THE SOURCES OF ENERGY IN WHITE DWARFS*

(Abstract)

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In the theory of the internal structure of white dwarfs it is assumed that there is no other essential source of energy than thermal energy. The thermal energy is about $3 \times 10^{39}\,T$ erg. When the temperature is 10^7 K, this energy is enough to supply a luminosity of the order of 10^{32} erg s^{-1} for about 10^6 yr.

In our group Sahakian and Avakian (1972) have shown that in white dwarf interiors there must exist some nuclear energy which is connected with the transformation of medium and heavy nuclei into those with more stable nuclear properties defined by the Fermi energy of the degenerate electron gas. This energy can be greater than the thermal energy by one or two orders of magnitude. Perhaps this energy plays an important role in the evolution of these stars.

Now we discuss another source of energy which is connected with the rotation of white dwarfs. Besides the kinetic energy of rotation, the star contains potential energy of deformation. Calculations of the internal structure of rotating white dwarfs show that the maximum angular velocity is of order 1 s^{-1} and that the deformation is of order of 10 to 20% of the radius of the star. It is easy to show that the additional deformation energy is $\Delta E \sim (GM^2/R)\,(\Delta R/R)$, where M is the mass of the star and R is its radius. If we take $GM^2/R \sim 2 \times 10^{50}$ and $\Delta R/R$ as 20%, then $\Delta E \sim 4 \times 10^{49}$ erg. The exact calculation of the deformation energy gives $W_g = \Delta Mc^2 - W_r = 8.96 \times 10^{-29}\,N - W_r$, where N is the total number of baryons in the star and $W_r = I\Omega^2/2$ is the kinetic energy of rotation. If we assume that the main source of energy is connected with rotation, then, as through its evolution the angular velocity decreases and the star contracts, gravitational energy of deformation will be released in the volume of the star, while the kinetic energy of rotation is released in the outer region of the star.

Such ideas bring us to the calculations of white dwarf models with internal sources. For solving this problem we need the distribution and temperature of the release of this energy. As a first approximation we assumed that the energy is released at a constant rate and distributed through the star by the law $C\varrho\Omega^2 r^2$, where C is a constant which can be calculated, if we know the rate of release of the energy. Thus the rate of release of energy is one free parameter in the problem. Our calculations show that this store of energy is enough to supply the luminosity of the order of a solar luminosity or more for 10^8 to 10^9 yr.

Reference

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