ABSTRACT

Spectral distribution theory is a statistical many-body theory to describe the global properties of open shell nuclei, but has enjoyed a fair amount of success in explaining the microscopic features of the nuclei also. We apply this theory to a variety of structure problems of current interest. Using the sd-interaction of Wildenthal spectral distribution method (SDM) studies are done for binding energies, excitation spectra and occupancies of single particle orbits for nuclei in the sd shell and comparisons are made with the shell model as well as the experimental values, thus checking the reliability of the predictions by SDM. Extensive systematic studies of sum rules for Gamow-Teller (GT) and M1 excitations by SDM are done for nuclei in the sd and fp shells and compared with other theoretical estimates. The sum rule strengths extracted from (p,n) and (p,p$'$), (e,e$'$) experiments are always quenched compared to the theoretical values. The studies include i) developing simple approximate β^- and β^+ decay sum rules, ii) using the polynomial expansion of SDM evaluation of the sum rules even going beyond the central limit theorem (CLT) terms wherever needed, iii) application of the new sum rule strength density method which agrees best with the shell model and seems to be the most promising procedure.

The strength distribution itself as a function of the excitation energy of the final nucleus for GT and M1 excitations is also studied and the fact that the high value of the strength correlation coefficient is able to bring the strength in the right domain and close to the shell model value

is quite encouraging. For the evaluation of the strengths and sum rules for nuclear states with $T \neq 0$, a proper formalism for obtaining average expectation values of non-isoscalar operators and operator products is developed.

Finally we construct a model to calculate the beta decay rates for nuclei with $A > 60$ needed for the evolution calculations of presupernova stars. The model uses sum rules where SDM occupancies are used and fixes the width of the Gamow-Teller strength distribution by giving a best fit to the halflives for a number of nuclei with $A > 60$. This model is useful also for predicting halflives of neutron-rich nuclei.