THz electrometry with all IR lasers

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The terahertz (THz) radiations (from 0.3 THz to 10 THz) compared to X-ray are intrinsically safe, non-destructive and non-invasive, thus is useful in many areas. However, the THz detection technology is still limited now [1]. In Durham University, we have built a THz electrometry system with 5-level EIT (electromagnetically induced transparency) based on thermal rubidium (Rb) atomic system excited by 3 infrared lasers. The principle here is, when the THz is on, the 4-level EIT ($5S_{1/2} \rightarrow 5P_{3/2} \rightarrow 6S_{1/2} \rightarrow nP_{3/2}$) will become a 5-level EIT and there is an extra peak appearing, as in Figure 1, whose amplitude is relevant to the THz radiation amplitude. We can make use of this peak amplitude change to determine the THz radiation amplitude. The sensing of 654 GHz and 1.02 THz has been observed. The advantage of our Rydberg detection system is high sensitivity because of the high polarizability of Rydberg atoms. Also because this system only uses 3 infrared lasers, it is cheap and simple compare to the 2-photon EIT system usually using expensive UV or blue laser [2,3]. This THz electrometry system may have wide applications in material identification or defect test as a novel THz spectroscopy method.

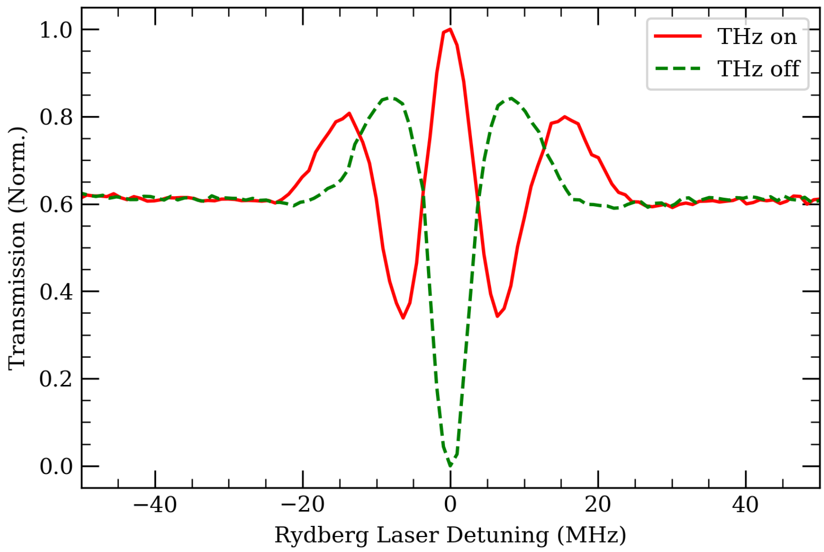

Figure 1. Experimental 5-level EIT signal with and without THz. THz frequency used here is 645 GHz for coupling $17P_{3/2}$ to $16D_{5/2}$ in Rb-85.

[1] R A Lewis, A review of terahertz detectors, J. Phys. D: Appl. Phys. **52** 433001 (2019).
[2] J. Sedlacek, A. Schwettmann, H. Kbler et al. Microwave electrometry with Rydberg atoms in a vapour cell using bright atomic resonances, Nature Phys **8**, 819824 (2012).
[3]Haoquan Fan et al. Atom based RF electric field sensing, J. Phys. B: At. Mol. Opt. Phys. **48** 202001 (2015).