Erratum: Towards an N-body model for the globular cluster M4

by Douglas C. Heggie

School of Mathematics and Maxwell Institute for Mathematical Sciences, University of Edinburgh, King’s Buildings, Edinburgh EH9 3JZ, UK

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The paper ‘Towards an N-body model for the globular cluster M4’ was published in MNRAS, 445, 3435–3443 (2014). It has been discovered that the description of the initial conditions, given in the first two paragraphs of section 2.1 of that paper, is incorrect. Instead of being generated from the initial data of the Monte Carlo simulation of Heggie & Giersz (2008), they were generated within the code NBODY6 using a roughly similar prescription to that adopted in the Monte Carlo code. For example, both codes generated the positions of the stars according to the Plummer distribution (with one difference, mentioned below), but did so independently. Thus, the second sentence of the abstract should be changed to read ‘The initial conditions, with \( N = 484,710 \) particles, were generated on the basis of a published study of this cluster with a Monte Carlo code.’ (The altered text is highlighted.) The remainder of this erratum describes the initial conditions actually used.

The differences between the initial conditions of the Monte Carlo and N-body studies are particularly marked for the binary stars. The masses of binary components in the Monte Carlo model were drawn from Kroupa, Gilmore & Tout (1991, equation 1), with a uniform mass ratio between components, restricted to component masses in the same range as for single stars. In the N-body model, however, they were drawn randomly from the mass function of single stars. A comparison of the distributions of the component masses is presented in Fig. 1.

Both codes generated binaries with a uniform distribution of the logarithm of the semimajor axis \( a \) in a certain range, and, for the N-body model, a thermal distribution of eccentricity \( e \). (For the Monte Carlo model the distribution of \( e \) was irrelevant, as that code used cross-sections for binary interactions, and the cross-sections were \( e \)-independent.) In the Monte Carlo model, binaries in which the initial periastron separation would have led to collision were avoided by the condition \( a > 2(R_1 + R_2) \), where \( R_1,2 \) are the radii of the components. In NBODY6, however, the default method for eliminating such binaries is a process of iterated increase of \( a \) and/or decrease of \( e \). The resulting distributions are given in Fig. 2, though the distribution of \( e \) in the Monte Carlo model is not shown, for the reason already stated.

No statistically significant difference has been found in the initial mass function of single stars; though the slope of the lower mass function is non-canonical, this was correctly adjusted in the N-body code. The radii (distance from the centre of mass) do differ slightly, however (Fig. 3), because by default NBODY6 removes stars with radii exceeding 10 times the scale radius of the Plummer model. The consequent rescaling of the model leads to a slight but noticeable general expansion.

One consequence of the differences between the N-body and Monte Carlo initial conditions, especially those in the binaries, is that the N-body model is initially more massive than the Monte Carlo model by 3 per cent, but the values are correctly given in the two papers and require no correction. More problematic are possible effects on the evolution, especially that of the binaries themselves. It was shown in Heggie & Giersz (2008) that the most noticeable

\* E-mail: d.c.heggie@ed.ac.uk

Figure 1. Distributions of the primary (top) and secondary (bottom) component masses of the binaries in the N-body and Monte Carlo initial conditions.
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change in the distribution of semimajor axis is the erosion of the softer binaries. Since these are underrepresented in the N-body model (Fig. 2, top), this does nothing to explain why the binary fraction soon becomes somewhat smaller in the N-body model than in the Monte Carlo model (Heggie 2014, fig. 7), though the relative difference is only of the order of 10 per cent. Also evident in the upper frame of Fig. 2 is the fact that the very hardest binaries are underrepresented in the N-body model. This implies that more of the harder binaries may be dynamically active, and this could help to explain why the time-scale of evolution of the N-body model (e.g. the time of ‘second core collapse’) is later in that model (Heggie 2014, section 3.2).

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