LETTERS TO NATURE

A Model for Type I Supernovae

A NUMBER of different mechanisms that could be responsible for Type I supernovae have been suggested¹⁻⁴ but the problem remains open. Because Type I supernovae are found in elliptical galaxies which are old stellar systems we are faced with finding a mechanism which involves stars of mass $\lesssim 1 M_{\odot}$. I suggest that hydrogen burning caused by mass transfer from a star of $0.7 M_{\odot}$ – $1 M_{\odot}$ to a degenerate hydrogen star of mass $\sim 0.1 M_{\odot}$ may be responsible. Mass transfer in close binaries is a well established process^{5,6}, and model calculations indicate that the lower mass limit for stars to ignite hydrogen on the main sequence is approximately $0.1 M_{\odot}$ ⁷⁻¹⁰. The evolution of a $0.1 M_{\odot}$ star shows⁹ that at 1.23×10^9 yr the central temperature is falling while the centre is becoming highly degenerate. If at a later time the star becomes suddenly compressed, raising the temperature of the non-degenerate nuclei enough to ignite hydrogen burning reactions, a thermal runaway occurs. The situation is analogous to the helium flash¹¹ and the carbon-oxygen flash^{12,13}; the latter event may produce a supernova¹⁴. The expected rise in central temperature of the degenerate star resulting from compression by the infall of mass from the primary star can be estimated as follows. The central density ratios of degenerate stars (represented by polytropes of index $n=1.5$) with mass ratios $(0.1 + \Delta M)/0.1$ are easily calculated¹⁵. Assuming that adiabatic compression, the corresponding central temperature ratios are given by

$$\frac{T_{0.1+\Delta M}}{T_{0.1}} = \left(\frac{\rho_{0.1+\Delta M}}{\rho_{0.1}} \right)^{2/3}$$

Fig. 1 shows this temperature ratio as a function of ΔM (the mass transferred from the primary). Only a moderate amount of mass need be transferred to increase the central temperature significantly. The validity of the assumption of

Fig. 1 Central temperature increase for a white dwarf from adiabatic compression resulting from the addition of mass ΔM .

an adiabatic compression depends on the ratio of mass transfer time, τ_{MT} , to the white dwarf cooling time, τ_c . From model computations τ_{MT} is found⁶ to be of the same order as the Kelvin-Helmholtz (thermal) time scale and for the originally more massive star is then $\tau_{MT} \approx 10^7$ yr. The cooling time for a hydrogen white dwarf of low mass is approximately $\tau_c \gtrsim 10^9$ yr (refs. 16, 17). So $\tau_{MT}/\tau_c \lesssim 10^{-2}$ and the assumption of an adiabatic compression is valid. More detailed calculations are required to determine whether the thermal runaway causes an explosion or results in the formation of a hydrogen burning main sequence star, but the conversion of $0.1 M_{\odot}$ of hydrogen to helium would release 1.3×10^{51} erg and the binding energy of a $0.4 M_{\odot}$ hydrogen white dwarf is 3.2×10^{48} erg.

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Strong Beaming of Jupiter's Non-Io-related Radio Emission

THE apparent decrease, after opposition, in the rate of receipt of decametric radiation from the planet Jupiter has been attributed to the eclipse of Jupiter by the Earth's magnetosphere¹. Dulk (private communication) noticed this effect when drawing histograms separately for the period before and after opposition for the apparitions in 1964 and 1965, and suggested that it might be due to the influence of the maximum usable frequency of the Earth's ionosphere on the reception of Jupiter's decametric radiation. But Gruber² showed that the Earth's ionosphere cannot significantly influence the probability of receiving Jupiter's decametric radiation over an