WHITE DWARF COOLING AND CRYSTALLIZATION

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We performed evolutionary calculations of CO white dwarf (WD) models of 0.4, 0.55, 0.8, 1.0, and 1.2 $M_\odot$ with helium surface layers (DB WD). These models were evolved from $\log L/L_\odot = 0$ to the phase corresponding to the fast Debye cooling ($\log L/L_\odot \approx -5.8$). The emphasis of this study has been placed on the behavior of the crystallization front. We employed a detailed evolutionary code in which neutrino emission processes, latent heat released during crystallization, convective transport of energy, and a complete equation of state have been taken into account. At a certain luminosity that depends primarily on the stellar mass of the model, WDs begin to develop a crystalline core as a result of the Coulomb interactions. We found the growth of the crystal phase to be quite similar for all the models here considered, which become completely solid in a narrow range of luminosity. In particular, the model with 1.2 $M_\odot$ begins to crystallize when its luminosity is about 100 times as high as the luminosity of crystallization onset for the 0.55 $M_\odot$ model. This fact causes the effect of the released latent heat on cooling times to be relatively more important for low mass objects.

We also study the crystallization process by means of an analytic model, which accounts for the numerical results. This treatment (based on the Mestel analytic model for WD cooling), considers an isothermal interior, a gaussian approximation for the density profile of the WD interior, and assumes a relation between luminosity and central temperature of the form $L \propto T_c^\alpha$, which is indeed verified by detailed numerical simulations (in particular, for the case of Kramers opacities, $\alpha = 3.5$). Under these assumptions we found that the theoretical crystal growth function is given by

$$\frac{M_{\text{cryst}}}{M} = \text{erf}(\sqrt{\frac{3\psi}{\alpha}}) - 2\sqrt{\frac{3\psi}{\pi\alpha}} \exp\left(-\frac{3\psi}{\alpha}\right),$$

(1)

where $\text{erf}(x)$ is the error function, $L = L_0 \exp(-\psi)$, and $L_0$ is the luminosity at the onset of crystallization. For more details, see Benvenuto & Althaus (1996)


A THERMAL SPUR PROBABLY ASSOCIATED TO THE H II REGION S54: A MODEL TO EXPLAIN RADIO RECOMBINATION LINE OBSERVATIONS

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H159 alpha line ($\lambda = 18$ cm) observations of a thermal spur, supposed to be emerging from the H II region S54, are reported. The spur had been previously observed in the H110 alpha recombination line by Mueller et al. (1987, A&A, 183, 327). From our observations, physical parameters of the ionized gas, are derived. An inhomogeneous thermal model which accounts for the Radio Recombination Line and continuum observations suggests the gas of the spur should be ionized by at least 40 B1 stars of average mass of 10 solar masses. A physical mechanism that could have created the spur and ionized the material is not yet known.

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