Probing surface distributions of α clusters in 20Ne via α-transfer reaction

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We analyze the α-transfer reaction ^{16}O(^{6}Li, d)^{20}Ne in order to investigate the surface manifestation of the α particle in the ground state of ^{20}Ne. The microscopic cluster model is adopted to describe ^{20}Ne and its α-^{16}O relative wave function is calculated by means of the generator coordinate method [1]. To perform the reaction calculation we employ the $d + \alpha +^{16}$ O three-body model based on the continuum-discretized coupled-channels method [2], which explicitly treat the breakup effect of the projectile ^{6}Li into the $d + \alpha$ continuum state. Numerical setups are explained in detail in Ref. [3].

In Fig. 1(a) we compare our calculated result of the cross section (CS) of the α-transfer reaction as a function of the emitting angle θ of d at 20.0 (solid line) and 42.1 MeV (dashed line) with the experimental data [4,5]. Our calculation essentially improves the result compared with the previous one [4,5] in the sense that the diffraction pattern of the measured CS is well reproduced by the calculation and the acceptable normalization factors given in the legend are obtained, although the incident energy dependence remains. This is due to the improvement of both the structure and reaction models. The physical meaning of the normalization is discussed in Ref. [3].

Through detailed analyses using a simple $\alpha +^{16}$ O two-body model [3], it is found that the CS at the forward angles, say $\theta \lesssim 40°$, is sensitive to the surface distribution of the relative wave function, i.e., the wave function in the region of the α-^{16}O relative distance r bigger than ~ 5 fm is probed on the CS at 20.0 MeV, as shown by Fig. 1(b). Note that, in Fig. 1(b), the wave function is normalized by the factor 0.261. Similarly the surface region $r \gtrsim 4$ fm of the wave function is found to be probed on the CS at the forward angles. This suggests that the surface manifestation of the α-cluster structure that populates at states below the α-threshold energy is able to be proved thorough α-transfer reactions.

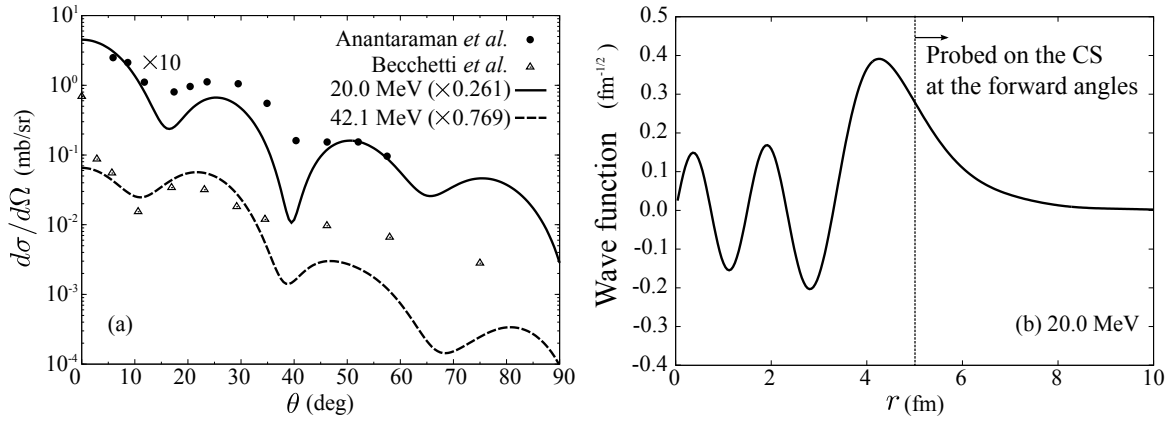

Figure 1: (a) Comparison of the calculated cross sections of ^{16}O(^{6}Li, d)^{20}Ne at 20.0 (solid line) and 42.1 (dashed line) with the measured data [4,5]. (b) The α-^{16}O radial wave function of the ground state of ^{20}Ne.

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