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Quantum-chaotic behavior of a particle interacting with independent scatterers

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A gas of interacting particles is a paradigmatic example of chaotic systems. It is shown [1] that, even if all but one particle are fixed in generic positions, the excited states of the moving particle are chaotic. They are characterized by the number of principal components (NPC)—the number of integrable system eigenstates involved into the nonintegrable one, which increases linearly with the number of strong scatterers. This rule is a particular case of the general effect of an additional perturbation on the system chaotic properties. The perturbation independence criteria supposing the system chaoticity increase are derived here as well. The effect can be observed in experiments with photons or cold atoms as the decay of observable fluctuation variance, which is inversely proportional to NPC and, therefore, to the number of scatterers. This decay indicates that the eigenstate thermalization is approached. The results are confirmed by numerical calculations for a harmonic waveguide with zero-range scatterers along its axis [2]. Millions of eigenstates are calculated with an effective numerical method, based on properties of high-rank separable perturbations.
1. V. A. Yurovsky, Phys. Rev. Lett. 130, 020404 (2023).
2. V. A. Yurovsky, arxiv/2301.06065.

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