HIGH-ENERGY GIANT RESONANCES AND THEIR PARTICLE DECAY

M.H. Urin

Kernfysisch Versneller Institute, 9747 AA Groningen, The Netherlands and
Moscow Engineering Physics Institute (State University), 115409 Moscow, Russia

Experimental and theoretical studies of high-energy giant resonances (GRs) have been undertaken in recent years to understand better how the different characteristics associated with GR formation (concentration of the particle-hole strength, coupling to the continuum, the spreading effect) are affected with increasing the GR energy. Most of high-energy GRs are the next vibration modes (the overtones) relative to the corresponding low-energy GRs (the main tones). A few overtones have been experimentally studied.

In this talk the results of semimicroscopic description of a number of high-energy GRs (considering as an example the ^{208}Pb parent nucleus) will be presented.[1] We concentrate on the direct-nucleon-decay properties of the following high-energy GRs:

(i) the isoscalar giant dipole resonance (ISGDR, the overtone of the spurious 1^--state associated with the centre-of-mass motion), the second isoscalar monopole and quadrupole resonances (ISGMR2 and ISGQR2, the overtones of the well-known ISGMR and ISGQR, respectively);

(ii) the charge-exchange (in the β^--channel) giant spin-monopole resonance (IVSGMR$^{(-)}$, overtone of the well-studied Gamow-Teller resonance);

(iii) the second isovector giant dipole resonance (IVGDR2, the overtone of the familiar E1-GR and the isovector partner of the ISGDR);

(iv) the isovector giant quadrupole resonance in the neutral channel (IVGQR, the high-energy main-tone giant resonance).

In our studies we use a semimicroscopic approach based on both the continuum-RPA (CRPA) method and a phenomenological treatment of the spreading effect. Within this approach a realistic phenomenological mean field and the Landau-Migdal particle-hole interaction, bound by some self-consistency conditions, are used as input quantities. Model parameters are taken from description of both the single-quasi-particle spectra and low-energy main-tone giant resonances. A modern version of the approach, as applied to isoscalar GRs, is given in Ref. [1]. In this approach we first check the ability to describe the GR gross properties: the particle-hole strength distribution and the energy-dependent transition density. Then we calculate the partial and total direct-nucleon-decay branching ratios (branchings) using sometimes the experimental spectroscopic factors for low-energy single-hole states of the daughter nuclei (^{207}Tl and ^{207}Pb in the considered case).

In the following a brief review of the obtained results is given. We describe satisfactorily recent experimental data on partial proton branchings for the ISGDR [2] and make corresponding predictions for the ISGMR2 and ISGQR2 [1]. The last resonance seems to have been recently observed [2, 3]. We confirm the earlier prediction concerning the large total branching (around 60%) for the direct proton decay of the IVSGMR$^{(-)}$ [4]. This value is in agreement with the experimental data of Ref. [5]. However, the calculated distribution of the total decay probability over the partial proton-decay channels is found to be in sharp disagreement with the experimental data. At the moment there is no explanation of the strong population of deep-hole states in ^{207}Pb found in Ref. [5]. We predict the main properties of the IVGDR2, the lowest energy isovector overtone in the neutral channel. In particular, we estimate the peak energy (around 34 MeV), the transferred momentum (around 0.6 fm^{-}1), which is appropriate for experimental studies of this resonance via (e,e')-scattering, and the total neutron and proton branchings (around 50% and 20%, respectively). The large proton branching makes it feasible searching for the IVGDR2 in inelastic scattering of light ions with the use of the coincidence technique.

Direct+semidirect (DSD) photoneutron reactions accompanied by excitation of the E1-GR are closely related to direct neutron decay of this resonance. An attempt to describe these reactions semimicroscopically has been undertaken in Ref. [6]. We apply the semimicroscopic approach to description of the asymmetry (relative to 90°) of the differential DSD (γ, n)-reaction cross section. The asymmetry is due to an interference of the DSD dipole and quadrupole (γ, n)-reaction amplitudes and exhibits a non-monotonic behavior in the vicinity of the IVGQR.

---

[1] The results are obtained in collaboration with M.L. Gorelik, I.V. Safonov, and B.A. Tulupov.

Calculation results are in a reasonable agreement with the corresponding experimental data [7], which allows us to estimate the IVGQR peak energy (around 21.5 MeV) and to describe other main properties of this resonance.

In conclusion, we are able to describe reasonably in a semimicroscopic way a number of high-energy GRs including their direct-nucleon-decay properties.

---

[1] M.L. Gorelik, I.V. Safonov, and M.H. Urin, Phys. Rev. C 69, 054322 (2004).
[2] M. Hunyadi et al., Nucl Phys. A 731, 49 (2004).
[3] M. Hunyadi et al., Phys. Lett. B 576, 253 (2003).
[4] V.A. Rodin and M.H. Urin, Nucl. Phys. A 687, 276c (2001).
[5] R.G.T. Zegers et al., Phys. Rev. Lett. 90, 202501 (2003).
[6] V.A. Rodin and M.H. Urin, Phys. Rev. C 66, 064608 (2002).
[7] T. Murakami et al., Phys. Rev. C 35, 479 (1987).