Towards new approaches of electromagnetic field sensing using cold Rydberg atoms

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Rydberg atoms, characterized by a very large principal quantum number $n \gg 1$, exhibit several interesting properties for quantum technologies. Their gigantic electric dipole moments make them extremely sensitive to electromagnetic fields. Our recent experiment demonstrated a technique for measuring both amplitude and frequency of a microwave field, using trap-loss spectroscopy of Rydberg states in a magneto-optical trap (MOT) [1].

Recent upgrades of the apparatus have led to a higher signal-to-noise ratio as shown in Fig. 1, improved long-term stability, and enhanced sensor sensitivity. We are developing a new measurement protocol that suppresses the effects of cooling light, thereby further improving detection performance. We are implementing arrays of optical tweezers as an additional step to trap the atoms [2], which promises higher spatial resolution and improved sensitivity. This work opens perspectives for applications in Terahertz imaging, light-shift calibration in optical clocks, and quantum-metrology experiments where inter-atomic entanglement enhances measurement sensitivity.

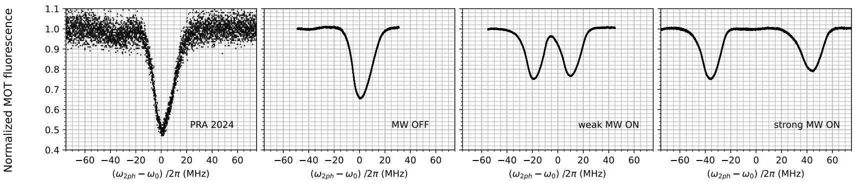

FIG. 1. Left: Published data from [1]. Right: Improved signal-to-noise ratio of the fluorescence and spectra for increasing microwave power.

[1] R. Duverger *et al.*, *Phys. Rev. Appl.* **22**, 044039 (2024).
[2] Y. Zhang *et al.*, *Phys. Rev. Lett.* **136**, 110802 (2026).

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