CHARACTERISTICS OF DI-PROTON EMISSION FROM LIGHT NUCLEI

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We will model the three-body breakup in even-Z nuclei near the proton drip line, where the pairing between the last two protons causes the one-proton decay channel to be energetically forbidden. More precisely, our goal is to calculate the angular distribution of protons emitted from the nucleus in a time-dependent framework. The relevant amplitudes are given by the overlap at time t of the initial and final wavefunctions describing the system. Then our task comprises three parts: the calculation of the wavefunction describing the system in its initial state, the forward time-propagation of the initial wavefunction to some time t, and the backward time-propagation of the final wavefunction to the same time t.

We obtain the initial wavefunction using a shell-model approach with a zero-range effective interaction. In this model the nucleus is described as a three-body system consisting of two protons interacting with each other and with a structureless core. Following Bertsch et al.,[5] we use a density-dependent, energy-cutoff delta function to simulate the proton-proton interaction. We then solve the Hamiltonian equation by a two-particle Green function method in coordinate space. Here we use the single-particle basis given by the eigenstates of the shell-model Hamiltonian, consisting of a kinetic energy operator, Woods-Saxon potential, and a spin-orbit interaction.

The forward time evolution of the two-proton system is described by the time-dependent Schrödinger equation, which we numerically solve by using a split-operator approach.[6] Since the independent degrees of freedom we are interested in are the spherical coordinates $r_1, r_2, \theta = \theta_1 - \theta_2$, it is convenient to write the Schrödinger equation in spherical polar coordinates. Then, we apply each of the propagators to the wavefunction written in a basis that is diagonal for the operator in question. Therefore we use the radial kinetic energy propagator and the angular momentum-dependent propagator in radial and angular space, respectively, while the interaction propagator is used in coordinate space. The appropriate basis transformations are introduced on a grid $\{r_{1i}, r_{2j}, x_k\}$, with $x_m = \cos(\theta_m)$ and $\theta_m = \theta_{1i} - \theta_{2j}$.

Finally, we assume that the final state of the two-proton system is described by a product of plane waves. The backward time evolution of the two-proton system is also described by the time-dependent Schrödinger equation, where the density-dependent effective interaction between the two-protons is now neglected. We numerically solve this equation in a scaled system of coordinates, which has the advantage of making the theory Galilean invariant,[7] and thus eliminates the rapid oscillatory character of the solutions and allows for very accurate numerical results.

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