Finite amplitude method and systematic studies of photoresponse in deformed nuclei

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Theoretical studies and predictions of properties of unknown nuclei are becoming more and more important subjects in nuclear physics. In order to find new features and useful concepts for these exotic nuclei, it is desired to perform systematic calculations for nuclei across the entire nuclear chart. The nuclear density-functional approach provides a promising tool for this purpose. For this purpose, the finite amplitude method (FAM), which we have recently proposed [1], is a powerful tool. The fully self-consistent calculation for deformed nuclei is easily achieved using the FAM, which we have recently developed [4]. The method allows us to avoid explicit evaluation of complex residual fields.

The essential idea of the FAM is to calculate the induced residual fields $\delta h(\omega)$ with the finite difference method ($\eta \ll 1$):

$\delta h(\omega) = \frac{1}{\eta}(h[\rho_0 + \eta \delta \rho(\omega)] - h_0)$.

Here, $h_0$ is the single-particle Hamiltonian in the ground state. Using forward and backward amplitudes, $|X_i(\omega)\rangle$ and $|Y_i(\omega)\rangle$, $h[\rho]$ can be calculated with non-hermitian densities

$\rho_0 + \eta \delta \rho(\omega) = \rho_0 + \eta \sum_i \{ |X_i(\omega)\rangle \langle \phi_i | + |\phi_i\rangle \langle Y_i(\omega)| \} = \sum_i \{ |\phi_i\rangle + \eta |X_i(\omega)\rangle \} \{ \langle \phi_i | + \eta \langle Y_i(\omega)| \}$,

where $|\phi_i\rangle$ are occupied single-particle orbitals at the ground state. In this way, the self-consistent random-phase approximation can be performed without explicit calculations of the residual interaction.

We have carried out systematic calculations for the electric dipole modes of excitation up to Ni isotopes in the fully self-consistent Skyrme-Hartree-Fock (SHF) plus random-phase-approximation (RPA) approach in the three-dimensional coordinate-space representation [2]. We solve the FAM equations in the three-dimensional Cartesian-coordinate-mesh representation without any spatial symmetries. We will show systematics of the centroid energies, widths, and deformation splitting of the giant dipole resonances, in comparison with experiments. We also discuss low-lying dipole modes in neutron-rich and proton-rich nuclei.

References