Abstract

In the present work elastic scattering measurements for the p+^{6}He and d+^{6}He systems, as well as the ^{6}He(d,t)^{5}He transfer reaction were performed at 26 MeV/n in inverse kinematics at the ACCULINNA-2 fragment separator. The obtained angular distributions of the elastic scattering were analyzed within the Optical Model (OM), and the transfer reaction angular distribution was analyzed using the Distorted-Wave Born Approximation (DWBA) method.

The obtained angular distribution of the differential cross section for the p+^{6}He elastic scattering is in good agreement with the data obtained by Wolski [1] at a slightly lower energy (25 MeV/u) measured at the ACCULINNA fragment separator. The data set is in agreement with the differential cross section calculated with the global OM potential of Varner [2] as well as the cross sections calculated using optical potentials by Wolski [1] and the optical potential obtained from microscopic Continuum-Discretised Coupled Channels (CDCC) calculations by Rusek [3].

The differential cross section of the d+^{6}He elastic scattering was measured for the first time with a good angular resolution thanks to the use of a CD_2 target. The experimental data set is reproduced well by OM calculations with the optical potentials derived from the p+^{6}He OM potentials using the folding method. This suggests that the influence of deuteron breakup on the elastic scattering is small. It also appears that the quadrupole deformation of the ^{2}H ground state has little influence on the d+^{6}He elastic scattering. From the set of global optical potentials for deuteron scattering considered, the potential of Zhang [4] fits the experimental data best.

The angular distribution of the differential cross section for the ^{6}He(d,t)^{5}He neutron transfer reaction was measured for the first time. The obtained cross section was analyzed using the DWBA method. The optical potentials used to generate the entrance channel distorted waves were the empirical potentials obtained from the analysis of the d+^{6}He elastic scattering. It was found that the choice of entrance channel potential has a minor influence on the final cross section. The exit channel wave functions were generated with the global Optical Model Potential (OMP) of Pang [5] and with the OMP obtained from folding the ^{4}He+t and n+t OM potentials with the wave function of the ^{5}He$_{\rm g.s.}$.

Wave functions of the cluster-to-core relative motion for ^{5}He$_{\rm g.s.}$+n and ^{2}H+n systems were obtained from the single particle binding potentials. It was observed that the remnant part strongly influences the differential cross section of the transfer reaction in the DWBA calculations. Post and prior approaches give different results with no remnant and almost the same result with the full remnant term.

The spectroscopic amplitude $S_{\rm 5He+n}$ for the ^{6}He$_{\rm g.s.}$=^{5}He$_{\rm g.s.}$+n configuration was adjusted so that the calculated differential cross section for the transfer reaction reproduced the data points. It was averaged over the determination of different entrance and exit channel potentials and equals $S_{\rm 5He+n} = 1.167\,^{+0.148}_{-0.140}$ after taking into account experimental and theoretical uncertainties. The spectroscopic factor ($SF_{\rm 5He+n}$) calculated from the spectroscopic amplitude equals $SF_{\rm 5He+n} = 1.36\,^{+0.35}_{-0.33}$ and is smaller than theoretical predictions, but agrees with them within the uncertainties.

Bibliography

[1] R. Wolski et al. “Cluster structure of 6He studied by means of 6He + p reaction at 25 MeV/n energy”. en. In: *Physics Letters B* 467.1 (Nov. 1999), pp. 8–14.

[2] R.L. Varner et al. “A global nucleon optical model potential”. en. In: *Physics Reports* 201.2 (1991), pp. 57–119.

[3] K. Rusek, K. W. Kemper, and R. Wolski. “6 He interaction with protons”. en. In: *Physical Review C* 64.4 (Sept. 2001), p. 044602.

[4] Y. Zhang, D. Y. Pang, and J. L. Lou. “Optical model potential for deuteron elastic scattering with 1p-shell nuclei”. In: *Physical Review C* 94.1 (July 2016), p. 014619.

[5] D. Y. Pang et al. “Global optical model potential for $A = 3$ projectiles”. In: *Phys. Rev. C* 79 (2 Feb. 2009), p. 024615.