Fusion of stable weakly bound nuclei

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A full understanding of the fusion and break-up processes induced by stable weakly bound projectiles is an essential step for the study of the fusion induced by radioactive beams and the production of nuclei near the drip lines. Whether the coupling between the relative motion and intrinsic degrees of freedom of such interacting nuclei may enhance the fusion cross section relative to one-dimensional potential predictions, or the break-up of the weakly bound nucleus before reaching the fusion barrier may inhibit it, is a subject of recent interest. If one wants to have a comprehensive picture of this problem, one has to study different energy regimes, from the sub-barrier to well above barrier energies and also one has to span different nuclear masses, in order to investigate the effect, on the fusion, of nuclear and Coulomb break-ups. The suitable nuclei for this kind of study are ^{9}Be, ^{6}Li and ^{7}Li , due to their small separation energies that should favor the break-up process.

In the studies of the break-up process and its influence on the fusion mechanism, different reaction mechanisms should be considered: Elastic or direct break-up (BU) corresponding to either large or low partial waves. Incomplete fusion (ICF) following the break-up, when not all of the fragments fuse with the target. Complete fusion (CF), either following the break-up, when all projectile fragments fuse with the target or not produced by break-up. Exclusive experiments should be able to distinguish most of these mechanisms.

In this contribution we give an overall picture of the present understanding of the field, based mostly on recent experiments performed by our group and collaborators, on the ^{9}Be + ^{208}Pb, ^{6,7}Li + ^{209}Bi, ^{6,7}Li, ^{9}Be + ^{27}Al, ^{64}Zn, ^{9}Be +^{19}F and ^{7}Li + ^{12}C systems and other systems involving tightly bound projectiles on the same targets and/or leading to the same compound nuclei. Systems studied by other authors are also used in order to help the full description of the subject. Our conclusions are that the BU corresponding to large partial waves is responsible for large differences in the break-up and reaction cross sections of the different weakly bound nuclei, but this is almost not reflected in the fusion cross section. The other three break-up processes are closely correlated and affect the CF process in such way that it reduces the CF cross section of systems with heavy targets, at high energies, due to the high ICF cross section. The suppression increases with decreasing break-up threshold. At low energies, due to the importance of the CF following the break-up, the total CF cross section is enhanced. The CF cross section of medium and light mass targets are not affected by the break-up, due to the decreasing of the predominance of the Coulomb break-up relative to the short range nuclear break-up.