Measurement of the Dipole Polarizability of $^{68}$Ni


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The Equation of State (EOS) of nuclear matter is at the center of many current research axes in nuclear science, ranging from nuclear structure considerations, over heavy-ion collisions to the physics of neutron stars. When dealing with radioactive nuclei with a large proton-neutron imbalance, one component of the nuclear EOS is of particular importance: the symmetry energy. Especially its density dependence is of interest, since this parameter has been shown to correlate strongly with nuclear properties such as the neutron-skin thickness or the amount of low-lying electric dipole (E1) strength [1]. Previously, measurements of low-lying E1 strength have been used to determine the parameters of the symmetry energy [2]. It has, however, been shown that the measurement of the dipole polarizability $\alpha_D$ is a more robust and less model-dependent observable to extract this information [3].

In an experiment performed at the R3B-LAND setup at GSI, Coulomb excitation of $^{68}$Ni was measured in inverse kinematics. By measuring the invariant mass of the $^{68}$Ni($\gamma$,n)$^{67}$Ni and $^{68}$Ni($\gamma$,2n)$^{66}$Ni decay channels, the excitation energy distribution of this nucleus was reconstructed in an energy window ranging from its 1n threshold and covering the regions of low-lying E1 strength and of the IVGDR. The latter was quantitatively measured at a centroid energy of $E_m = 17.1(2)$ MeV, with a width of $\Gamma = 6.1(5)$ MeV and exhausting 98.7(7)% of the energy-weighted sum rule (EWSR) [4]. Low-lying E1 strength described by a Gaussian function was also observed at $E_m = 9.55(17)$ MeV, with a width of $\sigma = 0.51(13)$ MeV and 2.8(5)% of the EWSR. Based on this observed E1 strength, a polarizability of $\alpha_D = 3.40(23)$ fm$^3$ was measured from the 1n threshold to the upper integration limit of 28.4 MeV. Relativistic RPA calculations using the FSUGold parametrization [5] provided the correlation between the observable $\alpha_D$ and the neutron-skin thickness $\Delta R_{n,p}$ of $^{68}$Ni, as shown in Fig. 1. The extrapolation to the measured value of $\alpha_D$ provides a neutron-skin thickness of 0.17(2) fm, which is in good agreement with the value obtained from the measurement of low-lying E1 strength [1]. This new method for the extraction of neutron-skin thicknesses will also be applied to more exotic systems, thus constraining the symmetry energy further.

References
