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Investigating finite-temperature dependence of electromagnetic dipole transitions in nuclei

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The significance of finite temperature effects in nuclear dipole transitions is evident across various applications in nuclear physics and astrophysics [1-4]. To describe temperature effects in electromagnetic transitions, we developed a self-consistent finite temperature relativistic quasiparticle random phase approximation (FT-RQRPA) based on relativistic energy density functional with point coupling interaction [5,6]. The isotopic chains of 40-60Ca and 100-140Sn closed- and open-shell nuclei are considered to study the evolution of electric dipole (E1) and magnetic dipole (M1) transitions at temperatures ranging from T=0 to 2 MeV. The analysis reveals that E1 giant resonance is moderately modified with temperature increase, and new low-energy excitations appear at higher temperatures, making a pronounced impact, particularly in neutron-rich nuclei. This happens because of the unblocking of new transitions above the Fermi level due to thermal effects on single-particle states. Similarly, for the case of M1 excitations, an interesting result is obtained for 40,60Ca nuclei at higher temperatures, i.e., the appearance of M1 excitations, which are forbidden at zero temperature due to fully occupied (or fully vacant) spin-orbit partner states. Additionally, the M1 strength peaks undergo a notable shift towards lower energies in Ca and Sn nuclei, primarily attributed to the decrease of spin-orbit splitting energies and the weakening of the residual interaction. This effect is particularly pronounced, especially above critical temperatures (Tc), where the pairing correlations vanish. In conclusion, the E1 and M1 responses demonstrate considerable dependence on temperature, and their effects could be important in modeling gamma strength functions and their applications in astrophysically relevant nuclear reaction studies.

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session

I. Nuclear Structure and Reactions

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