Symmetry of STRUCTURE

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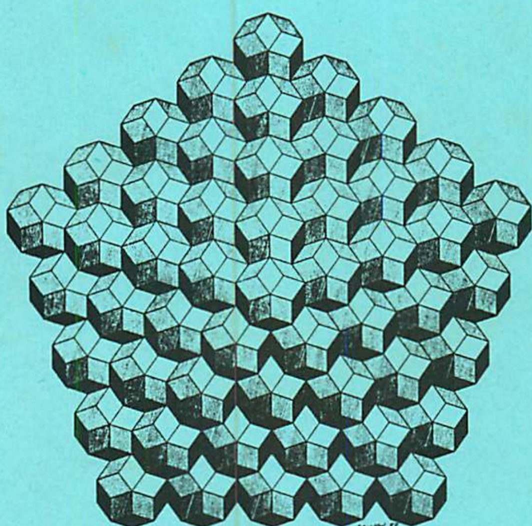
Abstracts

I.



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DYNAMIC SYMMETRIES IN THE MOLECULE-LIKE STATES OF ATOMIC NUCLEI

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Inspite of its small size the atomic nucleus is a composite object, and its structure shows considerable variety. From the viewpoint of theoretical description the number of its constituent particles, called nucleons, is an important parameter. It ranges between 1 and 260, being too large for most of the nuclei to treat each nucleon individually, and too small to treat them statistically. Due to this situation nuclear models play a crucial role. They are simplified theories of the nuclear structure which make the problem tractable but, hopefully, do not neglect the most important features. There are quite a few of them, giving good approximation to different structures. A model is called microscopic if its basic picture is that of the many-nucleon sytem, and it is called macroscopic or phenomenological if the nucleus is treated as a whole.

During the last one and a half decades several models were introduced which make use of the mathematical tools of group theory. Among them we can find the interacting boson models. The best-established and most successful version of them describes the rotational-vibrational motion of nuclei having either ellipsoidal or spherical shapes, or their shape change dynamically between these limits (Iachello and Arima, 1987).

In this model the building blocks i.e. the bosons have dual interpretation. Phenomenologically they are excitations of the collective motion, and microscopically they represent nucleon pairs.

Another interacting boson model proved to be succesful for the description of the rotational vibrational motion of molecules (Iachello and Levine, 1982).

There are good reasons to belive that some nuclear states are similar to molecule-like configurations, having dumb-bell shapes rather than ellipsoidal ones. Based on these arguments suggestions were made to apply the interacting boson model of molecules to these nuclear states (Iachello, 1981; Daley and Iachello, 1986). This can be done after some simple modification of the model assumptions (Cseh and Lévai, 1988).

The group theoretical models are intimately related to the concept of symmetry. By symmetry we mean the invariance under a transformation. Since the atomic nucleus has a shape, there is a possibility for shape symmetry, and many of the nuclei show it.

There is, however, an additional possibility to display symmetry; and this is related to the **Hamiltonian** of the system. Just like for any other microphysical object, for the atomic nucleus the most characteristic quantity is the energy of the sysytem represented by an operator called Hamiltonian. The symmetries of the Hamiltonian are deeper symmetries of the structure, they are consequences of the special type of the interaction between the constituent particles, i.e. they appear due to the special form of the Hamiltonian. These symmetries are referred to as dynamic symmetries, and they correspond to the limiting cases of the algebraic model.

The Hamiltonians corresponding to dynamic symmetries provide us with energy spectra which can be compared to those of the experimental studies. It turns out that for many nuclei the model spectrum approximate the real one fairly well (Iachello and Arima, 1987). An example of this kind (Cseh, 1988) is shown in Fig.1.

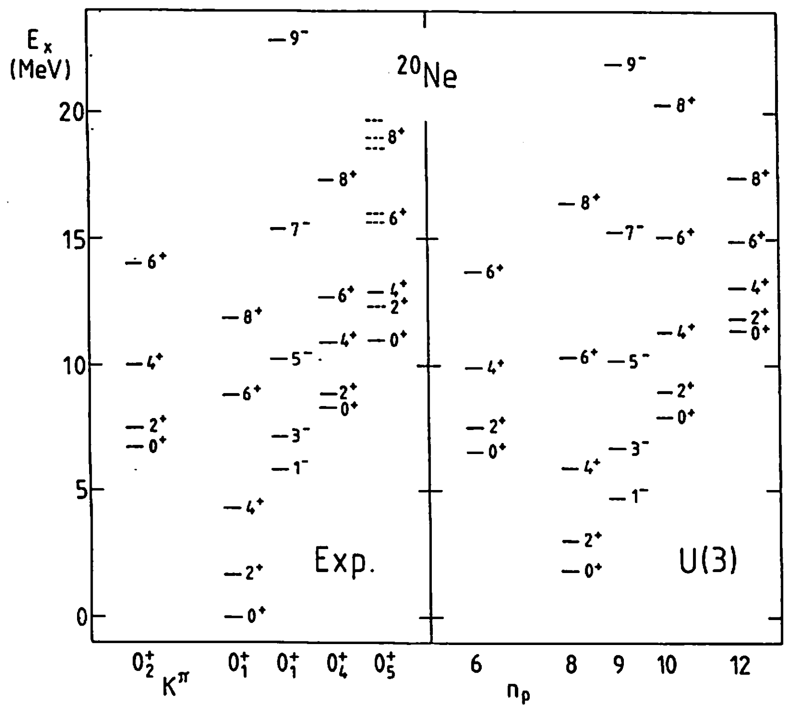

Fig.1. *Molecule-like states of the ^{20}Ne atomic nucleus in comparison with a model spectrum corresponding to a dynamic symmetry.*

To sum up: the dynamic symmetries of the nuclear and molecular physics are model symmetries, because the symmetry transformations act in a model space. They are approximate or broken symmetries rather than exact ones. The dynamic symmetries give the connection between the macroscopic or shape symmetries and the microscopic symmetries of the system . The reason why these nice features of the concept of dynamic symmetry are really valuable is that Nature shows evidence for the approximate realization of these symmetries.

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