Experimental studies of the strength function below binding energy

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Most of the electric dipole (E1) response of atomic nucleus is exhausted by the Isovector Giant Dipole Resonance (IVGDR). However, below IVGDR and around neutron separation energy, a small fraction of fragmented dipole states is also present, and associated with so called "Pygmy Dipole Resonance" (PDR), which was interpreted as a collective oscillation of number of neutrons at the nuclear surface against the inert proton-neutron core. However, this rather intuitive model is still under theoretical evaluation and further experimental data is of the utmost importance. One of the key questions is whether the PDR has a collective or single-particle nature. Moreover, it was shown in the (γ, γ') and (α, α'γ) experiments that low-lying E1 states have mixed isospin properties. As the photon probe excites all states, alpha particles are sensitive to only isoscalar part.

In order to shed more light into the structure of PDR our group was involved in the campaign of experiments performed using (^{17}O,^{17}O'γ) reaction at LNL-Legnaro, Italy. Inelastic scattering of ^{17}O ion beam at 20 MeV/A was used to excite the resonance modes in the ^{124}Sn, ^{140}Ce and ^{208}Pb targets. Gamma rays were detected by five triple clusters of high-resolution AGATA-Demonstrator and eight large volume scintillators ($LaBr_{3:}Ce$). The scattered ^{17}O ions were identified by two ΔE-E Si telescopes of the TRACE array mounted inside the scattering chamber. The telescopes consisted of two segmented Si-pad detectors, each made of 60 pixels. As a result of the campaign, the fraction of the Isoscalar Energy Weighted Sum Rule (ISEWSR) exhausted by the PDR was estimated for each nucleus.

For the future experiments using proton cyclotron at CCB in IFJ PAN Krakow and new alpha-particle and heavy-ion Cyclotron at Heavy Ions Laboratory in Warsaw we consider to use similar detection technique with different possibilities. We stress the importance of using different probes e.g.:

- *protons*: excitation mechanism similar to photons close to 0^o scattering angle;
- *alpha particles or ^{17}O*: isoscalar nature, more surface interactions;
- *deuterons or ^{13}C*: neutron transfer reaction mechanism – selectivity to single-particle transitions.

Another important feature, is the high energy resolution both for gamma and particles detection. The perfect opportunity would be to use AGATA array coupled to PARIS array and magnetic spectrometer like e.g. "Grand Raiden" at RCNP Osaka. This is important, as it would allow to precisely identify the decay branch using gamma-particle coincidence matrix. The PDR are postulated to be mainly ground-state transitions, therefore the estimation of the branching to low-lying states would be very important.

In the talk, brief description of the proposed method and different technical aspects will be given, as well as expected physical outcome.