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The Search for Quantum Chaos: Doubly Excited Autoionizing States of Helium

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The classical three-body problem of celestial mechanics--sun, moon, earth for example--has long been known to manifest both regular and chaotic dynamics. Three charged particles obey the same inverse-square force law, and should thus exhibit the same dynamics. Yet the actual dynamics of the two electrons in the helium atom--the simplest three-body quantum system--are determined by the Schroedinger equation, which is linear, and which thus cannot lead to chaotic behavior. Furthermore, the low-lying doubly excited states of the helium atom occur in seemingly regular progressions, labeled by sets of approximately good quantum numbers. What then are the manifestations of the underlying classical chaos in the quantum spectrum of helium? What will be the signatures of the onset of quantum
chaos? We report on recent results from experiments and theoretical modeling which clearly show that the threshold to this new regime has now been passed for the first time in a three-body quantum system with known Hamiltonian.

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