Splitting of Isoscalar and Isovector Giant Multiple Resonances in Spherical Neutron-Rich Nuclei

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We suggest a new explanation of the splitting of both the isoscalar and the isovector modes in spherical neutron-rich nuclei within the Fermi liquid drop model (FLDM). The FLDM provides the existence of the isoscalar and isovector vibrations, related to the two different dimensionless zero-sound velocities $s$ and $s'$. They are determined by the isoscalar and the isovector Landau interaction amplitudes, respectively. Due to the macroscopic self-consistency and the boundary condition on the free nuclear surface the FLDM shows a new satellite structure of the isovector and isoscalar giant multipole resonances in addition to the predictions of commonly used isospin splitting shell model (ISSM) and dynamical collective model (DCM).

We have performed the calculations of the characteristics of the isovector giant dipole resonance (IVGDR) and its satellite for several isotopes of Ca and Sn nuclei. We determined the energy $E_{GDR}$ of the main IVGDR and its satellite, their relative strength $m^{(s)}/m^{(m)}$ and the depletion of the energy weighted sum rule (EWSR), $m_1/m_{EWSR}$. The splitting magnitude in our FLDM almost does not depend on the neutron excess $N-Z$ and there is an agreement with the experimental data. This is in contrast to another splitting effect predicted by the ISSM which shows an increase of the energy splitting of the IVGDR with the isospin quantum number $T_3=(N-Z)/2$. The satellite strength ratio $m^{(s)}/m^{(m)}$ is small and increases linearly with the asymmetry parameter $X=(N-Z)/A$ in contrast to both the opposite ISSM-splitting behavior like $1/T_3$ and the case of splitting due to deformation in the collective model, with approximately equivalent strengths of the peaks. The relative strengths and the depletion of the EWSR for all (Fermi-liquid) satellites turn into zero and they disappear in the symmetric limit $X=0$. The strength ratios of the two peaks and their depletion of the EWSR are also in agreement with the experimental results presented by squares or triangles.