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NUMERICAL SIMULATIONS OF OPEN CLUSTERS

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We performed N-body numerical simulations of NGC 6475, using its observed stellar positions, proper motions and momenta of the radial velocity distribution as initial conditions. Also, we statistically recovered stellar positions and velocities with respect to the plane of the sky. We found the system is highly unstable, probably due to an excess of positive energy.

We wanted to investigate whether it is possible to integrate a real open cluster backwards in time, thus discovering where its cradle was, or at least whether a systematic motion, towards some galactic region where the cluster was born, is present nowadays in its stars.

To this end, we chose NGC 6475 because it has about 120 members with observed stellar positions and proper motions, plus estimated distance and lifetime (Dias, Lépine, & Alessi 2001, 2002). In order to have all six phase space coordinates of the stars, we first numerically computed the surface density of the cluster, and Abel-inverted the result to obtain an estimate of the volumetric density profile. With this profile, we then drew radial distances with respect to the baricentre using the Monte Carlo technique, taking into account that the component on the sky is fixed by observation. The individual radial velocities were drawn from a Maxwellian distribution with mean and dispersion taken from Gieseking (1985).

We put the cluster thus built in a suitable galactic orbit. To this end, we first rotated from (spherical) equatorial to (spherical) galactic coordinates, and then mapped to Cartesian galactic coordinates. The Sun's motion with respect to the LSR was substracted, and the origin of coordinates was translated to the Galactic center (the y axis had to be inverted in this last operation in order to keep a direct triad). Then the LSR velocity was added and a Galactic inertial frame was thus obtained, into which the equations of motion can be integrated once a Galactic potential is added. We chose the potential model proposed by Gómez et al. (2010), composed of a bulge, a disc and a dark halo.

We assigned 10 solar masses to each star, and integrated backwards until a time equal to the estimated age of the cluster was reached. We found that the half mass radius (the three-dimensional radius that encompasses half of the total mass) grows dramatically, reaching values of 200 pc. Since this radius is insensitive to escapees, and therefore allows to estimate the size of the cluster, it is clear that the initial conditions, as per the observations, cannot account for the dynamics of the cluster. Moreover, differential rotation stretches the cluster, scattering it into vast volumes along its orbit.

We've tried assigning 83 solar masses to each star; although the half mass radius grew less, still grew, i.e., the stars of the cluster did not converge to any region in particular.

When we put 5,000 solar masses in the baricenter of the cluster, mimicking a small molecular cloud, and traveling with the cluster along its lifetime, the half mass radius keeps a value around 10 pc (the actual size of the cluster) throughout. Although in this case the cluster at least did not explode, it is difficult to justify a cloud accompanying the cluster during millions of years.

We plan to better the model by adding primordial binaries and/or reversed-escapees, trying to greatly diminish the internal energy of the cluster in order to keep it bound against positive energy and differential rotation.

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