Non – equilibrium processes in nuclear reactions with heavy ions

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Abstract

The report is a brief overview of the theoretical and experimental status of heavy ion reactions. The emphasis is on non-equilibrium processes in nuclear reactions. The effects due the possible cluster structure of the projectile nucleus, which is excited during the collisions, is discussed. Particular attention is paid to the description of the angular distributions of secondary particles in the framework of the exciton model. As example, the experimental data on the double differential cross section of the secondary particles emitted from the reactions induced by Oxygen are consider. Estimates within the presented models with different clusterization probabilities of clustering in ^{16}O are compared with the experimental data.

This method permits the direct simulation of experimental situation, in particular, nuclear lifetime measurements by the crystal blocking technique. Part of the report will be devoted to a discussion of the experimental results of the Vandana Nanal *et al.* work [1].

The decay times of compound nuclei formed in the $^{12}C+^{28}Si \rightarrow {}^{40}Ca$ and $^{19}F+^{28}Si \rightarrow {}^{47}V$ fusion reactions were estimated [2], [3]. The method was used in analysis of the time characteristics of compound nucleus decay in the $^{12}C+^{28}Si \rightarrow {}^{40}Ca$ and $^{19}F+^{28}Si \rightarrow {}^{47}V$ reactions. The calculation results are compared with experimental data [1]. In the frames of discussing approach the pronounced difference between production times for even Z and odd Z evaporation residue is detected ('Oscillating or Staggering Effect'). This effect certainly connected with the even – odd deference in the nuclear level densities. The nuclear lifetime is directly proportional to the nuclear level density. Thus the even-odd difference in the nuclear level density should be directly registered by measurements of nuclear lifetimes. However, absolute values of the times depend strongly from the level density model. Emphasize that, odd-even differences remain independently the level density models. This effect is more pronounced for even – even compound nucleus ^{40}Ca than for ^{47}V. For this two reactions the neutron evaporation probability is essentially smaller than one for proton or α – particles. Following this for the $^{12}C+^{28}Si$ reaction the Z even – N even and Z odd – N even daughter nuclei are more probable. In the case of the ^{47}V deexcitation, even N in daughter nuclei is more probable, but deexcitation processes starts from the Z odd nucleus. Therefore in the case of the ^{40}Ca deexcitation the even – even nuclei have higher excitation energies on average than for the decay of ^{47}V. Perhaps this differences in the excitation energies is responsible for the decrease the odd-even effects in the production time of residues.

In addition, odd-even differences remain independently the level density models. However, absolute values of the times depend strongly from the level density model. Apparently in analysis of experimental data connected with nuclear lifetime the most important role plays the choose the theoretical model for level density. So, new experimental techniques and accurate analysis of the old experimental data on nuclear lifetime are very promising for the development of our conception of the nuclear level density.

References

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