Analysis of a low-energy correction to the eikonal approximation

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The eikonal approximation, in which the distortion effect of scattering wave is assumed to be weak and then it is evaluated as a deviation from the plane wave, has been adopted for description of nuclear reactions. Recently, it was reported [1] that, for a breakup reaction at a low incident energy, the eikonal approximation failed to coincide the cross section with that obtained from the method of the continuum-discretized coupled-channels (CDCC) [2], which describe breakup reactions with a quantum way. In this work, we analyze a Coulomb correction for the low-energy breakup reaction to models employing the eikonal approximation.

In the correction [3, 4], the impact parameter b is replaced by $b' = \frac{\eta}{K} + \sqrt{\frac{\eta^2}{K^2} + b^2}$, under the concept of the closest approach in Rutherford scattering, where K (η) is the projectile-target wave number (Sommerfeld parameter). This correction is applied to two reaction models employing the eikonal approximation; one is the dynamical eikonal approximation (DEA) [5, 6] and the other is the eikonal-CDCC (E-CDCC) [7, 8]. The detail of the calculation is given in Ref. [9].

Figure 1 shows the breakup cross section of ^{15}C on ^{208}Pb at 20 MeV/nucleon as a function of the emitting angle θ of the n-^{14}C center of mass system after dissociation. Both results of DEA (thick solid line) and E-CDC (dashed line) overestimate the CDCC prediction (thin solid line), and their diffraction patterns shift to forward angles. If we adopt the correction to DEA and E-CDCC, the results respectively shown as the dash-dotted and dotted lines are significantly improved, though the decrease by the latter is somewhat strong at $\theta \gtrsim 5°$. It is also confirmed that, in the energy spectrum of the breakup reaction, the correction significantly improves the result. This indicates that the concept of the "trajectory" involving the correction is still effective to describe the breakup reaction even though complicated processes, for instance nuclear-Coulomb interference and multistep effect, may exist for the low-energy reaction.

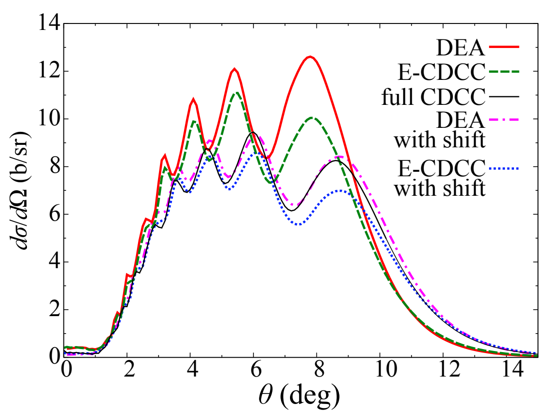

Figure 1: Angular distribution of the breakup reaction of ^{15}C on ^{208}Pb at 20 MeV/nucleon. See the text for detail.

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