RCNP
NUCLEAR PHYSICS
LECTURE

Title

Collective excitations in nuclei : The isoscalar and isovector electric giant resonances and spin-isospin charge-exchange modes

Lecturer

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Date/Time

February 21 Tue, 2017	Lecture I	13:00-14:30
	Lecture II	15:00-16:30
February 22 Wed, 2017	Lecture III	10:30-12:00
	Lecture IV	13:00-14:30
followed by Colloquium by Prof. Harakeh at the same place from 15:00 on 22nd		

Place

Lecture Room 1, 6th floor, RCNP Main bldg.

More than seven decades ago, the isovector giant dipole resonance (IVGDR) was discovered in g-ray absorption spectra. In the following years, its macroscopic properties such as excitation energy, width and exhaustion of the Thomas-Reiche-Kuhn (TRK) sum rule were determined for stable nuclei up to uranium.

A rich spectrum of other giant resonances of different multipolarities and spin and isospin structure was expected on theoretical grounds. In the seventies, the isoscalar giant quadrupole resonance (ISGQR) was first discovered in electron scattering followed by the isoscalar giant monopole (ISGMR), dipole (ISGDR) and octupole (ISGOR) resonances in inelastic α scattering.

A historical overview of the discovery of giant resonances will be given and their description in terms of macroscopic and microscopic models will be outlined. Energy-weighted sum rules and transition densities for the IVGDR and the isoscalar giant resonances will be discussed. It should be further emphasized that collective modes are important not only for nuclear structure studies but also for determining key parameters of the equation of state (EOS) of nuclear matter.

In addition to the isoscalar and isovector giant resonances, charge-exchange spin and spin-isospin modes are important. A prime example are the Gamow-Teller (GT) transitions, which play very important roles in various phenomena in nature. In nucleosynthesis, the β-decay of nuclei along the s- and r-processes determine the paths that these processes follow and the abundances of the elements synthesized. In supernova collisions, GT transitions are of paramount importance in the pre-supernova phase where electron capture occurs on neutron-rich *fp*-shell nuclei at the high temperatures of giant stars. Electron capture is mediated by GT transitions. Electron capture removes the electron pressure that keeps the star from collapsing precipitating a cataclysmic implosion followed by a huge explosion throwing much of the star material into space and leaving a neutron star or black hole behind. Furthermore, in $2\nu2\beta$-decay, virtual GT transitions via 1^+ states of the intermediate nucleus, determine the rate and therefore the lifetime of 2β-decaying nuclei. The $0\nu2\beta$-decay is much more interesting since if it occurs it establishes the Majorana character of the neutrino and allows a determination of its mass. However, a good determination of the matrix element connecting both ground states is important. Here, in addition to GT transitions that are important in $2\nu2\beta$-decay, higher multipolarity spin-isospin modes play an important role in determining this matrix element. Experimental aspects of this will be discussed.

In these lectures, the experimental techniques for studying isovector, isoscalar and charge-exchange isospin and spin-isospin collective modes will be delineated. The extraction of the transition strength by means of comparison with distorted-wave Born approximation (DWBA) calculations will be discussed.