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Cluster Effective Field Theory calculation of electromagnetic breakup reactions with Lorentz Integral Transform method

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We present the study of the ^{9}Be photo-disintegration process, $\gamma + {}^9\text{Be} \to \alpha + \alpha + n$, in the low-energy regime. This reaction is of astrophysical interest because the inverse process, including both sequential and direct reactions combining two α and a neutron into ^{9}Be, represents an alternative path to the formation of ^{12}C in a neutron-rich environment.

The ^{9}Be system shows a clear separation of scales: the shallow binding of ^{9}Be below the $\alpha\alpha n$ three-body energy threshold, and the deep binding of the α particle. As a consequence, at low energies, ^{9}Be nucleus can be studied as a three-body *clustering* system interacting through *effective* potentials. Unlike the calculations that can be found in the literature, where phenomenological potentials have been employed, we make an attempt to use potentials derived from an Halo Effective Field Theory (EFT) [1].

First we calculate the ^{9}Be three-body binding energy with the Non-Symmetrized Hyperspherical Harmonics (NSHH) method [2], including both two-body (α-α and α-n) and three-body *effective* potentials. We then study the ^{9}Be photo-disintegration reaction cross section via the Lorentz Integral Transform method [3]. Following the Siegert theorem, we compute the nuclear current matrix element using the dipole operator. This ensures that the contributions of the two- and three-body nuclear currents, due to the characteristics of the potentials employed (as momentum dependence and non-locality), are included in the calculation. We will discuss the results focusing on their dependence on the EFT parameters, and in connection with the experimental data.

The present formalism provides a starting point to study also other processes of astrophysical interest, such as the ^{12}C photo-disintegration reaction $\gamma + {}^{12}\text{C} \to \alpha + \alpha + \alpha$.

References

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