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Study of giant resonances with active targets

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The presence of coherent motions of particles in many-body systems, i.e. collective motions, is a common feature in several branches of physics. In atomic nuclei, a particular case of nuclear collective motion is represented by the giant resonances (GR) [1], which are the subject of this presentation. These resonance states play a key role in the understanding of the nuclear structure because of their connection with the bulk properties of atomic nuclei.
Giant resonances can be macroscopically viewed as a quantum oscillation of two fermionic liquids (neutron and protons) involving spatial (L), spin (S) and isospin (I) degree of freedom. In the case of an isoscalar oscillation (ΔI=0) neutron and protons move together in phase. On the other hand, in an isovector oscillation (Δ I =1) neutron and protons move in opposite direction.
The isoscalar giant monopole resonance (ISGMR) measures the collective response of the nucleus to density fluctuations (ΔI, ΔS, ΔL=0) [1]. The ISGMR is particularly interesting for its connection with the incom- pressibility of the nucleus KA, which, in turn, can be linked to the incompressibility of nuclear matter K∞, an important ingredient of the nuclear-matter equation-of-state (EOS). The EOS, essentially, describes the binding energy per nucleon as a function of nuclear density and it plays an important role in the description of heavy-ion nuclear collision, the collapse of the heavy stars in super novae explosion and the description of neutron stars [2]. In order to improve the understanding of this nuclear mechanism, new experimental data in unstable nuclei far from the stability are needed [3].
The reaction mechanism used to excite the ISGMR is the inelastic scattering of the nuclei of interest on an hadron isosclar probe, typically an α particle. The use of an active target coupled with silicon detectors allows to measure the α particles at forward angles (where the maximum of the cross section is located) and with a very small kinetic energy [4].
In addition, the (α,α') reaction can be also used to excite isoscalar dipole states (L=1, I=0) around the neutron separation energy [5]. These states, also called pygmy dipole resonance (PDR), are of great interest for the impact on astrophysical phenomena, such as r-process nucleosynthesis [6]. The nature of the PDR is largely debated. SpecMAT [7], an active target placed in a high magnetic field and coupled with scintillation detectors, will be a powerful detector to observe PDR in unstable nuclei.
In this presentation the use of active targets to study ISGMR and PDR will be shown.

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