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Heavy-ion fusion cross-section calculations in classical microscopic equations of motion approach

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Abstract. Fusion cross-sections for $^{16}O + ^{16}O$ reaction earlier calculated in classical microscopic equations of motion approach, with Lennard-Jones form of NN interaction potential are overestimated compared to the experimental data at lower energies. This large deviation was attributed to possible breakdown of classical approximations at lower energies. The aim of this paper is to show that this discrepancy was rather due to certain assumptions made in the specification of initial conditions; in particular due to neglect of Coulomb interaction between the colliding ions at far off distances. Use of Lennard-Jones potential is also critically examined.

Keywords. Classical microscopic equations of motion approach; $^{16}O + ^{16}O$ reaction; fusion cross-section; Lennard-Jones potential; nucleon-nucleon potential.

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In recent years, classical microscopic equations of motion approach has been widely used to study heavy-ion reactions (Bodmer and Panos 1977, 1981; Bodmer *et al* 1980; Wilets *et al* 1977, 1978; Ramamurthy and Kataria 1978; Callaway *et al* 1979; Kitazoe *et al* 1981; Dixit *et al* 1983; Dixit *et al* 1985; Kiselev *et al* 1983; Kiselev 1985; Molitoris *et al* 1984; Vicentini *et al* 1985). In this approach, nucleons within the colliding nuclei are considered as classical point particles, interacting via an effective two-body interaction. Constants of the interaction are chosen so as to reproduce ground state characteristics of nuclei such as binding energies and root-mean-square (rms) radii. Collision dynamics is studied by computing trajectories of all the participating nucleons, by numerically integrating coupled classical equations of motion:

$$m\mathrm{d}^2\mathbf{r}_i/\mathrm{d}t^2 = -\nabla_i\left(\sum_{j\neq i} V_{ij}\right) \tag{1}$$

for different initial conditions of collision energies and impact parameters. Since all the translational degrees of freedom are explicitly included, dissipation of relative kinetic energy required for fusion and deep-inelastic collisions is naturally built-in in this approach without any additional assumptions of frictional forces (Birkelund *et al* 1979) or nuclear shape parametrizations (Schroder and Huizenga 1985).

Ramamurthy and Kataria (1978) studied $^{16}O + ^{16}O$ reaction with Lennard-Jones form of nucleon-nucleon potential

$$V(r_{ij}) = 4\varepsilon[(\sigma/r_{ij})^{12} - (\sigma/r_{ij})^6]. \tag{2}$$