Nuclear deformation and the spontaneous symmetry-breaking

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Loosely speaking a symmetry is spontaneously broken, if the Hamiltonian is symmetric, but the ground state of the system is not. E.g. the energy operator is spherically invariant, but the ground state is deformed. This is a typical case for atomic nuclei.

This spontaneous breaking of the spherical symmetry has been discussed in different models, but (up to the best of our knowledge) not in the Elliott model [1], which was the first theoretical framework to account for collective phenomena like deformation and rotation within the spherical shell model.

A recent analysis [2] revealed, how the spherical symmetry of the intrinsic Hamiltonian of the Elliott-model is broken spontaneously, due to the
i) separation of the slow and fast degrees of freedoom,
ii) degeneracy of the ground state, related to the appearance of Goldstone modes, and
iii) how the spherical symmetry recovers, when the collective degrees of freedom are also considered.

The discussion of the sponatenous breaking within the Elliott-model seems to be especially simple in comparison with the previous treatments. Furthermore, it is applicable not only to the quadrupole deformation of a single-shell [1], but also to the octupole deformation of two major-shells [3], as well as to the molecular configurations of many major shells [4,5].

It truns out that this kind of spontaneous breaking [2] accompanies the dynamical symmetry breaking in many structure models.

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