Quantum chaos in nuclei and hadrons

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A survey of chaotic dynamics in atomic nuclei is presented [1]. It is well known that the energy spacing distribution of proton and neutron resonances in nuclei at about 7 or 8 MeV excitation energy agrees very well with random matrix theory (GOE) predictions. The study of energy level fluctuations in theoretical spectra obtained for example with the shell model are generally in very good agreement with GOE as well. However, the analysis of experimental energy levels for bound states does not provide such a clear answer in any nucleus, not even in the very few nuclei where the whole spectrum of bound states is believed to be known. And even when the data of several nuclei belonging to the same nuclear region are gathered together in order to improve statistics, the results exhibit level fluctuations somewhat intermediate between the GOE and Poisson limits which characterize chaos and order, respectively, in quantum systems, although some statistics may be closer to one of the limits.

We consider several methods of analysis of spectral fluctuations, including traditional statistics like the nearest neighbor spacing distribution *P(s),* the Dyson-Mehta $\Delta 3$ statistic and the localization length [1], as well as the more recent approach based on time series analysis methods [2-4]. We discuss the results for experimental and theoretical energy spectra in nuclei [1,5] and focus attention on the uncertainties in the analyses that can arise from unfolding procedures [6] and imperfect spectra [7].

Finally, we discuss work in progress on a statistical analysis of baryon and meson mass spectra, comparing the results for quark models and experimental data [8].

References

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