Towards sensitivity optimization of EIT-based RF quantum sensing using microfabricated vapor cells

Davide Sera[1,3], Francesco Albergo[1], and Vito Giovanni Lucivero[1,2]

[1]Dipartimento Interateneo di Fisica, Università degli Studi di Bari Aldo Moro, 70126 Bari, Italy
[2]QSENSATO Srl, Via Giovanni Amendola 173, 70126 Bari, Italy
[3]Thales Alenia Space Italia, Via Saccomuro 24, 00131 Rome, Italy

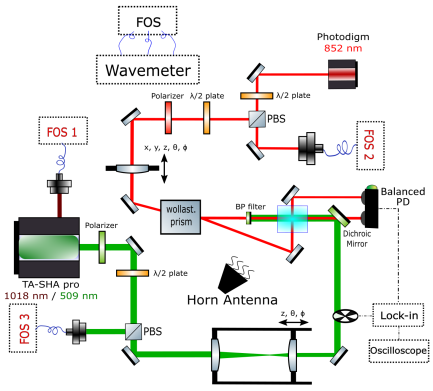
Abstract

We study how engineered cesium ladder-EIT linewidths govern sensitivity to weak RF fields via Autler-townes splitting and perform systematic parameter optimization to guide the design of all-glass vapor cells for Rydberg sensors and integrated architectures.

This work addresses a central problem in thermal-vapor Rydberg sensing: the identification of the spectroscopic optimal experimental conditions that maximize RF-field sensitivity. We present a systematic study of the EIT linewidth versus key probe and coupling parameters such as optical power, beam geometry, and the interplay of homogeneous and inhomogeneous broadening mechanisms [1].

To analyze the measured spectra, we combine a phenomenological Voigt fitting procedure with steady-state density-matrix simulations. Voigt fits are used to extract effective homogeneous and inhomogeneous linewidth contributions directly from the experimental data, while the density-matrix model provides a physically grounded reference for validating the observed trends.

Finally, we correlate the optimized EIT response with the onset and visibility of RF-induced Autler–Townes splitting, establishing a direct connection between linewidth optimization and RF sensing performance in Doppler-broadened Rydberg ensembles [2]. While the present investigation is carried out in a free-space configuration, the results are also relevant for future compact implementations, including laser-written vapor cells [3].



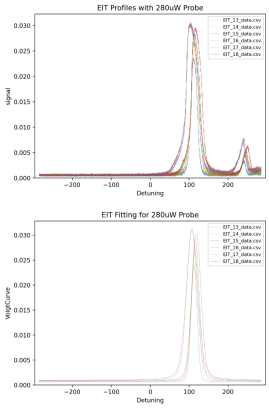


Figure 1 (left): Experimental setup for cesium ladder-EIT and RF-dressed spectroscopy. The setup provides independent control of optical powers, beam geometry, and RF excitation, enabling systematic linewidth and thus sensitivity optimization.

Figure 2 (right): Typical EIT resonances and Voigt fits acquired at different coupling powers.

References

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