

Quantum Sensing of Microwave Electric Fields with Rydberg Atoms

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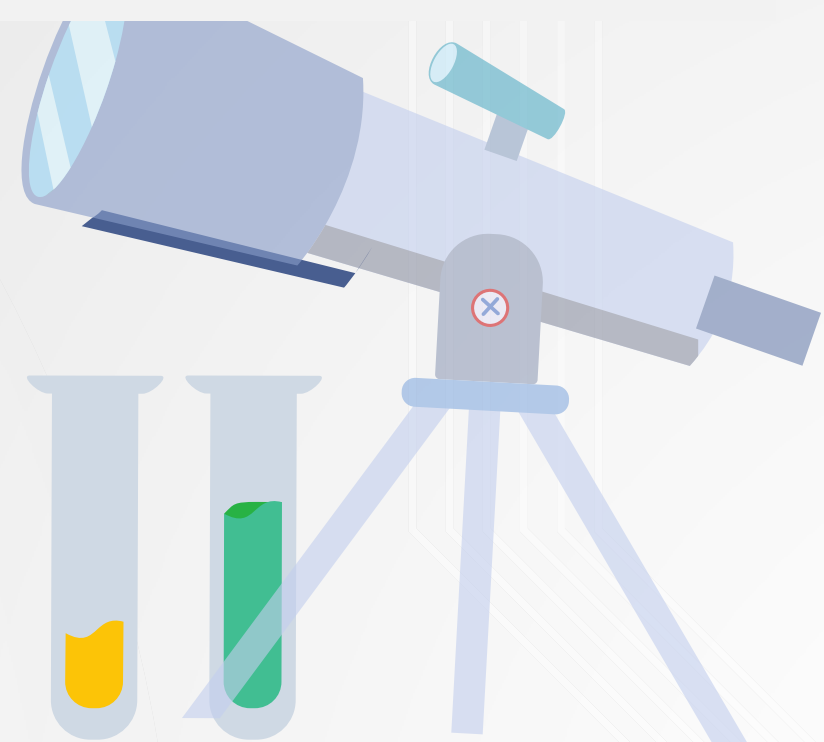


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Abstract

Rydberg atoms are effective sensors for electromagnetic field because of their large dipole moments. With the electromagnetically-induced-transparency (EIT) scheme, we can observe the minor shift happening on the states caused by the induced fields with high contrast signals. The shifts of the states can be read from the spectra splitting with magnetic Zeeman effect or electric Stark effect and Autler-Townes effect.

However, the sensitivity to the fields is limited to the spectral linewidth, or the quantum decay rate of the states. To enhance the electric field sensing, we use the heterodyne scheme to overcome the limit. Two microwaves were induced as the AC electric fields to generate the interferences on the spectra with higher response to the field strengths. We observe the system after optimizing for the best EIT signals, and analyze the best condition to receive the highest heterodyne signals, revealing the relationship between the EIT and the heterodyne scheme. Our theory models indicate the evolution of the EIT signals and the heterodyne signals. After the optimization, the detectable electric field was enhanced with heated vapor cell to the level around $4.6\mu\text{V}/\text{cm}$, which was about 5 times better than the same system under room-temperature, and the dynamic range was around 45 dB. Through enhancing the detecting scheme for higher sensitivity and broader bands, the sensor can serve as the receiver for wireless communications, THz applications, etc.



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