Numerical Accuracy in Solving Coagulation Equation for Planetary Accumulation

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The effects of coarse mass-coordinate divisions in numerical computations of the coagulation equation are examined. The numerical accuracy is essential to the estimate of the growth times of dust and planets. In the numerical simulation of coagulation, we often introduce logarithmic divisions of mass coordinate in order to cover a wide mass range. In the

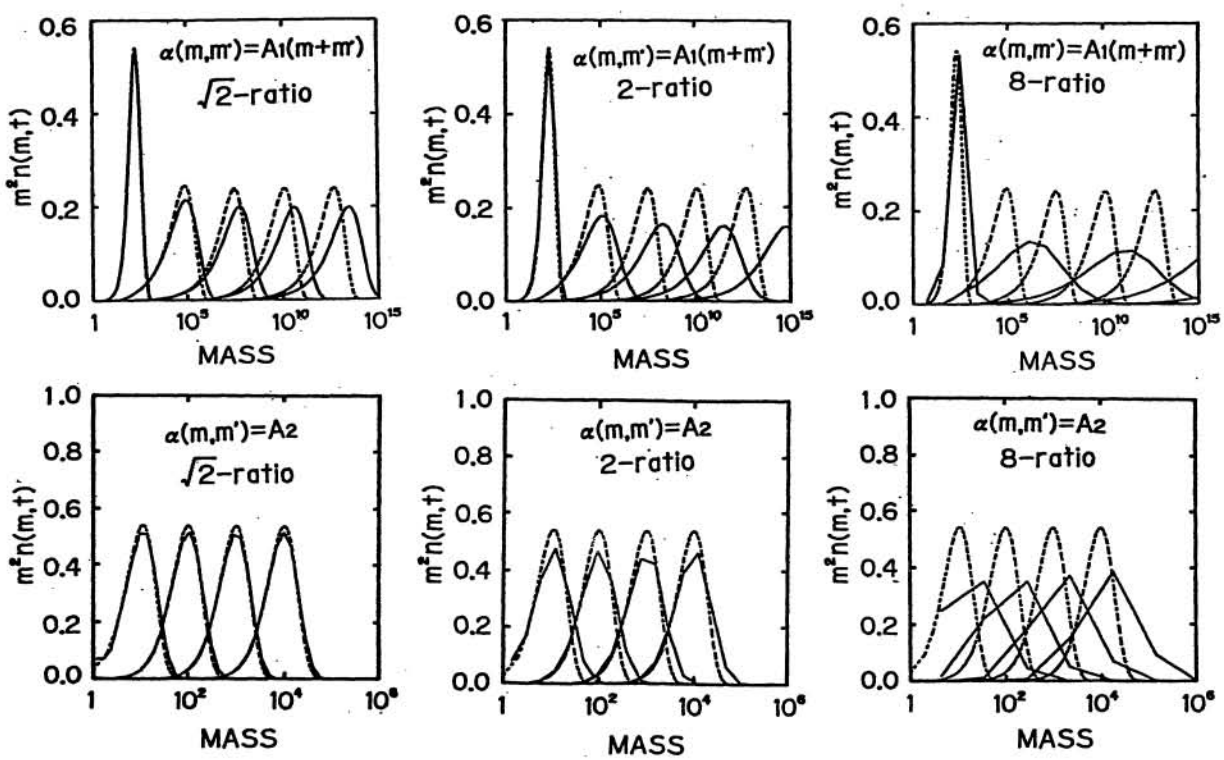

Fig.1. Comparison between analytic (dashed curves) and numerical (solid curves) distributions $m^2n(m,t)$ in the case of $\alpha(m,m') = A_1(m+m')$ at five stages; $t = 0, \tau_1, 2\tau_1, 3\tau_1$, and $4\tau_1$, and in the case of $\alpha(m,m') = A_2$ at four stages; $t = \tau_2, 10\tau_2, 100\tau_2$, and $1000\tau_2$ [Ohtsuki et al.(1989)].

previous numerical simulations, various values of this common ratio of divisions were used; $\sqrt{2}$[1,2,3], 2[4], 8[5,6], and 10[7].

In this work, three different logarithmic divisions with common ratios $\sqrt{2}$, 2, and 8 are used to numerically solve the coagulation equation in cases of simple forms of coalescence rate $\alpha(m, m')$, where analytic solutions are known. The comparison of numerical solutions and analytic ones shows appreciable discrepancies between them and the discrepancies are quite large in the cases of larger common ratios; the coagulation is considerably accelerated (Fig.1). Comparison between the simulations of planetary growth with these three types of divisions is also made to show that growth time in early stages differs by a factor of about ten between the cases of common ratios $\sqrt{2}$ and 8 (Fig.2). This suggests that the previous numerical simulations of coagulation process with common ratios of 2 or 8 were very likely affected with this artificial acceleration.

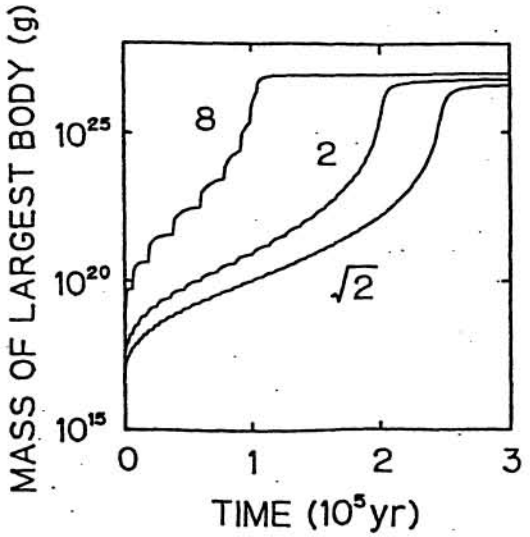

Fig.2. Growth curves of the largest planetesimal in the case where $\alpha(m, m')$ is given by usual gravitational collision rate formula with the relative velocity $v = 5 \times 10^{-4} v_K$, for three common ratios of logarithmic mass-coordinate divisions ; $\sqrt{2}$, 2, and 8 [Ohtsuki et al.(1989)].

References

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