Study of dipole excitation of neutron rich Ni isotopes

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In previous experiments at GSI, the LAND collaboration has observed a sizeable fraction of low-lying E1 strength (below the giant dipole resonance region) in ^{20,22}O and ^{130,132}Sn nuclei [1]. In general, microscopic calculations conclude that in lighter neutron-rich nuclei the low-lying dipole strength arises from single neutron excitation. In contrast, the low-lying dipole states in medium heavy nuclei such as ^{130,132}Sn display to some extent the feature of a neutron pygmy resonance. More measurements are required to establish the universal collective nature of the low-lying dipole excitation. Measurements of dipole-strength functions in exotic nuclei might also help in constraining the isospin and density dependent parts of the effective interaction. With this motivation, an experiment was carried out to study the dipole-strength distribution in the continuum by measuring the electromagnetic excitation of the neutron-rich nuclei ^{68,70,72}Ni. For comparison, electromagnetic excitation of ^{56}Ni (N=Z) was also measured, thus covering a wide range of isospin from N-Z = 0 to N-Z=16. Another aspect of the experiment is the study of the evolution of the shell structure in the Ni isotopes far way from stability. Neutron-rich nuclei are often characterized by a very diffuse neutron density distribution at the surface, which would results in a reduced spin-orbit interaction and a more harmonic-oscillator like mean field. For the Ni isotopes, this should lead to a shell gap at N=40 and a reduction of that at N=50. Measurements, using the same experimental setup, were also carried out to extract single-particle occupancies via knockout reactions to study the structure and magicity of the neutron-rich Ni isotopes.

The experiments were performed using the FRS and the LAND setup at GSI. Radioactive ions provided as mixed secondary beams by the FRS were unambiguously identified and momentum analyzed on an event-by-event basis. The heavy fragments emerging after dissociation in the Pb target were again identified and momentum analyzed using position-sensitive pin diodes, the large acceptance dipole magnet ALADIN, scintillating fiber arrays and a time-of-flight wall consisting of organic scintillators. Gamma-rays and neutrons were detected using an array of CsI(Tl) detectors surrounding the target and the LAND situated ∼15m downstream respectively. Additional measurements were performed with a ^{12}C target and without target to estimate the nuclear contribution and the contributions coming from the other materials present in the beam line, respectively. A CH_2 target was used for the measurement of knockout reactions induced by protons. The fast protons from knockout reaction were detected by a plastic scintillator surrounding the beam pipe in the forward direction and by the CsI array.

[1] T. Aumann, Eur. Phys. J **A 26**, 441 (2005) and references cited there.