SYSTEMTIC STUDY OF HEAVY-ION FUSION REACTIONS AT EXTREME SUBBARRIER ENERGIES

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Heavy-ion fusion cross sections are analysed in terms of the *S* factor. It is shown that the unexpected steep falloff in cross section with decreasing energy, which has been observed for several heavy-ion systems at energies far below the Coulomb barrier [1], translates into a well-defined maximum of the *S* factor. We argue that the *S* factor for heavy-ion fusion must exhibit a maximum when the *Q*-value is negative, because it has to go to zero when the center-of-mass energy becomes less than -*Q*, which corresponds to the ground state of the compound nucleus. The surprising result is that the *S* factor has its maximum at a high excitation energy of the compound nucleus, typically in the range of 20 to 30 MeV. We therefore suspect that the steep falloff in the fusion cross section, and the closely related maximum in the *S* factor, is an entrance channel phenomenon rather than an effect of the compound nucleus.

In order to study the new phenomenon in more detail, fusion cross sections of ^{64}Ni +^{64}Ni have been measured down to the 100 nb level. Detailed coupled-channels calculations have been carried out for the fusion reactions of ^{64}Ni +^{64}Ni and ^{60}Ni + ^{89}Y. These calculations, and also a comparison with the results of Ref. [2], demonstrate that the conventional coupled-channels calculations are unable to reproduce the steep falloff of cross sections at extreme subbarrier energies.

An overview of heavy-ion fusion reactions that exhibit a maximum in the *S* factor at low energies will be presented. The systematics of the energy, E_s, where the maximum occurs is parametrized with a simple empirical formula.

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References

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