Effect of vapor cell glass on the error of microwave power measurements

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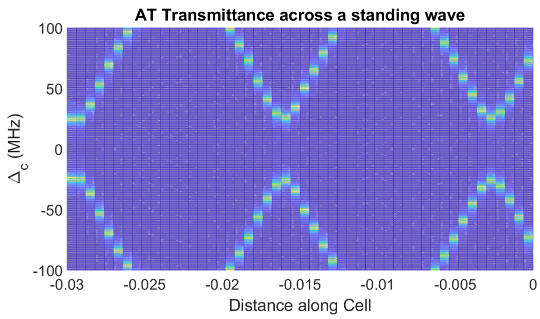
Room-temperature Rydberg atoms can be used for SI-traceable microwave electrometry. Room-temperature Cesium atoms are excited to a high Rydberg state with a probe and coupling laser to the point that they exhibit electromagnetically induced transparency. In this state, the Rydberg atoms can be used to measure microwave power by exhibiting Autler-Townes (AT) splitting, which looks like two peaks in the probe laser transmission when the frequency of the coupling laser is swept (Δ_c in Figure 1a). The distance, in frequency, between the two peaks is dependent on the power of the microwave electric field [1, 2]. In this work, we build a glass vapor cell into a waveguide (Figure 1b) to make SI-traceable power measurements of K band microwave fields, as described in [3]. A large source of error in microwave electrometry measurements is due to a standing wave that is caused by the dielectric walls of the glass vapor cell itself. A standing wave presents an inhomogenous field to our Rydberg atoms which broadens the AT lines (Figure 1a), and therefore reduces the accuracy of the power measurement [3]. The standing wave must be well chacterized inside the vapor cell to properly calibrate it's effects out of measurements. In order to reduce the effect of the standing wave, we simulate various dielectric window properties and propose a method to independently measure these effects using a Vector Network Analyzer



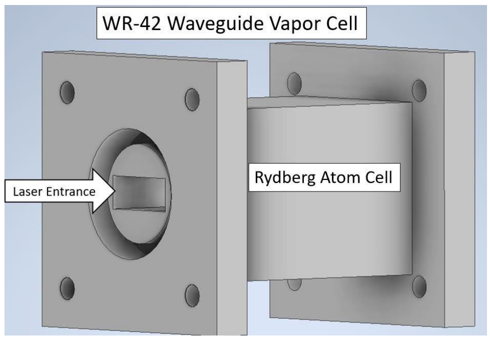


Figure 1: (a) The simulated transmittance through the atomic gas in the presence of the standing wave (b)A vapor cell WR-42 waveguide that experiences microwave standing waves

[1] C. Holloway et al, Broadband Rydberg Atom-Based Electric-Field Probe for SI-Traceable, Self-Calibrated Measurements, IEEE Transactions on Antennas and Propagation **62**, 12 (2014).
[2] Jonathon A. Sedlacek et al, Microwave electrometry with Rydberg atoms in a vapour cell using bright atomic resonances, nature physics, 8, 819-824 (2012).
[3]C. Holloway et al,A Quantum-Based Power Standard: Using Rydberg Atoms for a SI-Traceable Radio-Frequency Power Measurement Technique in Rectangular Waveguides, APL , **94101**,113 (2018).