A Digital Terahertz Power Meter Based on an NbN Thin Film

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We have further studied the effect of subjecting a superconducting Hot Electron Bolometer (HEB) element made from an NbN thin film to microwave radiation. Since the photon energy is weak, the microwave radiation does not simply heat the film, but generates a bi-static state, switching between the superconducting and normal states, upon the application of a small voltage bias. Indeed, a relaxation oscillation of a few MHz has previously been reported in this regime [1]. Switching between the superconducting and normal states modulates the reflected microwave pump power from the device. A simple homodyne setup readily recovers the spontaneous switching waveform in the time domain. The switching frequency is a function of both the bias voltage (DC heating) and the applied microwave power.

In this work, we use a 0.8 THz HEB waveguide mixer for the purpose of demonstration. The applied microwave pump, coupled through a directional coupler, is at 1 GHz. Since the pump power is of the order of a few µW, a room temperature amplifier is sufficient to amplify the reflected pump power from the HEB mixer, which beats with the microwave source in a homodyne set-up. After further amplification, the switching waveform is passed onto a frequency counter. The typical frequency of the switching pulses is 3-5 MHz. It is found that the digital frequency count increases with higher microwave pump power. When the HEB mixer is subjected to additional optical power at 0.8 THz, the frequency count also increases. When we vary the incident optical power by using a wire grid attenuator, a linear relationship is observed between the frequency count and the applied optical power, over at least an order of magnitude of power.

This phenomenon can be exploited to develop a digital power meter, using a very simple electronics setup. Further experiments are under way to determine the range of linearity and the accuracy of calibration transfer from the microwave to the THz regime.

References

1. Y. Zhuang, and S. Yngvesson, "Detection and interpretation of bistatic effects in NbN HEB devices," *Proc. 13th Int. Symp. Space THz Tech.,* 2002, pp. 463–472.