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Neutron Star Binaries in Open Clusters

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We use N-body simulations of open clusters to examine the evolutionary history of binaries containing neutron stars. The model includes consistent treatment of all the relevant processes (Aarseth 1996):

- Synthetic stellar evolution
- mass and radius as a function of time (Eggleton et al. 1989)
- Accurate treatment of close encounters
- Perturbations of binaries and stable multiple systems - Exchange reactions (involving triple and binary-binary interactions) - Collisions → blue stragglers
- Binary evolution (primordial and dynamically formed)
- Tidal interactions (Mardling & Aarseth 1996) - Stable mass transfer - Common envelope evolution - Magnetic braking - Gravitational radiation - Mergers (including blue stragglers)
- Mass loss
- Stellar winds - Supernovae - Evaporation of stars from the cluster
- Neutron star formation
- Supernovae with kick velocities of Lyne & Lorimer (1994), Drukier (1996) - Accretion-induced collapse

Our aim is to study cluster retention of neutron stars formed in binaries. This entails tracing the evolutionary history of their progenitors. In particular, we examine the effect of the cluster environment on the distribution of orbital periods, mass ratios and eccentricities which may be affected by exchange or external perturbations. The present model consists of 10^4 Population I stars with a realistic mass function ($0.4 - 12\ M_\odot$), containing 5% primordial binaries. The initial distribution of binary periods and eccentricities includes the effect of tidal evolution of pre-main sequence stars (Mardling & Kroupa 1996). The initial conditions are generated from a King model (escape velocity 4 km s^{-1}) with the cluster describing a circular orbit in a galactic tidal field. Each model is followed until complete evaporation (~5-6 billion years).

The following evolutionary sequence illustrates the kind of complex dynamical interactions which can lead to the formation of a neutron star binary. This system, with its non-primordial companion, escapes the cluster and becomes another neutron star binary in the field. This kind of sequence has been seen in several open cluster simulations and leads one to question whether or not a substantial fraction of neutron star binaries in the field, in particular interacting systems such as X-ray binaries, may have been formed in clusters. Note the

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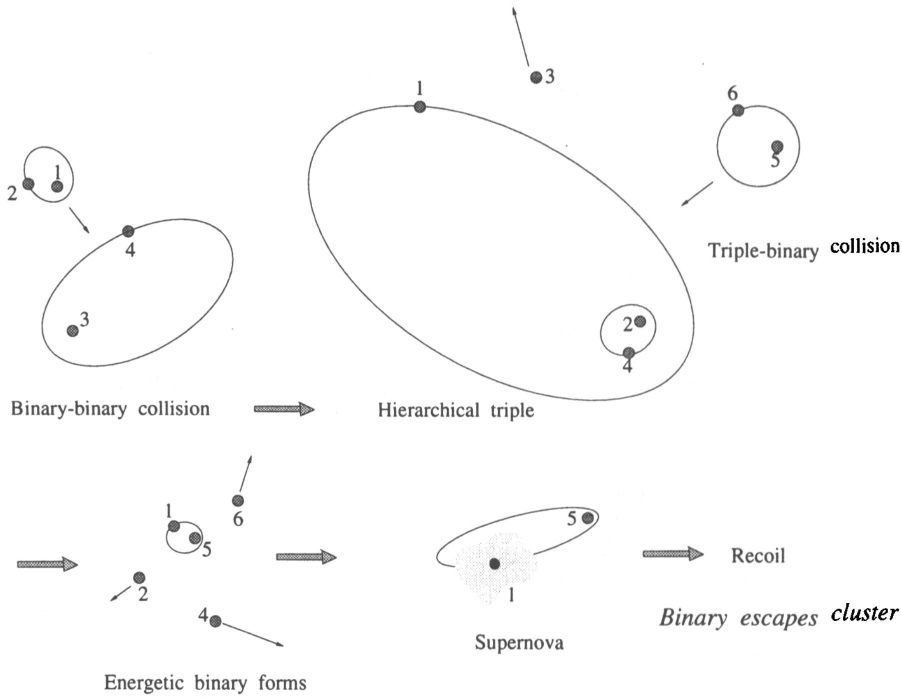

numbering of the stars in this figure; consecutive numbers in a binary indicate that it is primordial. Note also that the eccentricities are accurate and relative sizes are to scale.

Finally, we note the possible membership of the of X-ray pulsar X0142+614 in the open cluster NGC 663 (Hellier, 1994). If this neutron star binary is a true member of this cluster, it is evidence that open clusters are capable of retaining neutron stars, as are globular clusters which retain them in large numbers.

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