PhD PROPOSAL

Specialty: Theoretical Physics

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New aspects of chaos-assisted tunneling and applications to cold atoms physics

In standard textbooks, quantum tunneling is often presented through barrier tunneling in one dimension, where it follows simple laws and is well understood. However, as soon as the system can present chaotic properties, new phenomena appear. In particular, chaos-assisted tunneling is a mechanism by which the tunnel rates have reproducible fluctuations by orders of magnitude over a small parameter range [1]. This process is reminiscent of universal conductance fluctuations which arise in condensed matter disordered systems, and can be seen as a quantum interference signature of the chaotic dynamics. In the ergodic regime, chaos-assisted tunneling is well understood and the distribution of tunneling rates has been calculated [2].

However, it is known that other types of transport properties can also appear in chaotic systems and their influence on tunneling is not known. In particular, we have very recently shown that Anderson localization, a localization effect driven by the interplay between disorder/chaos and quantum interference, strongly modifies the tunneling process, leading to new types of tunneling [3]. The aim of this PhD is to study chaos-assisted tunneling in completely new regimes, where quantum transport is affected by localization, multifractality (known to appear at the Anderson metal-insulator transition and in so-called pseudo integrable systems [4], [5]) or interactions (naturally present in a cold atom context). The objective is first to build the theoretical framework to understand these new regimes, and then to use it as a new toolbox to control cold atom experiments through complexity.

The PhD will be supervised by a team of researchers of the Laboratoire de Physique Théorique de l'IRSAMC, Toulouse. These studies will be realized in close contact with the experimental group of D. Guéry-Odelin and J. Billy at LCAR who study such types of systems with cold atom experiments. The project will require the use of both numerical simulations and analytical calculations.

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References:
[1] S. Tomsovic and D. Ullmo, « Chaos-assisted tunneling'' Physical Review E 50 (1), 145 (1994).
[2] F. Leyvraz and D. Ullmo `The level splitting distribution in chaos-assisted tunnelling'' Journal of Physics A: Mathematical and General 29 (10), 2529 (1996).
[3] E. Doggen, B. Georgeot and G. Lemarié, "Chaos-assisted tunneling in the presence of Anderson localization", submitted (2017) (arXiv:1610.00587).
[4] J. Martin, I. García-Mata, O. Giraud, and B. Georgeot "Multifractal wave functions of simple quantum maps", Physical Review E 82, 046206 (2010).
[5] R. Dubertrand, I. García-Mata, B. Georgeot, O. Giraud, G. Lemarié and J. Martin "Two scenarios for quantum multifractality breakdown", Physical Review Letters 112, 234101 (2014).