Low-Energy Dipole Modes of Excitation Below the Neutron Separation Energy

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A wide variety of nuclear structure phenomena have been investigated with the nuclear resonance fluorescence technique during the last few decade[1]. Spectroscopic experiments on two-phonon excitations of even-even nuclei near closed shells revealed large magnetic dipole strengths in heavy deformed nuclei. The corresponding excitations have been associated with scissors-like oscillations of the deformed proton density distribution against the neutron distribution, and this excitation mode was, accordingly, called the "scissors mode". Large electric dipole transitions to the ground states have been observed in spherical nuclei near Z = 50 and N = 82. They are assumed to arise from the coupling of quadrupole and octupole vibrational modes of the nucleus. In neutron rich nuclei so-called pygmy dipole resonance, has been predicted as a clustering of states close to the neutron separation energies $E_x \sim 5.5$ - 8 MeV. The High-Intensity γ-ray Source (HIγS) utilizing the intra-cavity back-scattering of free electron laser photons allows one to produce a unique beam of high-flux γ-rays with high polarization and selectable energy resolution which is ideal for low-energy γ-scattering experiments. At present, γ-ray beams with energies from 2 to 56 MeV are available with intensities as high as $10^5 – 5x10^6$ γ/s, and energy spread of 3% or better, and nearly 100% linear polarization. The nuclear resonance fluorescence experiments have been performed at HIγS on nuclei close to the neutron closed shell N=82 using four 60% efficient HPGe detectors, determining excitation energies, spin, parities, and decay branching ratios of these low modes of excitations. A Highly-sensitivity studies of E1 and M1 excitations at energies close to the neutron emission threshold has been performed. A complete determination of the parity of the dipole excitations below the neutron threshold will be presented. All low-lying dipole states in these nuclei turned out to be excited by E1 transitions. The deduced low-energy mode of excitations will be compared with QPM calculations with multiphonon extension[3].

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