Electromagnetic Excitation of Neutron-Rich Ni Isotopes

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As a response to an external electromagnetic field, a nucleus can be collectively excited to a Giant-Resonance state. The Giant Resonances, and in particular the isovector Giant Dipole Resonance (GDR), have been extensively studied both theoretically and experimentally in stable nuclei. In the early 1990s, theoretical studies predicted the presence of low-lying dipole strength below the GDR region in isospin-asymmetric nuclei. This new dipole mode, usually referred to as Pygmy Dipole Resonance (PDR), has been attributed to the oscillation of a neutron- or a proton-skin against an isospin-saturated core [1]. More recently, experimental developments allowed the investigation of the dipole response of short-lived nuclei. In particular, neutron-rich Sn isotopes were studied using heavy-ion-induced electromagnetic excitation at relativistic energies in inverse kinematics at the LAND-R^{3}B setup at GSI. The differential cross section $d\sigma/dE^*$, which is obtained from invariant-mass reconstruction, shows the presence of low-lying strength in the dipole response that cannot be explained by the GDR alone, and which has been associated with the Pygmy Resonance mentioned above [2].

In order to study the dipole response of neutron-rich Ni isotopes including ^{68}Ni, a similar experiment has been performed by the LAND collaboration using the Coulomb excitation technique. The neutron-evaporation channels have been investigated and the strength distribution was obtained. Measurements were performed with three different targets (C, Sn and Pb) in order to distinguish electromagnetic and nuclear-induced excitations. A measurement without target yielded the background contribution. While electromagnetic excitation occurs at impact parameters larger than the sum of the radii of the colliding nuclei, the nuclear contribution stems from a narrow impact-parameter range close to the grazing impact parameter b_c. This determines the target dependence of the nuclear cross section σ_N scaling basically with the sum of the two radii, *i.e.*, $\sigma_N \propto A_T^{1/3} + A_P^{1/3}$. In addition to this 'black-disc' approach, we have considered a model taking into account the transparency of the nuclei for an impact-parameter range Δb, yielding $\sigma_N \propto [b_c - \Delta b/2]\,\Delta b$. Here, we adopt the parameterization of b_c based on empirical nuclear densities and Eikonal calculations, which has been checked against measured cross sections for electromagnetic dissociation of stable nuclei [3]. The charge dependence of the electromagnetic contribution $\sigma_c \propto Z_T^{\alpha}$ was determined from a semi-classical calculation resulting in, *e.g.*, $\alpha = 1.61(2)$ for the 1n cross section of ^{68}Ni. Fits to the obtained cross sections with the three targets show that both models lead to the same results. It is then possible to determine the nuclear component of the interaction with Pb using the results obtained on C, *e.g.*, $\sigma_N^{Pb} = 1.57(20)\,\sigma^C$ for ^{68}Ni.

The preliminary analysis of both integrated and differential cross sections for electromagnetic dissociation of $^{67-69}$Ni shows that the cross sections cannot be explained only by the excitation of the GDR with parameters from various systematics. In particular, a larger cross section in the low-energy part of the spectrum is observed, which can be described by the addition of extra dipole strength exhausting 5 to 10% of the energy-weighted sum rule. The comparison of our result, which refers to the dominant neutron-decay, with a recent (γ,γ') measurement for ^{68}Ni [4] yields a decay branching ratio of about 3% for the gamma back-decay of the Pygmy resonance in this nucleus.

Although the analysis is still on-going, we can say in summary that evidence for the presence of a low-energy component in the dipole-strength distribution of neutron-rich Ni isotopes has been obtained indicating, a systematic nature of the PDR mode.

References

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