EXTREME SOLAR SYSTEMS
ASP Conference Series, Vol. 398, © 2008
D. Fischer, F. A. Rasio, S. E. Thorsett, and A. Wolszczan, eds.

The Singleton Fraction of Stars Formed in Stellar Clusters

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Abstract. Most stars form in some sort of stellar cluster or association. In such clusters the number density of stars can be very high. Thus, single stars in such clusters may undergo frequent close encounters with other stars and exchange encounters with binary systems. The perturbation caused by the other star in a close encounter or by the companion star in a binary can have significant effects on the evolution of any planetary system around the initially single star. If the planetary system which formed around the single star was originally solar-system-like, planet-planet interactions, induced by the perturbation from other stars, may change it significantly and leave it more like some of the planetary systems which are observed around other stars. Only if the host star of an initially solar-system-like planetary system never undergoes any encounters with other stars and is never exchanged into a binary may the planetary system remain solar-system like. We define such a star to be a SINGLETON.

1. Introduction

We have today detected more than 200 planets around other stars. Many of these planets are more massive than Jupiter and are found on orbits which are much tighter than that of the Earth's. On top of this many of them have eccentric orbits. There are many ways to explain this, such as migration within the planetesimal disk and/or planet-planet interactions due to an initially unstable system emerging out of the disc. Our idea is instead that planetary systems like the solar system form around initially single stars and then are changed into systems resembling the observed planetary systems. This change is caused by planet-planet interactions, induced by close encounters and/or exchange encounters with binaries in young stellar clusters. An example of this is if the host star of a solar-system-like planetary system is exchanged into an inclined and not too wide binary. The so-called Kozai Mechanism (Kozai 1962) will then

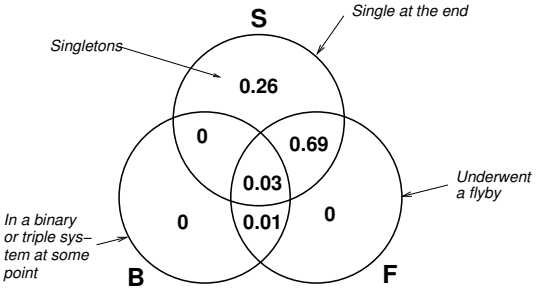

Figure 1. The average result for the 10 realizations we ran for a cluster with initially 700 stars and a half-mass radius during its lifetime of between 4 and 5 pcc. At the start of the simulations only 468 stars were single and only the result for those stars are in the diagram. The fraction of singletons is the fraction of stars which have never interacted with another star. Thus in this particular cluster 26 per cent of the initially single stars remained as singletons.

operate, giving rise to strong planet-planet interactions as the eccentricity of the outer planets is periodically increased (Malmberg et al. 2007).

2. The Singleton Fraction

We define a singleton to be a star which formed single, has never suffered a close encounter with another star and has never been in a binary. A planetary system around a singleton will evolve without the influence of external forces. A planetary system around a non-singleton (a fly-bin) however, will be affected by the passing star or the stellar companion. To study how important such effects are we have numerically simulated a range of stellar clusters (Malmberg et al. 2007). An example of the results from these simulations can be seen in Fig. 1., where the average result for a cluster with initially 700 stars is shown. When analyzing the simulations of all the clusters' which we have studied we find that the singleton fraction in the solar neighborhood is significantly different from one. If we, for example, look at solar type stars, i.e., stars within the mass interval $0.8M_{\odot}$ and $1.2M_{\odot}$, we find that the fraction of single stars which are not singletons is between 5 and 10 per cent.

Acknowledgments. Melvyn B. Davies is a Royal Swedish Academy Research Fellow supported by a grant from the Knut and Alice Wallenberg Foundation. Ross P. Church is funded by a grant from the Swedish Institute. Dougal Mackey is supported by a Marie Curie Excellence Grant under contract MCEXT-CT-2005-025869. Mark Wilkinson acknowledges support from a Royal Society University Research Fellowship.

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