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To fuse or not to fuse: That is the question

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Fusion reactions provide an avenue for extending the periodic table creating nuclei, powering the stars and in the near future, solution of the energy problem. The fusion of complex (composite) nuclei is governed by a delicate balance between the attractive nuclear and repulsive Coulomb interactions. Detailed experiments made in the last three decades have shown that the fusion process cannot be understood as a simple barrier penetration by a structureless object with a potential depending only on the distance between the centers of the colliding systems. The associated tunneling probability was shown to be extremely sensitive to the plasticity of the intrinsic structure that can evolve during the process and to the interplay of the many open and virtual channels, whose amplitudes may be tuned by varying the beam energy and/or choosing different projectile-target combinations. Thus the theoretical tool to conceptually understand the modification of barrier(s) towards fusion due the coupling of direct reactions to the elastic channel is a coupled channel approach. To obtain a complete understanding of fusion process necessitates also the investigation of the associated direct channels.

Short-lived Radioactive Ion Beams (RIB) with weak binding, unusual neutron/proton asymmetry and extended spatial distributions (halos) provide a new vista to probe such a multidimensional tunneling. The experimental conditions for measuring the fusion cross sections using low intensity RIB combined with the need to identify a complete amalgamation of project and target (complete fusion) made these measurements challenging. The role of exotic structures on the tunneling process and its interconnectivity with other open channels especially coupling to unbound states (breakup) and transfer channels have been pursued mainly using beams of 6,8He, 9Li, 11Be. Such studies have focused mainly on light ion beams as they show a large variety of exotic structures as compared to heavier nuclei. The coupling to states in the continuum in such nuclei is also being used to study open quantum systems and the effect of dechorence to describe nuclear reactions. Studies of the tunneling of composite objects are also of fundamental interest in molecular processes and transport in nanodevices

In this talk after a brief historical overview of the major stepping stones of fusion with stable beams, we will review the recent status of the field and our present understanding of fusion with radioactive ion beams and discuss perspectives in this field.

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