Foundations of Quantum Mechanics and Collapse Models

Quantum mechanics is undoubtedly a successful theory. Nevertheless, it is still puzzling the scientific community with its unsolved problems. Where does the border between the quantum (microscopic) and the classical (macroscopic) world lay? How can one reconcile quantum linearity with the lack of macroscopic superpositions? What is the role of the wave function? How does it collapse? These are only few of the open problems on the foundations of quantum mechanics.

The group is engaged in developing and testing models of spontaneous wave function collapse, which aim at giving a coherent answer to the questions above. After the seminal model by Ghirardi, Rimini, and Weber [1], several models describing the wave function collapse were developed in the following years [2]. The group is focused on two research directions: testing current collapse models, working in close contact with experimental physicists, and developing their extensions to dissipative and non-Markovian dynamics, and to the relativistic framework [3].

The experimental testing of collapse models in particular is giving important results, greatly reducing the allowed parameter space, as shown in Figure 1.

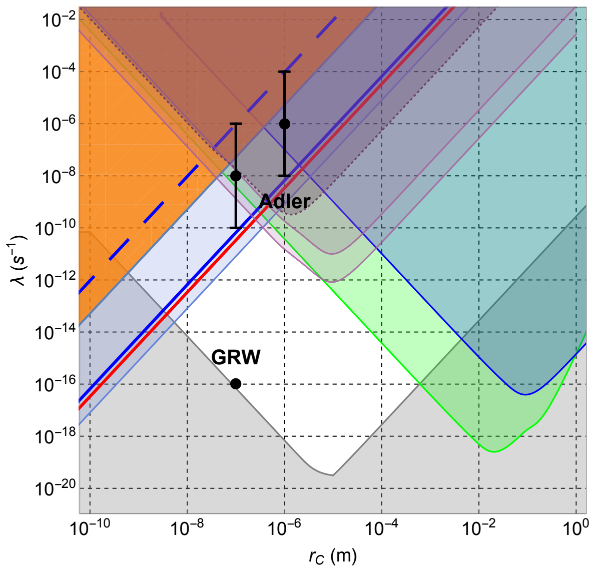

Figure 1 - Parameter space for the Continuous Spontaneous Localization (CSL) model [2]. λ is the collapse rate and r_C is the correlation distance of the noise providing the collapse. All the shaded areas correspond to experimentally and theoretically excluded values of the parameters. Here, all the upper bounds but that denoted by the red line were inferred from our group, mostly in collaboration with other experimental and theoretical researchers. The orange area is inferred from a cold atom experiment [4], the light blue area from x-ray emission from a Germanium sample [5], the two purple areas from millikelvin nanomechanical cantilever experiments [6], green and blue areas respectively from LISA Pathfinder and LIGO noise analysis [7], the grey area from theoretical considerations [8], the blue and red lines (and corresponding upper bounds) from the spectrum excitations of fermion and phonons respectively [9].

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