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Manifestation of chaos in nuclear structure phenomena

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The description of giant dipole (GDR) and monopole (GMR) resonance decay widths requires to trace the spreading of the highly excited, collective states along the hierarchy of particle-hole configurations with various degree of complexity. Naturally, one would expect that chaotic component of intrinsic structure of a finite many-body quantum system, exhibited in its spectral properties at low excitation energy, may transform from the secondary constituent to the dominant one in basic characteristics of the considered system with increase of the excitation energy. Indeed, our analysis of the dipole and monopole strength distributions in the lead region indicates on the onset of statistical properties close to those of the Gaussian Orthogonal Ensembles (GOE) of the Random Matrix Theory (RMT). We show that employment of the random distribution for the coupling between microscopic one-phonon states and two-phonon states, generated by the GOE distribution, gains a better insight into the description of general properties of the decay widths. Our microscopic calculations (based on the Skyrme forces) demonstrate that Landau damping of the one-phonon states is the basic mechanism of the decay widths of the GDR in heavy nuclei around 208Pb [1]. However, the incorporation of ideas, borrowed from the RMT, providing the effective counting of the two-phonon
configurations, contributed additionally to redistribution of the isovector dipole strength distribution. On the other hand, it is found that the main contribution into the decay of the GMR in this nuclear region is determined by a small number of two-phonon states strongly coupled to low-energy surface vibrations [2]. While a vast majority of the coupling matrix elements (that are small in value and following the GOE distribution) are responsible for the fine structure of the GMR decay width. A remarkable agreement between the results of the full microscopic calculations (based on QRPA phonons coupled by means of the microscopic coupling matrix elements with calculated two-phonon states) with those of the developed approach confirms the vitality of the proposed ideas.

1. A.P. Severyukhin, S. Åberg, N.N. Arsenyev, R.G. Nazmitdinov, Phys. Rev. C, 104, 044327 (2021).
2. N.N. Arsenyev, A.P.Severyukhin, R.G. Nazmitdinov, JETP Letters, 118, 718 (2023).

Section

Nuclear structure: theory and experiment

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