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Effect of nuclear quadrupole interactions on the dynamics of two-level systems in glasses

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We consider the effect of the internal nuclear quadrupole interaction on quantum tunneling of complex multi-atomic two-level systems. Two distinct regimes of strong and weak interactions are found. They depend on the relationship between the characteristic energy of the internal interaction λ_*, which is directly proportional to the number of tunneling atoms per tunneling system, and a bare tunneling coupling strength Δ_0. When $\Delta_0 > \lambda_*$, the internal interaction is negligible and tunneling remains coherent, being defined by the strength of Δ_0. When $\Delta_0 < \lambda_*$, coherent tunneling breaks down and the effective tunneling amplitude decreases by an exponentially small overlap factor $\eta^* \ll 1$ between the internal ground states of the left and right well, affecting thermal and kinetic properties of tunneling systems.

The theory is applied to interpret the anomalous behavior of the resonant dielectric susceptibility in amorphous solids for $T \leq 5mK$ in terms of the nuclear quadrupole interaction. This interaction breaks coherent tunneling for $T \leq 5mK$, where the characteristic tunneling amplitude becomes comparable with the interaction strength. We suggest clarifying experiments using external magnetic fields to test the theories predictions and to shed some light on the internal structure of tunneling systems in amorphous solids.