Abstract Submitted
for the TSF19 Meeting of
The American Physical Society

Emergence of Quantum Chaos in a Model 4-Body System

COOPER JOHNSON, NIRAV MEHTA, Trinity University — We implement the method of "slow variable discretization" (SVD) to solve the Schrodinger equation for the (quasi)-bound state energy levels of a system of four interacting atoms moving in one spatial dimension. The SVD method we implement treats the hyper-radius (a measure of the overall size of the system) as a "slowly varying" parameter. This parameter can then be discretized using the "discrete variable representation" (DVR) technique, which guarantees our numerical approximations will converge to being exact given a large enough basis size. To measure chaos, we appeal to the Bohigas, Giannoni, and Schmidt conjecture, which states a classically chaotic system can be statistically described by random matrix theory in quantum mechanics, where random matrix theory makes predictions for the nearest neighbor energy level spacings. We calculate the distribution of energy-level spacings and fit it to the Brody distribution to extract a Brody parameter. A calculation in the adiabatic hyperspherical representation in which all nonadiabatic couplings are ignored gives a perfectly Poisson distribution, corresponding to a Brody parameter of zero. A calculation with SVD, on the other hand, which implicitly incorporates nonadiabatic couplings, yields a Brody parameter of 0.571, indicating a sizable degree of level repulsion characteristic of the transition from an uncorrelated system to one with chaos.

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Date submitted: 02 Oct 2019 Electronic form version 1.4