PREFACE

A major problem in the theory of nuclei is to obtain an understanding of the nuclear forces operating within nuclei as distinct from the forces between two free nucleons. Despite the large amount of work by Brueckner and many others (which has helped to clarify and, to a large extent, justify the conceptual basis of nuclear shell model), calculations of nuclear properties, such as energy levels starting with free nucleon-nucleon interactions, present considerable mathematical complexity and are not in general easy to carry out without the aid of large computers. As a result, most shell model calculations are in practice done by assuming a relatively simple effective interaction. In this dissertation an attempt is made to study in a systematic way the nature of this effective interaction in several simple nuclei.

The work of Brueckner and others shows that the effective nuclear forces are non-local or momentum-dependent and also configuration-dependent. However, they are non-singular, i.e., will not have an infinite repulsive core, as is generally assumed in free nucleon forces. With these considerations in mind, we suggest in chapter II a method by which nuclear spectra may be calculated, and which may exhibit clearly the above properties of the effective forces. The idea is to

express the matrix elements of the nuclear Hamiltonian in terms of the matrix elements of the interaction in two-particle states of different spin, isotopic spin and relative orbital angular momentum. This procedure would be somewhat analogous to the analysis of the nucleon-nucleon scattering data in terms of phase shifts in different states of two nucleons. It is pointed out that, if enough experimental data on energy levels is available, it should be possible to study directly the nature of the effective interaction in different spin and i-spin states and, in particular, a simple type of momentum-dependence, viz., angular-momentum-dependence of the forces, can be easily brought out. The formalism for such calculations is described in chapter II, and it is then applied to some simple nuclei such as Ti^{50}, O^{18} and T = 1 states in Li^{6}. Although the experimental data is not sufficient at present to make more definite analysis, it is pointed out that the even-state (singlet) interactions appear to be relatively configuration-independent, whereas the odd-state (triplet) forces appear to vary from nuclei to nuclei. More data will not only enable us to make these statements more precise, but will also enable us to extend the analysis to other states (such as T = 0 states), and other heavier nuclei. We would like to stress the importance of our method of analysing the effective interaction in states of relative orbital angular momentum which should be more powerful and useful to

elucidate the properties of the effective interaction rather than the conventional method of expressing the interaction in terms of various multipoles.

In chapter III some additional considerations are presented for the special case of isotopes O^{18} and O^{19}. In the first section, the results of our analysis of chapter II are compared with the results of other authors who made calculations of O^{18} spectrum. Next, the parameters of the effective interaction are tested by calculating the energy levels of O^{19}. It is found in chapter II that several different sets of parameters could give equally satisfactory results for O^{18}. Here we find that, if some of the excited states of O^{19} have their spins and parities measured, it may be possible to distinguish between some of these different sets of parameters. Finally, in section 3, the available data on the energy levels of O^{18} and O^{19} (eight levels) is reanalysed (by partial inversion of the energy matrices) to determine the matrix elements of the interaction in O^{18} states. This provides an additional check on the interaction parameters discussed in chapter II.

At the end of the thesis, reprints of our published work are included. These refer to the work included in the thesis as well as some work (nuclear interactions in $s_{1/2}$-doublets, etc.) not included in the thesis in the interest of homogeneity.

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