ESR8: Coherence and decoherence of a single-ion qubit immersed into an environment

Supervisor: Michael Köhl

Host Institution: University of Bonn

Duration: 36 months

Planned secondment: University of Basel

Description:

In quantum information processing it is important to manipulate a qubit in a coherently controlled way. Trapped atomic ions have been successfully employed in this field, since they are very well isolated from the environment and therefore offer long coherence times. However, when an isolated ion is coupled to an environment, it will become gradually entangled with many degrees of freedom and therefore eventually decoheres [1,2,3]. Therefore the question remains of how quantum computing could work under realistic conditions (i.e. when there is a finite coupling between qubit and the environment), and how it could potentially be optimised.

In this project, we plan to investigate decoherence mechanisms of a single or a few trapped ions controllably coupled to an environment. Particular focus will be on the question whether the environment could also be used as a resource to generate or protect entanglement between ions. We plan to investigate this process by carefully tailoring the properties of the environment, for example its dimensionality or the coupling strength between ion and environment. To this end, the project is concerned with the design, buildup and operation of the next generation of hybrid ion traps, where the tools for fast preparation and detection of the ion‘s spin coherence are already integrated into the trap. Specifically, we plan to employ recently developed optical fiber cavities [4] as an integral part of a new setup.

References:

[1] L. Ratschbacher et al., Phys. Rev. Lett. 110, 160402 (2013).
[2] L. Ratschbacher et al., Nature Physics 8, 649 (2012).
[3] C. Zipkes et al., Nature 464, 338 (2010).
[4] M. Steiner et al., Phys. Rev. Lett. 110, 043003 (2013).

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