Towards cavity-enhanced detection of single rare earth ions

J. Benedikter[1] , B. Casabone[2], T. Hümmer[1], A. Ferrier[3], P. Goldner[3], T. W. Hänsch[1], H. de Riedmatten[2], D. Hunger[4]

[1]Faculty of Physics, Ludwig-Maximilians University, Munich, Germany
[2] Institute of Photonic Sciences,Castelldefels, Spain
Chimie ParisTech, ENS, Paris, France
E-mail: david.hunger@kit.edu

Rare earth ions doped into solids provide outstanding optical and spin coherence properties, which renders them as promising candidates for optically adressable quantum memories and multi-qubit registers. However, due to the dipole-forbidden nature of the coherent transitions, they couple only weakly to optical fields. This limits most experiments to macroscopic ensembles, where inhomogeneous broadening complicates and limits quantum control.

Here we present an approach to get efficient access to individual ions or small ensembles by coupling them to a high-Finesse optical microcavity. We employ fiber-based Fabry-Perot cavities [1] with high finesse and a free-space mode volume as small as a few λ^3 to achieve substantial Purcell enhancement. This offers the potential to boost the spontaneous emission rate by several orders of magnitude (up to 10^4), thereby making the weak transitions bright.

We report on the current status of our experiment, where we investigate $Eu3^+$:Y_2O_3 nanocrystals [2] coupled to a cavity in a cryogenic environment.

References

[1] D. Hunger et al., NJP **12**, 065038 (2010)

[2] A. Perrot et al., PRL **111**, 203601 (2013)