SCIENTIFIC REPORT

Implementation of the project IDEI 42/05.10.2011
october – december 2011

Binary nuclear systems

Objective: *Influence of the charge density variation on the fusion process*

The charge density evolution is considered through the transition shape from separated projectile and target up to the final compound nucleus configuration. Only tip-to-tip collisions have been accounted for, since they produce the lowest Coulomb barriers. Spheroidal nuclei have been studied. We considered the charge density as dependent on the non-overlapped volume, where the evolution takes place from the initial touching point up to the final compound nucleus value. We found two laws of variation producing intermediary mass and charge values proportional to the volumes. So the charge density is geometry dependent. The intermediary variations Z1i/A1i and Z2i/A2i are functions of the semiaxis ratio. These values influence the level schemes through the dependence of the oscillator frequencies along and perpendicular to the symmetry axis. The frequency ratio depends on the semiaxis ratio. The energy levels obtained in this way have been used in the Strutinsky shell correction method.

The macroscopic energy is calculated as the sum of the Coulomb and nuclear Yukawa-plus-exponential terms. The charge densities are volume dependent. It is modified as a function of the intermediary mass and charge numbers. Its volume modifies with the distance between centers. In this way the charge density influence the macroscopic terms in the total deformation energy during fusion. We obtained the Coulomb and Yukawa-plus-exponential energy variation as well as the total macroscopic part as a function of different laws of variation for the projectile semiaxes, for ^{36}Ar+^{66}Fe $\rightarrow$ ^{102}Ru. The total deformation energy has been minimized against the semiaxis ratios, hence against different charge density paths. One can see that during the overlapping process, the minimum energy path corresponds to the unchanged ^{36}Ar radius. Hence the overlapping takes place with constant charge density at the beginning and modified one at the end of the process. Macroscopic energy variation spread between -3 and 4 MeV. Such a variation is important in the calculation of the action integral and WKB penetrability.

The influence of the charge density variation through the geometric transition laws has been studied in connection with the shell correction energy E_{shell}. The energy difference between different laws is up to 2 MeV, more pronounced at the end of the process. The sum of the macroscopic and microscopic terms reach 4 MeV, especially at the last part of the process. These variations are important since 1 MeV difference in the deformation energy can trigger 3 orders of magnitude variation in the penetrability value within the WKB calculation.

The conclusion of this report is that the influence of the charge density variation upon the cold fusion barriers manifests through geometrical parameters which characterize the nuclear shape transition from separated projectile and target up to the compound nucleus. The charge density modifies such that the fusion barrier can be lowered down to 4 MeV. This result can lead to significant differences in the fusion cross section values.

The results and the calculation algorithm have been used to study binary nuclear processes. They have been published as follows:

ISI articles:

1. D. N. Poenaru, R. A. Gherghescu, W. Greiner, Phys. Rev. Lett. 107, 062503(2011).
2. D. N. Poenaru, R. A. Gherghescu, W. Greiner, Phys. Rev. C83, 014601 (2011).

International conferences:

1. R. A. Gherghescu, D. N. Poenaru, W. Greiner, invited lecture, Nuclear Physics Symposium, Split, Croatia 2011
2. R. A. Gherghescu, D. N. Poenaru, W. Greiner, invited lecture, International Conference on Exciting Physics, Makutsi, South Africa, 2011

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