Study of the breakup channel in $^{11}Li+^{208}Pb$ collisions at energies around the Coulomb barrier.

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We present a new study for the system $^{11}Li+^{208}Pb$, measured at the radioactive nuclear beam facility of TRIUMF (Vancouver, Canada) at energies around the Coulomb barrier (E_{lab} = 24.3 and 29.8 MeV)[1,2]. The halo nucleus ^{11}Li is composed of a core nucleus of ^{9}Li and two loosely bound neutrons. Due to the weakly bound structure, this nucleus is easily polarizable. Thus, in the presence of the strong electric field produced by the target nucleus ^{208}Pb, the projectile will be distorted and, eventually, it can be removed from the elastic channel. This phenomenon, known as

dipole Coulomb polarizability, produces a strong reduction of the elastic cross section with respect to the Rutherford prediction. In addition, this phenomenon gives rise to a large breakup probability of the weakly bound projectile[2].

In this work, we concentrate on the analysis of the elastic data as well as the inclusive breakup cross sections[1,2]. For the latter, two kinds of analyses are presented. First, we present an analysis based on the semiclassical theory of Alder and Winther of Coulomb excitation[3]. We introduce a new quantity, termed as reduced breakup probability, defined as the usual breakup divided by some kinematical factors.

We find that the reduced breakup probability as a function of the collision time is, for sufficiently large collision time, independent on the scattering energy, or the target properties, and becomes a function only of the B(E1) distribution of the halo nucleus. Inclusion of higher Coulomb multipoles or nuclear forces do not alter this picture. Thus, from the reduced breakup probability data we can extract useful information about the structure of the weakly-bound nucleus, such as the separation

energy and the behaviour of the B(E1) distribution at low excitation energies, close to the breakup threshold[2].

The data have been compared also with Continuum-Discretized Coupled-Channels (CDCC) calculations, assuming a simple two-body model for the ^{11}Li projectile (2n-^{9}Li). These calculations include higher order Coulomb multipolarities, as well as nuclear couplings, are included to all orders. The interpretation of our data indicate that the large breakup probabilities found at forward angles, might be due to a large B(E1) probability just above the breakup threshold, which might be even larger than the values previously mentioned in the literature[4].

[1] M. Cubero et al. Phys.Rev.Lett. 109, 262701 (2012)
[2] J. P. Fernandez-Garcia et al. Phys. Rev. Lett. 110, 142701 (2013)
[3] K. Alder, A. Winther, Electromagnetic excitation: Theory of Coulomb excitation with heavy ions (North- Holland, 1975).
[4] T. Nakamura et al., Phys. Rev. Lett. 96, 252502 (2006).