Internship in ESA's Advanced Concepts Team
on
Classical states from open quantum dynamics

Topic description

Quantum theory is well understood at microscopic level. At macroscopic scales, however, physics is dominated by classical effects. The phenomenon of decoherence explains this quantum to classical transition, by taking into account the interaction between the system and unobserved degrees of freedom [1]. Quantum dynamics of open system governs which classical states emerge. Nonetheless for complex, realistic interactions the classical pointer states are poorly understood. In this case, the question of the emergence of objective properties, already explored in the context of quantum Darwinism [2], becomes unclear.

The aim of this stage will be to understand what are the classical states emerging from complex interactions between the system and the environment, using both analytical and numerical tools. The candidate will analyze simple systems, like qubits or harmonic oscillators, monitored by several competing Markovian environments. This will naturally lead to re-explore the question of objectivity by developing quantum information theoretic tools to assess the classicality of the states from the perspective of the environment. Finally, the applicability of those models and methods to relevant experiments will be investigated.

Candidate's tasks

- Analyzing and simulating simple models of quantum dynamics.
- Explore relevant experimental implementations.
- Developing tools for quantum Darwinism.

The ideal candidate

Mandatory:

- Understanding of quantum physics.
- Programming skills in Python.

Desirable:

- Knowledge of quantum trajectories [3].

References

[1] Jean-Michel Raimond and Serge Haroche. *Exploring the quantum*. Oxford University Press, Oxford, 2006.

[2] Wojciech Hubert Zurek. Quantum darwinism. *Nature Physics*, 5(3):181, 2009.

[3] Jean Dalibard, Yvan Castin, and Klaus Mølmer. Wave-function approach to dissipative processes in quantum optics. *Physical review letters*, 68(5):580, 1992.