QUANTUM NOISE CONTRIBUTION TO THE RECEIVER NOISE TEMPERATURE OF HEB THZ HETERODYNE RECEIVERS

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Typical measured DSB receiver noise temperatures of HEB mixer receivers are about 800 K to 1,000 K at 1.6 THz and 1,500 K to 1,800 K at 2.5 THz. The quantum noise limit for the DSB noise temperature of linear heterodyne receivers (inferred from that of linear amplifiers [1]) is hf/2k = 38 K at 1.6 THz and 60 K at 2.5 THz, and it would then seem that one could neglect the quantum noise limit contributes to the total receiver noise temperature of present state-of-the-art HEB THz receivers. To investigate more carefully whether this is indeed the case, we have applied contemporary concepts related to quantum noise ([1, 2] and references cited there) to HEB mixer receivers. By including effects due to the optical input losses of the receivers, as well as a simplified version of the Active Zone model [3] recently applied to NbN phonon-cooled HEBs, we conclude that about 14 % of the measured receiver noise temperature in a typical NbN HEB THz receiver at 1.6 THz may be attributed to quantum noise, while at 2.5 THz the estimated fraction due to quantum noise is 16-20 %. As further noise temperature measurements are performed *beyond* 2.5 THz we estimate that the above fraction may approach 50 %, even if no future improvements in the intrinsic noise performance of such receivers are assumed (the latter also seems likely to occur). We estimate the magnitude of an additional noise contribution from the warm parts of the optics at the receiver input, about 11-14 % at 1.6 THz. The noise temperature contribution due to the warm optics increases much more slowly with frequency.

We conclude that it is justified to attempt experimental demonstration of quantum noise effects in the present generation of HEB THz receivers.

[1] C. M. Caves, “Quantum Limits on Noise in Linear Amplifiers”, Phys. Rev. D, vol. 26, No. 8, pp. 1817-1839, October 1982.

[2] A.R. Kerr, M. J. Feldman, and S. –K. Pan, “Receiver Noise Temperature, the Quantum Noise Limit, and the Role of the Zero-Point Fluctuations,” in Proc. 8th Int. Nat. Symp. Space Terahertz Technology, March 25-27, 1997, pp. 101-111.

[3] H.F. Merkel, P. Khosropanah, K.S. Yngvesson, S. Cherednichenko, M. Kroug, A. Adam, and E.L. Kollberg, "An Active Zone Small Signal Model for Hot Electron Bolometric Mixers," 12th Intern. Symp. Space THz Technol, San Diego, CA, Febr. 2001, pp. 67-74.