# Rydberg Atom Based Sub-Wavelength Imaging

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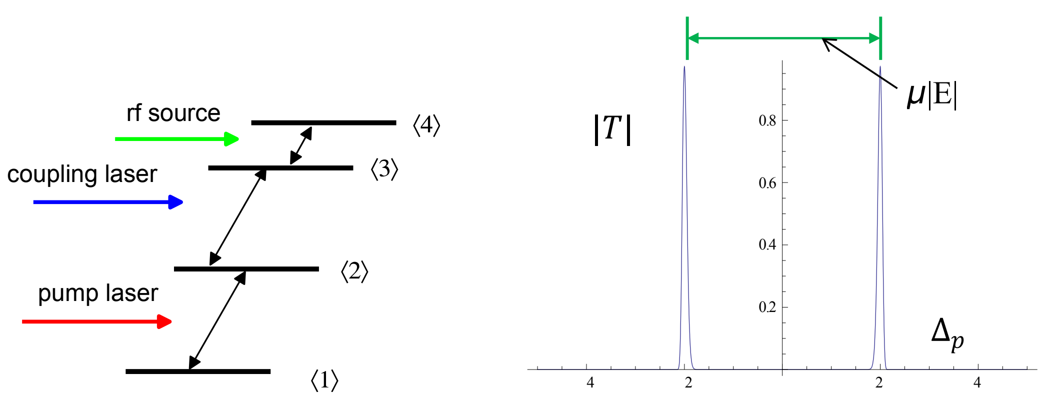
We present a revolutionary new approach for sub-wavelength imaging of rf –to-tetra-hertz fields. The new approach is based on the interaction of RF-fields with Rydberg atoms: where alkali atoms are excited optically to Rydberg states and the applied RF-field alters the resonant state of the atoms. For this approach, the Rydberg atoms are placed in a glass vapor cell. This vapor cell acts like an RF-to-optical transducer: covert an RF E-field to an optical frequency response. The probe utilizes the concept of Electromagnetic Induced Transparency (EIT), where the RF transition in the four-level atomic system causes a split of the transition spectrum for the pump laser, as seen in Figure 1. This splitting is easily measured and is directly proportional to the applied RF field amplitude. Therefore, by measuring this splitting we get a direct measurement of the RF E-field strength. The significant dipole response of Rydberg atoms over the GHz regime suggests this technique could allow traceable measurements over a large frequency band including 1-1000 GHz.

In this new approach, the atoms in the optical beam are the ones that interact with the field. As a result, the width of the optical beam (on the order of microns) governs the spatial solution of the measurement. Thus, sub-wavelength imaging is possible from rf to terahertz frequencies. Since this approach is based on an atomic interaction it will be self-calibrating due to atomic resonances, and have vastly improved sensitivity and dynamic range over current E-field probes (<0.01 mV/m: *two orders of magnitude improvement over current approaches*.




(a) (b)

Figure 1. E-Field Probe concept: (a) four-level atomic system, and (b) EIT signal in the pump laser for an applied RF E-filed.

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