Modelling Multilevel Rydberg-Atom Electrometry

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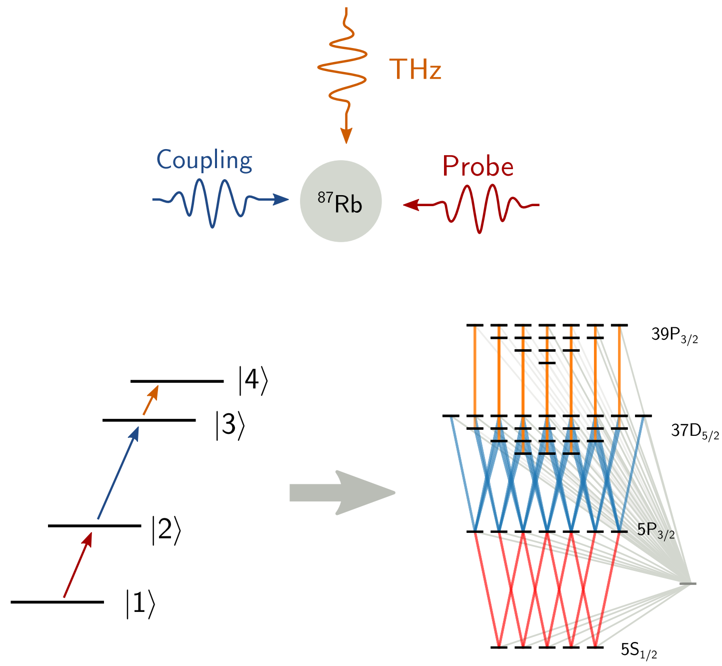
Rydberg atoms are exceptional electric-field sensors: they are inherently SI-traceable, calibration-free and extremely sensitive [1], and they able to sense terahertz-frequency fields, bridging the elusive “terahertz gap” [2]. In experiments, the measurement of the electric field is mapped to the transmission of a probe beam. This has been demonstrated repeatedly in the literature, though the complexities of real atoms are ignored and remain unexplained in most studies. When varying the polarization of the measured field, these complexities manifest directly in the observations [3]. We present a density-matrix treatment of an atomic Rydberg system, a model which evolves from the commonly-used 4-level system to a Doppler-averaged 53-state system necessary the explain the polarization-dependent behaviour.



[1] C. L. Holloway et al., “Electric field metrology for SI traceability: Systematic measurement uncertainties in electromagnetically induced transparency in atomic vapor”. In: Journal of Applied Physics 121 (2017), p. 233106.

[2] C. G. Wade et al., “Real-time near-field terahertz imaging with atomic optical fluorescence”. In: Nature Photonics 11 (2017), p. 40-43.

[3] J. A. Sedlacek et al., “Atom-Based Vector Microwave Electrometry Using Rubidium Rydberg Atoms in a Vapor Cell”. In: Physical Review Letters 111 (2013), p. 063001.