thin layer above the much more massive carbon envelope, effectively disguising the star as a helium-atmosphere white dwarf.

But between 18 000 and 23 000 degrees Kelvin, convection in the carbon zone probably dilutes the thin helium layer. At these temperatures, oxygen, which is heavier than carbon, has probably sunk too deep to be dredged to the surface. The astronomers say that models of stars nine to 11 solar masses might explain their peculiar carbon stars.

Astronomers predicted in 1999 that stars nine or ten times as massive as our sun would become white dwarfs with oxygen-magnesium-neon cores and mostly carbon-oxygen atmospheres. More massive stars explode as supernovae. But scientists aren’t sure where the dividing line is, whether stars eight, nine, 10 or 11 times as massive as our sun are required to create supernovae.

We don’t know if these carbon atmosphere stars are the result of nine-or-10 solar mass star evolution, which is a key question, Liebert said. The astronomers plan making new observations of the carbon atmosphere stars at the 6.5-meter MMT Observatory on Mount Hopkins, Arizona, in December to better pinpoint their masses. The observations could help define the mass limit for stars dying as white dwarfs or dying as supernovae.

Reference

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