Neutron Breakup reactions

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Neutron(proton) breakup from the projectile is the process which carries most of the cross section in reactions initiated by weakly bound nuclei. The experimental and theoretical analysis of such processes has been based on the assumption that breakup occurs in peripheral collisions and that the effect of the final state interaction of the neutron with the target (nuclear breakup) and of the core recoil (Coulomb breakup) can be treated as incoherent processes.
The observables which have been measured in most of the cases are total breakup cross sections, core parallel momentum distributions and sometimes neutron angular distributions. The latter as useful to disentangle the effects of nuclear and Coulomb breakup.
The shape of core momentum distributions depend in a very characteristic way from the angular momentum and spin of the single particle initial state and from the initial binding energy. Absolute cross sections on the other hand are proportional to the single particle state spectroscopic factors and comparisons of measured and calculated cross section has been used to check shell model predictions and/or extract unknown spectroscopic factors.

The situation is very delicate when the initial neutron separation energy is not known from mass measurements, as in the 19C case. For this nucleus the coulomb breakup experimental energy distribution has been compared to the theory to extract the initial binding energy value.

Studies of radioactive nuclei rely heavily on the theoretical support and it is therefore very important to check the accuracy of existing models and in particular their predictive power. The latest developments in reaction theory have been made in studies of the coulomb breakup.
Two issues are important:
i) to check the accuracy of first order perturbation theory calculations ;
ii) clarify the nuclear-coulomb breakup relative importance and possible interference. Recently the numerical solution of the Schroedinger equation with both nuclear and coulomb effects has become available. At the same time a semi-analytical model has been proposed, based on the semiclassical approximation, for evaluating consistently and in the presence of each other, both nuclear and coulomb breakups.

To support the theoretical results we propose to make a fully exclusive measure of one neutron breakup from ^{11}Be and ^{19}C on a heavy and on a light target. The first nucleus is very well known and could be used as a test case. It would be important to detect in coincidence the neutron and core in a selected, small range of out-of-the-reaction plane angles. In this way nuclear and coulomb breakup can be distinguished and interference effects can be seen. At the same time gamma-rays from the core in coincidence with the breakup events will allow to separate contributions from various initial states in the projectile. On the other hand gamma-rays from the target will give information on the core-target interaction (trajectory of relative motion) and clarify whether one neutron breakup might occur at impact parameters smaller than the strong absorption radius and therefore in correspondence to sligthly deep inelastic core-target reactions. So far both theory and data analysis have relied on the hypothesis of a core-target elastic interaction.