EVOLUTION OF GLOBULAR CLUSTERS INCLUDING A DEGENERATE COMPONENT

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Low mass X-ray sources observed in many globular clusters are usually interpreted as compact binaries with degenerate components (e.g., Hertz and Grindlay 1983). Degenerate stars can exist in globular clusters if the IMF contains a sufficiently large number of high mass stars. Since the main-sequence lifetime is a very steep function of stellar mass, most of degenerate stars can be regarded as primordial. If the typical mass of degenerate stars is higher than that of main-sequence stars, mass segregation makes the core crowded with degenerate stars. Tidally captured binaries between degenerates and main-sequence stars can abundantly form as the core density becomes very high.

We used the isotropic orbit-averaged Fokker-Planck code, originated from Cohn (1980), to follow the dynamical evolution of globular clusters containing primordial degenerate stars with individual masses higher than those of main-sequence stars. The total mass of the cluster is $10^5 M_\odot$ and the parameters for main-sequence stars are fixed at $m_{MS}=0.7M_\odot$ and $R_*=0.57R_\odot$. The mass ratio m_D/m_{MS} and the number ratio N_D/N_{tot} are regarded as free parameters. The interactions involving three-body binaries are treated as a collection of many small changes in energy and incorporated within the Fokker-Planck framework. The same technique as in Statler et. al. (1986) is used for the interactions involving tidally captured binaries.

Clusters having a sufficiently large population of degenerate stars may be approximated as single component clusters with point masses since the core is almost entirely dominated by degenerates due to the mass segregation process. Three-body binaries provide most of the energy to maintain the quasi-static post-collapse expansion. The structure of post-collapse clusters in this case becomes self-similar, and the physical parameters of such clusters follow simple power laws in time:

$$\rho_o \propto t^{-2} \; ; \quad v_o \propto t^{-1/3} \; ; \quad r_c \propto t^{2/3} \; ; \; r_h \propto t^{2/3} \; ,$$

where ρ_o is the central density, v_o is the central velocity dispersion,

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r_c is the core-radius, and r_h is the half-mass radius. On the other hand, tidally captured binaries play a dominant role if there initially exist only a small number of degenerate stars. Numerical solutions similar to those of Statler et. al. (1986) are obtained in such cases.

Some clusters having very small core radii have flatter surface brightness profiles than that of an isothermal sphere. The logarithmic slopes of observed surface brightness profiles of "post-collapse" clusters lie between -0.75 and -1.25 (Djorgovski and King 1986; however, see Lugger et. al. 1987 for even flatter profiles), while the density distribution of post-collapse clusters (thus well relaxed) is expected to be close to that of isothermal sphere, which has logarithmic slope -1 for the surface density profile. Surface brightness profiles that are flatter than that of an isothermal sphere can be understood if these clusters have dynamically significant amounts of degenerate stars as envisaged in the present study. For example, the post-collapse cluster for the model with $m_D/m_{MS}=1.86$ and $N_D/N_{tot}=0.06$ has logarithmic slope -0.64, which is close to the surface brightness profile of M15 as measured by Lugger et. al. (1987). The post-collapse cluster for the model with $m_D/m_{MS}=1.25$ and $N_D/N_{tot}=0.04$ has a similar distribution for matter and light.

The number of tidally captured binaries in post-collapse clusters is typically several times 10^1. The inferred average number of compact binaries (cataclysmic binaries) from X-ray observations ($\sim$10 per galactic cluster according to Hertz and Wood 1985) is consistent with the average number of tidally captured binaries of our model if $\sim$20% of the galactic globular clusters are in the post-collapse stage (Djorgovski and King 1986). More detailed results of this study will be published in The Astrophysical Journal.

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