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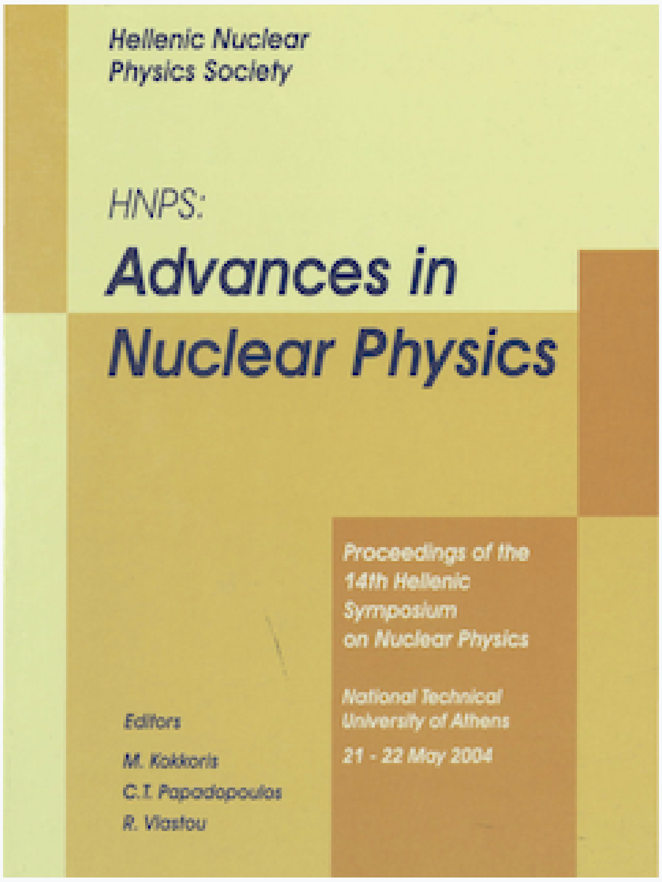

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Abstract

We have undertaken the study of the ^{6}Li breakup on a ^{28}Si target near the Coulomb barrier through an angular distribution measurement. α's were recorded in coincidence with deuterons in order to determine exclusively the breakup of lithium. Preliminary results are analysed and are discussed, in a discretized coupled channel framework (CDCC).

The nucleus ^{6}Li is a weakly bound nucleus (^{6}Li $\rightarrow \alpha +$ d, S $_\alpha$=1.471MeV) which, resembles the halo nucleus ^{6}He (e.g see in [1] and references therein). In this context, a study of its direct and sequential breakup may help in understanding the resonant and non-resonant breakup process in halo nuclei [2]. Moreover, the breakup of ^{6}Li, as a coupled channel effect is directly connected with the anomalous behavior of the optical potential around barrier as was pointed out in [3] with consequences on subbarrier fusion. Therefore it is plausible why there is a world wide effort on both theoretical and experimental grounds, concerning the elastic scattering and reaction channels at near barrier energies of weakly bound nuclei[3–13].

We have studied recently the α-particle yield, produced by the scattering of ^{6}Li on a ^{28}Si target at near barrier energies [13]. According to our study which included CDCC calculations, the yield was attributted to breakup and transfer reactions. As it was suggested, the two processes had to be unfolded from the α-production yield in order to draw valuable conclusions about the reaction mechanisms in this interesting energy region. In this context, a study of the exclusive breakup of ^{6}Li on ^{28}Si was undertaken in the present work, in a complete coincidence experiment.

Our experimental setup has been described in detail in a previous work [3] and only a short summary pertinent in this work, will be given here. A $^6Li^{+3}$ beam was delivered by the TN11/25 HVEC 5.5 MV Tandem accelerator of the National Research Center of Greece-DEMOKRITOS at 13 MeV. Beam currents were of the order of 15 nA. The beam impinged on a 210 μgr/cm^2 thick, self supported natural silicon target, tilted by $\pm 45^0$ (depending on the detector position) and the reaction products were detected by three telescopes set ~15 cm far from the target. Telescope 1 (ΔE =100 μm, E=1500μm) was set on a top table and used to detect deuterons. Lithium ions and some of the alpha's were stopped in the first detector while deutrons were well discriminated from protons with the ΔE-E technique. Telescopes 2 and 3 (ΔE =10 μm, E=200μm) were set on a bottom rotating table, concentric to the top one. The telescopes were separated by 20 degrees and were able to discriminate between alpha's and elastic lithium, the last one used for normalization purposes. An additional Si detector of 200 μm was set in an arm fixed to 40 ^{0} to be used also for normalization. Telescope 1 was kept fixed at 40^0 and subsequently at 30^0 in respect with telescope 2 and 3 which were rotated in order to obtain the following pairs of angles θ_d/θ_α =40/30,40/50,30/20,30/40,30/55,30/75. The minimum relative energy, possible in this detector configuration can be seen in Fig. 1, in which the relative energy, (E_{ad}, is plotted against the angle $\theta_{cm}(^6Li^*)$ at which the excited ^{6}Li is scattered.

The obtained inclusive cross sections were found to be consistent with our previous α-production measurements [13] giving support to our normalization. The exlusive results are presented in Fig.2, where are compared to CDCC calculations. It has to be noted, that due to shortcomings with our aquisition system we had to employ a very low beam current and the accumulated coincident events were of the order of 5 to 10 counts per pair of detectors. This gives a big uncertainty to our results but still can give the trend of the breakup cross section. In a future experiment, it will be desirable to increase the coincident rate and this is expected to be obtained by cutting the elastic part. Another point that should be underlined is that the transformation of the double differential cross sections obtained from the experimental data in the laboratory system, $d^2\sigma/d\Omega_d\, d\Omega_\alpha$, to the center of mass system, $d\sigma/d\Omega_{cm}(^6Li^*)$ was obtained under the following assumptions : a)sequential breakup and b)decoupling of the α and deutron particles allowing the factorization of the above double differetial[14]. Taking into account the angular distribution results and under the above assumptions, a total breakup cross section was obtained equal to σ=4±6 mb. This, within error, is of the same order of magnitude with the total breakup cross section predicted by the CDCC calculation, equal to 16 mb. Taking into account the α-production cross section and total reaction cross section obtained previously [3] as 533mb and 954mb respectively, we conclude that the reaction channel of breakup at near barrier energies is negligible. Therefore, the variation of the optical potential anomaly at barrier between ^{6}Li and stable projectiles has to be sought elsewhere.

In summary,

We have presented preliminary results on the breakup of ^{6}Li on ^{28}Si at 13 MeV. The very low experimental cross section compatible within error with the CDCC prediction calls for further work in the direction of other direct reaction channels, like transfer reactions in order to enlight the controversy of the optical potential anomaly between weakly bound and stable nuclei. Further statistics is necessary to establish the experimental point at θ_{cm}=75^{0}, as origintaing from sequential breakup to the second resonant excited state of ^{6}Li*. Also data at smaller angles are needed to differentiate between sequential and direct breakup processes.

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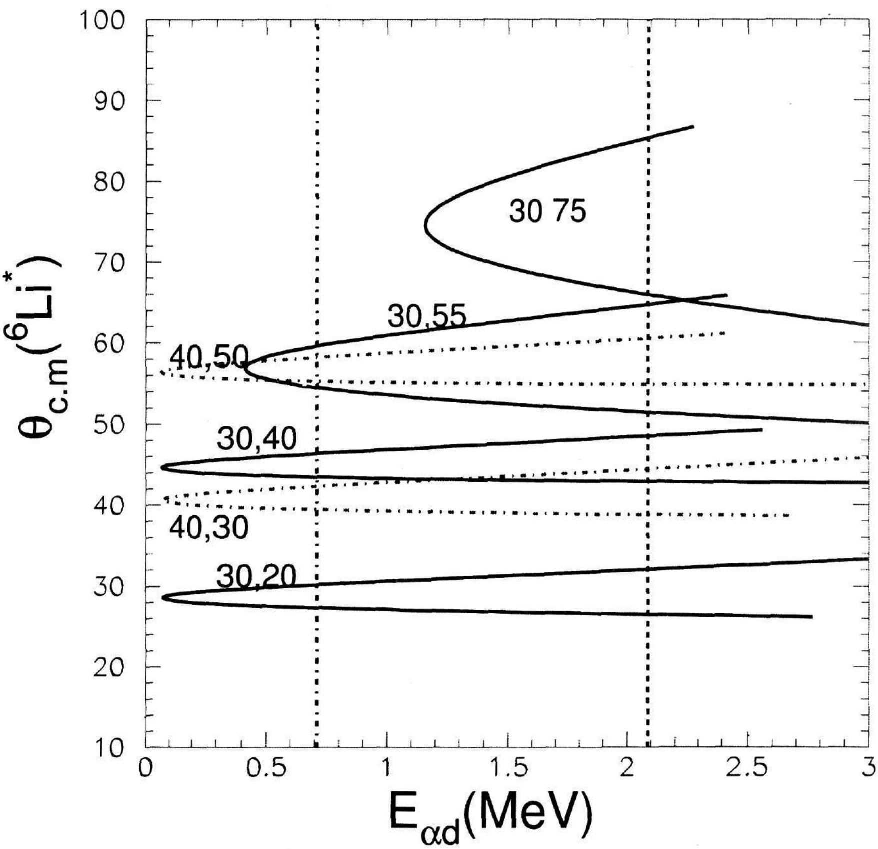

Fig. 1. Relative energy E_{ad} versus θ_{cm} (^{6}Li*) for pairs of angles chosen in this work to detect deutrons and alphas in coincidence. The vertical lines signify the available relative energies in the case of sequential decay via resonant excited states in ^{6}Li.

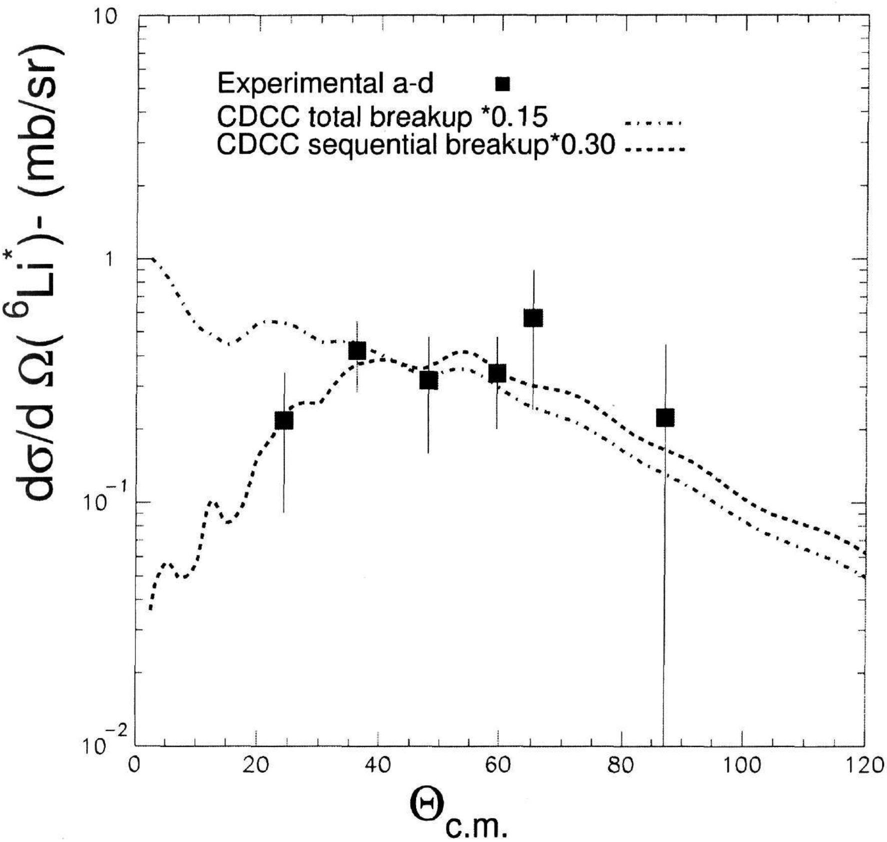

Fig. 2. Exclusive breakup cross sections at 13 MeV. Experimental results are designated with solid boxes. The lines represent CDCC predictions for sequential breakup (dashed line) and total breakup (dotted-dashed line) that is sequential plus direct. The theoretical predictions are normalized to the data.