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Nuclear structure, form factors, quadrupole moments, and electronuclear sum rules

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Nuclear structure properties are here studied through the use of linear energy weighted sum rules.

Electronuclear energy weighted sum rules are derived by considering the double commutator of various single-particle operators, $G(\alpha)$, with the nuclear hamiltonian H , that is $S(\alpha\beta) = [G(\alpha), [H, G(\beta)]]$. Neglecting any contributing nuclear forces, various specific sum rules are shown, with particular emphasis on the angular momentum projected ones for transitions between arbitrary states. The possibility of generating a hierachy of sum rules by using the commutators $S(\alpha\beta\gamma) = [G(\gamma), [H, S(\alpha\beta)]]$, $S(\alpha\beta\gamma\lambda) = [G(\lambda), [H, S(\alpha\beta\gamma)]]$, ... is suggested.

From the linear energy weighted sum rules, selection rules for the matrix elements connecting perfect giant electric multipole states to other states in even nuclei are obtained. In addition, in the appropriate limits, matrix element relations which reflect upon the harmonic vibrational model are also obtained.

The problem of centre of mass motion effects is treated in detail and cumbersome expressions are obtained. However comparatively simple bounds are possible for the pure multipole moment and pure form factor sum rules.

A method of studying the transition form factors is rigorously formalized through the use of a representation of an identity operator for a restricted set of non-orthogonal states. The formalism is now applicable to both isoscalar and isovector transitions and it is of potential use in

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electron excitation. Various consequences are indicated. It is proved that the longitudinal multipole form factor cannot be factorized into a product of momentum transfer and a function of excitation energy over the entire range of momentum transfer. The possible ambiguity arising out of some present methods of giant resonance identification is shown, the magnitude estimated, and a suggestion made to verify the reality of the reported new giant resonances.

For even nuclei, formulae are derived for calculating the quadrupole moments of the excited states, in particular the 2^+ states. Calculated results for a wide variety of nuclei are compared with experiments and very good agreements are obtained. The possibility of model independent extraction of quadrupole moment from electron scattering is also indicated.