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Extension of Migdal-Watson formula and its application to binary breakup reaction

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Resonance phenomena appearing in low-energy nuclear reactions are very important in studies of nucleosynthesis in cosmos because reaction rates in the synthesis are strongly affected by the resonance parameters: resonance energy and decay width. In particular, the inelastic scattering to the continuum energy states above the particle decay threshold, which is often called breakup reaction, is very useful to explore the resonance parameters.
In order to derive the resonance parameters from the observed strength of the breakup reactions, the evaluation of the non-resonant background strength is indispensable because the resonant enhancement, which has the strong energy dependence, are embedded in the non-resonant background contribution with a broad structure. Since the background strength is structure-less and must have the weak energy dependence, the shape of the non-resonant background strength is often assumed by the simple analytic function or evaluated from the simple reaction mechanism, such as the direct breakup without the final state interaction between the decaying fragments. Unfortunately, there is no theoretical prescription to describe the non-resonant background strength on the basis of the simple analytic formula.
In this report, we propose an analytic formula to evaluate the non-resonant background strength by extending the Midgal-Watson (MW) theory [1], which was originally considered for the s-wave breakup reaction in the charge neutral systems [2-4]. In the evaluation of the background strength for the binary breakup, we employ the complex scaling method (CSM), which is a powerful tool to describe the few-body continuum states [5].
We have calculated the non-resonant breakup strength of ^{20}Ne into α + ^{16}O and ^{12}Be into α + ^{8}He by CSM, and the CSM strength is fitted by the analytic function, which is obtained by the extended MW formula. We will demonstrate that our analytic formula can nicely reproduce the non-resonant strength in these binary breakup reactions. Moreover, we will report the physical meaning of new parameters, which are introduced in extending the original MW formula, in connection to the spatial size of the initial wave function in the breakup reactions.

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Experimental nuclear physics

Theoretical nuclear physics

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