THE ISOMORPHIC MODEL AS APPLIED TO LIGHTER NUCLEI

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ABSTRACT

The isomorphic model, supporting that the nucleon most probable positions form a high spatial symmetry point space, is here presented on more fundamental grounds, and is successfully applied to almost all ground-state properties of nuclei between O and Ni.

INTRODUCTION

The isomorphic model[1-3] is in essence a shell model, although it has been developed independently of the established shell model.

THE MODEL

The main assumption of the simple shell model, i.e. that each nucleon in a nucleus moves (in an average potential due to the other nucleons) independently of the motions of the other nucleons is here understood in terms of a dynamic equilibrium in the following sense. Each nucleon in a nucleus at the ground state is in a dynamic equilibrium with the other nucleons and, as a consequence, its motion may be described independently of the motions of the other nucleons. In particular, here, we consider a specific equilibrium of nucleons, which is valid whatever the law of nuclear force may be. This leads directly to Leech[4] polyhedra which are employed to represent dynamic average forms of the nuclear shells, separately for neutrons and protons. A basic property[5] of these polyhedra is that the angles $\theta_\ell^m = \cos^{-1}(m/\sqrt{\ell(\ell+1)})$ formed by the possible directions of the orbital angular momentum vector with respect to the quantization axis are identical to the angles formed by certain symmetry polyhedral axes with respect to an axis common for all polyhedra and taken as the quantization axis. This property permits the assignment of the quantum numbers ℓ and m to the polyhedral vertices. In order to differentiate among vertices which correspond to successive appearances of the same ℓ value, the principal quantum number n is employed and in order to differentiate vertices of neutron polyhedra from those of proton polyhedra the isospin quantum number τ is employed. Finally, we draw a distinction between two neighboring vertices of the same polyhedron (same τ) which both have the same set of the three quantum numbers n, ℓ and m, by using the spin quantum number s. Thus the model permits, in a physical sense, a one-to-one correspondence (isomorphism) between the sets of five

quantum numbers (n, ℓ, m, s and τ) and the Leech polyhedral vertices. This means that a nucleus with known quantum numbers of its nucleons has a unique representation in the isomorphic point space. The properties of this nucleus result directly as properties of this isomorphic structure.

RESULTS

Properties of nuclei between O and Ni examined in a consistent manner using no adjustable parameters are magic numbers, average nuclear density, overall neutron-proton ratio, rms neutron, proton, and mass radii, quadrupole moments, isospin symmetry, spin parity, magnetic moments and Coulomb energies. The predictions in almost all cases are within the experimental error.

CONCLUSIONS

It seems that the isomorphic model contributes significantly to a better understanding of the independent-particle model.

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