Quantum Fluctuation Effects on Nuclear Fragment Formation*

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Many-body systems described by wave packets contain quantum fluctuations which may significantly affect the statistical properties [1]. The effect can be included in dynamical treatments by means of a quantal Langevin force [2,3]. We have adapted the treatment to QMD simulations of nuclear collisions where the individual nucleons are described by gaussian wave packets. This augmentation endows the system with larger fluctuations and the excitation of the emerging fragments is smaller. These two features conspire to enhance the production of intermediate-mass fragments. The effect on the mass discribution of atomic clusters has also been studied [4].

The usual QMD treatment leads to primary fragments that are typically sufficiently excited to emit nucleons and it is therefore essential to consider the statistical decay chain. This process causes a strong suppression of the IMFs, and a corresponding enhancement of lighter fragments. By contrast, the quantum Langevin treatment leads to fragments having a relatively small degree of excitation and, consequently, a larger proportion of them survive the statistical decay.

Our results for Au+Au collisions (illustrated in fig. 1) indicate that the inclusion of the quantum fluctuations in the wavepacket dynamics leads to a significant increase in the production of massive fragments with low excitation. Although the experimental data are not yet reproduced quantitatively, the improvement is significant over the results obtained with the usual treatments in which the quantum fluctuations are ignored. This general qualitative result suggests that the underlying quantum nature of the nuclear many-body system may indeed play a significant role in fragmentation reactions.

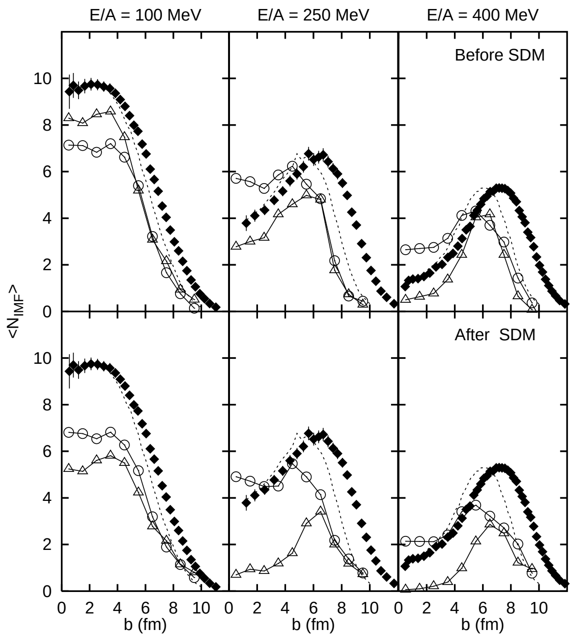

Figure 1: IMF multiplicity before and after statistical decay for central Au+Au collisions. Circles and triangles indicate QMD results at given energies with and without the quantal Langevin force, respectively. The upper and lower parts show the distributions before and after the statistical decay [5], respectively. The experimental data [6] are shown by solid diamonds.

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