Intrinsic quantum chaos in the complex atomic system of protactinium

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Quantum chaos, initially experienced in scattering resonances of nuclei, today is a widely discussed phenomenon observed in various complex quantum systems. In this talk we discuss the occurrence and experimental investigation of intrinsic quantum chaos within the highly complex atomic system of protactinium, as expressed in the arrangement of energy levels. The resulting repulsion of individual states can be traced back to chaotic mixing of a very large number of single electron states, which arise from the five easily excitable electrons within up to four different open valence shells. In order to analyze a reasonable fraction of energy levels of given parity and angular momentum, the highly complex spectrum of the protactinium atom was probed experimentally in different ranges of excitation energy by using multi-step laser resonance ionization spectroscopy. Together with the available literature data we can reproduce a complete overview of excited states of the protactinium atom from ground state up to energies above the first ionization potential. By investigation of the repulsion of states as well as the correlated spectral fluctuations, we derive how intrinsic quantum chaos in this system evolves with energy and emphasize its significance already at moderate excitation energy.