The nuclear potential in heavy-ion fusion

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The interactions between nuclei are commonly described using the Coulomb potential and the nuclear potential. These potentials combine to form the barrier which must be overcome for fusion to occur. A knowledge of the nuclear potential is fundamental to any model of fusion. In coupled channels models the nuclear potential not only affects the width of the fusion barrier but also the coupling strengths. Predictions of fusion cross-sections therefore critically depend on the nuclear potential around the barrier.

The nuclear potential is usually taken to be of Woods-Saxon form which is defined by three parameters: the depth, the radius and the diffuseness. The diffuseness parameter defines the fall-off or shape of the nuclear potential and thus directly affects the the barrier shape and the coupling strengths, which to first order depends on the derivative of the potential[1]. Fits to high precision fusion cross-sections at above barrier energies for an increasing number of reactions[2, 3] have consistently required values of the diffuseness parameter ~ 1.5 times higher than the commonly accepted value of $\simeq$0.63 fm deduced from elastic scattering. This discrepancy leads to several questions. What is the true diffuseness of the nuclear potential? Is a Woods-Saxon parameterization appropriate for describing the potential? Does friction play a role in producing a larger effective diffuseness in fusion?

To gain a better understanding of these issues, fusion cross-sections at energies much below the Coulomb barrier have been measured. At these deep sub-barrier energies the fusion process is dominated by quantum tunnelling, and the measurements may yield an independent and sensitive measure of the diffuseness parameter. The talk will present our current understanding of the observed anomalies and the possible need for introducing physical effects which have been ignored in the commonly used models of fusion thus far.

[1] M. Dasgupta *et al.*, Annu. Rev. Nucl. Part. Sci. **48** (1998) 401.

[2] C.R. Morton *et al.*, Phys. Rev. C **60** (1999) 044608.

[3] J.O. Newton *et al.*, Phys. Rev. C **64** (2001) 064608.