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ON THE CHOICE OF THE INITIAL CONDITIONS IN AN N-BODY EXPERIMENT

S. Ninković[1] and Z. Ćatović[2]

[1]*Asronomical Observatory, Volgina* 7
11050 *Beograd, Yugoslavia*
[2]*Institute of Astronomy, Mathematical Faculty*
Studentski trg 16, 11000 *Beograd, Yugoslavia*

Summary: The authors discuss the choice of the initial conditions in their numerical experiment concerning a simulation of a hypothetical open cluster containing 100 stars (mass points) based on the N-body approach.

1. INTRODUCTION

As well known, the dynamics of open star clusters is of a collisional type. The encounters, much more frequent than in the surrounding field, result in a relatively short relaxation time. Therefore, an approach where the interaction of the stars is direct following Newton's universal-gravitation law is fully justified.

It is clear that any experiment of such kind will be dependent of the initial conditions and of the applied mathematical method. Therefore, the intention of the authors is to discuss the choice of the initial conditions and the mathematical formalism applied by them.

2. THE INITIAL CONDITIONS

Our test stellar system contains 100 stars corresponding to the open clusters among the real stellar systems. For simplicity we neglect the presence of interstellar matter in it. Each star is characterised with seven parameters: the coordinates, the velocity components (or phase coordinates taken together) and the masses. The latter ones are treated as invariable throughout the experiment so that the only way of distinction among the stars is their masses.

The choice of the initial phase coordinates is done in a way enabling, at the initial moment, avoiding of any preferable concentration of massive stars near the centre of the system and vice versa. Also, at the initial moment, we have no binaries in the system since we expect both effects (concentrating of massive stars towards the centre and formation of binaries) to arise sponatneously in the course of our experiment.

Though, the test cluster is considered as isolated, or self-consistent, nevertheless its spatial limits are chosen to be within the tidally allowed sphere (Lagrangian neutral sphere, e. g. King, 1962). The distribution of stars in the distance to the centre is presented in Fig. 1.

The initial values for the velocity components follow from the condition that the cluster is gravitationally bound, i. e. its total kinetic energy is less than the modulus of the potential energy. The distrbution of the star impulses is presented in Fig.2. Both distributions (Figs. 1 – 2) are intended to comprise a completely random situation where the circumstance of gravitational binding should produce the future evolution.

The mass-distribution law (Fig. 3) is chosen according to the modern concepts (e. g. Marochnik and Suchkov, 1984 - p. 202); the interval is $[0.1,\mathcal{M}_\odot, -50\mathcal{M}_\odot]$, the mean mass is equal to $2.3\mathcal{M}_\odot$ and the dispersion to $7.05\mathcal{M}_\odot$. The choice of the interval is based on the usual mass values along the main sequence. The amount of the mean mass should be noted; it follows from the circumstance that the presence of early-spectral-type stars in the real open clusters should be expected.

3. THE MATHEMATICAL FORMALISM

For the numerical integration of the equations of motion we used symplectic integrator of the fourth order. This technique for the numerical integration of the ordinary differential equations conserves integrals of the equations exactly (Yoshida, 1992), i.e. truncation errors are constant throughout the integration process. However, we should mention here that it does not reduce round off erors.

We check validity of integrations by values of the first integrals (in this case one has ten integrals) on every step of integration.

4. FIGURES

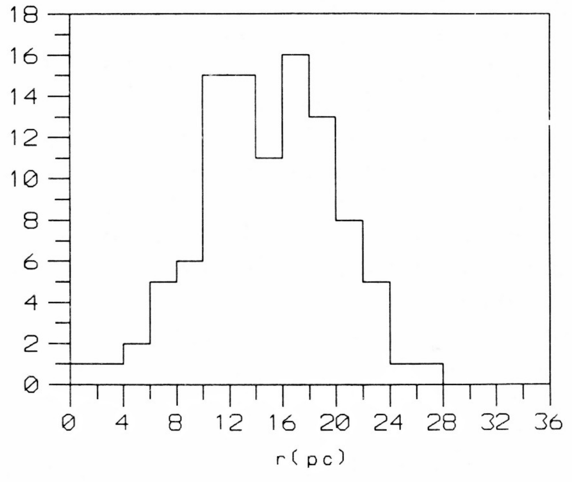

Figure 1. Histogram: number of stars versus distance to the barycentre

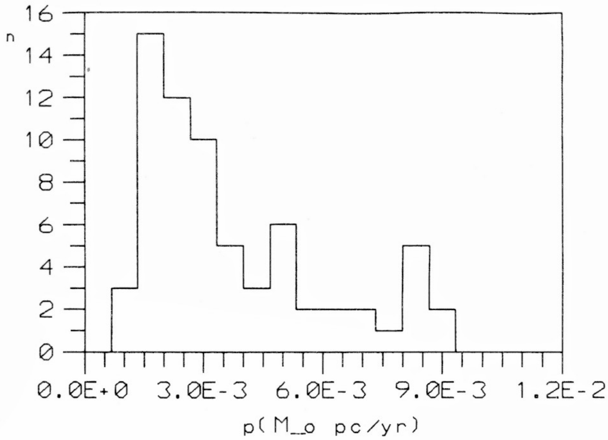

Figure 2. Histogram: number of stars versus impuls

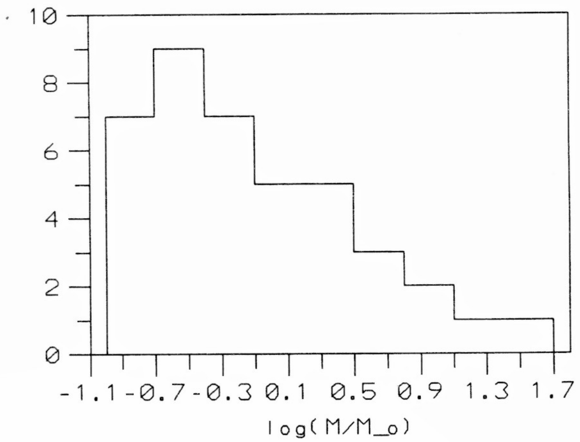

Figure 3. Histogram: number of stars versus mass

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