Collectivity of pygmy resonance in spherical and deformed Ni and Fe isotopes

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The possible occurrence of the pygmy dipole resonances has been studied experimentally and theoretically. The appearance of the low-lying dipole modes were observed not only in unstable spherical nuclei (for example, neutron-rich $N = 82$ nuclei, ^{132}Sn, ^{138}Ba, ^{140}Ce) but also in stable nucleus ^{208}Pb and in unstable defromed nucleus ^{26}Ne. On the theoretical side, the dipole response has a zero-energy mode corresponding to the spurious center-of-mass motion. Thus, self-consistency is important for decoupling of spurious states. We present the first results of fully self-consistent Skyrme RPA calculations for low-lying dipole modes in the spherical nuclei ^{68,78}Ni and deformed nucleus ^{72}Fe.

The RPA calculation was carried out by means of the mixed representation. In the mixed representation, particles are described in the coordinate representation while holes are represented in the HF single-particle basis. There are several merits in this approach: Firstly, it is relatively easy to take into account all terms of the residual interaction including spin-orbit, Coulomb terms and time-odd components. Secondly, the upper energy cut-off is very high. Thirdly, thanks to the use of the coordinate representation, we can treat deformed nuclei on the same footing as spherical nuclei. In these calculations the continuum is discretized.

We obtained the low-lying dipole state in ^{68}Ni at the vicinity of the neutron threshold energy, which exhausts 0.8 % of the energy-weighted sum rule value. This state consists of a superposition of some neutron excitations of hole states close to the Fermi level to loosely bound states and resonant states. Thus, this dipole state has collectivity although it is not so large. The transition density in Fig. 1 is clearly different from that of the giant resoances and shows the characterictic of the pygmy-type one, large contribution at the region out of nucleus.

The deformed nucleus ^{72}Fe has also the low-lying dipole strengths. However, the strengths are fragmented because in deformed nuclei the dipole modes are coupled with the higher angular momentum modes. Thus, each peak has small collectivity compared with those in spherical nuclei.

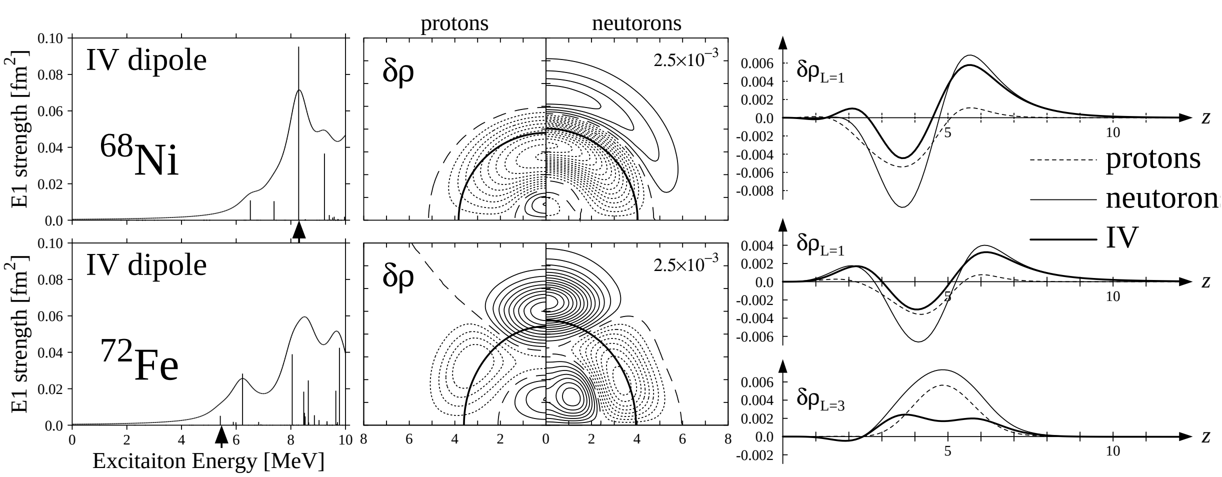

Figure 1: Left panels: Isovector E1 strengths in ^{68}Ni and ^{72}Fe. Arrows present neutron threshold energies. Center panels: Contour map of transition densities of the pygmy resonance at 8.3 MeV in ^{68}Ni and 8.1 MeV in ^{72}Fe. Right panels: Proton, neutron, and isovector transition densities projected to dipole (octupole) mode $\delta\rho_{L=1}$ ($\delta\rho_{L=3}$).