NUCLEAR SYMMETRIES — CHAOTIC SPECTRA

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In the spectra of molecules, atomic nuclei, and other many-body systems, the low-lying excitations often display a pattern suggestive of group symmetries, such as rotational or vibrational bands, even though the many-body spectrum is, in principle, complex and the interactions themselves have no trace of the symmetry groups displayed. This raises the question, to what extent does the low-lying spectrum acquire order simply from the most basic properties of the Hamiltonian? These properties include rotational invariance, possibly other symmetries such as isospin, and the fundamental nature of the interaction, which is predominantly two-body in character. Given an ensemble of Hamiltonians of this form, some properties might occur often, while others would occur rarely and would depend sensitively upon the detailed form of the two-body interactions. An example might be a rotational spectrum: one could imagine that a typical ground state might behave as a solid. Then many members of the ensemble would have a rotational band built on the ground state. Stated another way, many-body calculations often rely upon model interactions such as pseudopotentials in atomic and molecular physics, and the Skyrme, quadrupole–quadrupole, and other interactions in nuclear physics that, despite being drastic simplifications, reproduce many key properties. We ask the logical extension: which properties remain as the Hamiltonian gets more and more arbitrary?

In a first article [C. W. Johnson, G. F. Bertsch, and D. J. Dean, Phys. Rev. Lett. **80**, 2749 (1998)], we discussed some of the consequences of choosing a random quasi-particle ensemble (RQE) of interactions. These random interactions are invariant under the Pandya transformation, and hence place pairing and collective nuclear properties on an equal footing. In the first article, we investigated properties of nuclear spectra in just a few nuclei under the assumption of degenerate single-particle energies. We propose to continue this work by lifting that degeneracy. We will characterize the RQE by its random properties (e.g. spectral rigidity, entropy) and compare the spectra and wavefunctions generated by the ensemble to those of realistic interactions. Interestingly, in some cases the RQE produces ground states of maximal spin, where the low-spin states are pushed up in excitation energy. These particular cases can be described as ferromagnets, and we shall investigate the properties of those Hamiltonians that give rise to such ground states.

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