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The Quantum Zeno Effect in the Local Ionisation of a Bose Einstein Condensate

Abstract: In quantum physics measurement can influence the dynamic of the system crucially. A frequent measurement can suppress the dynamics within the measured system. This is called the quantum Zeno effect (QZE). While the QZE in a two-level-system is textbook material it becomes surprisingly complicated in the case of position measurement. The macroscopic quantum state of a Bose-Einstein condensate (BEC) is one of the few quantum systems allowing the study of the QZE in position measurement. In the group of Klaus Sengstock a new experiment was being set up, dedicated to the investigation of the local ionisation of a BEC by ultra-short laser pulses. A local ionisation of the BEC is analog to an irreversible position measurement and can therefore give rise to the QZE.

In the theoretical study that will be presented the QZE in a BEC submitted to a local dissipative defect is investigated. The behaviour of this open quantum system depends on several parameters: the size of the dissipative defect, effect of inter-atomic interaction, dissipation rate, to name but a few. The quantum Zeno suppression has been quantitatively investigated by numerically solving the time-dependent Gross-Pitaevskii equation. While the investigation first focusses on continuous local dissipation, an extension of the numerical simulation to pulsed position measurement allowed the comparison of both regimes. Additionally an alternative approach for an ideal BEC in one dimension is presented that allows an intuitive insight of the QZ-dynamic. In this approach it becomes apparent that a pulsed measurement leads to a different dynamic than a continuous measurement and that there is no mapping possible between the two regimes.