32nd URSI GASS, Montreal, 19–26 August 2017

Microwave Power Measurements Using Rydberg Atoms

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Extended Abstract

We are building a system that will allow the calibration of continuous microwave or millimeter-wave power-meters. The system uses a substitution method where the RF field amplitude is probed by a laser-atom interaction [1]. In order to reach a wider and higher range of frequencies, our system will measure Rabi oscillations between highly excited states [2].

One advantage of the highly excited (Rydberg) states is the large number of transitions in the millimeter wavelength range. Although it will not work over a continuous spectra, the system will allow us to match one or more discrete frequency in any given wavelength band. Typically one hundred frequencies would be available between ten to one hundred Gigahertz.

When the waveguide size is too small (higher frequencies), the interaction region is located in front of a horn antenna whose gain is calculable. The Rabi frequency is measured and compared to the measured incicent power. Both the RF field distribution and the dipole moment should be available (calculable).

The Rydberg atoms can be prepared in the "circular" state where the angular momentum is maximum. For this state, the electron wavefunction has the shape of a thin ring and could almost be described by a classical orbit [3]. Circular Rydbergs are metastable, hydrogen-like, and extremely sensitive to electromagnetic fields. The preparation of the atoms in this state would greatly improve the measurements [4]. The circular Rydberg states are more stable, ie. they have a longer lifetime, and for each circular level, there a single magnetic quantum state. [5].

The Rydberg states are very sensitive to the electric field. It is necessary to superpose a static electric field to the RF one. If the measurement is done inside the waveguide, then it is slitted and a bias voltage is applied to the two halves. However, if the measurement is made in front of a horn, then a bias voltage can be applied to the horn. The detection of the excited states is done using the electric field ionization method. This requires to ramp an electric field across two capacitor plates. The electron is detected using a micro-channel plate electron multiplier located behing one of the plates.

During this presentation, we will describe the aparatus and report on the experiment progress.

References

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