Shot noise in carbon nanotube based Fabry-Perot interferometers:technical details

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The basic diagram of the circuit used to measure noise is displayed in figure 1a. The biasing is done by means of two $20k\Omega$ resistors also mounted on a printed circuit board (PCB). One of them is used for DC biasing. The other one is used for AC measurement of the conductance at about $2kHz$. The current fluctuations in the NT result in voltage fluctuations along the two 200Ω resistors placed on the PCB at the same temperature as the sample ($1.5K$). The two signals are fed into two coaxial lines and separately amplified at room temperature by two independent sets of low noise amplification stages (gains: $G_1 = 7202 \pm 100$, $G_2 = 5199 \pm 30$, amplifiers NF SA-220F5). The two signals are subsequently fed into the two inputs of a spectrum analyzer which calculates the cross correlation spectrum. This technique allows to average out the voltage noise of the amplifiers and to reduce the contribution of their current noise [1]. Each noise point corresponds to 4 averaging runs of 60000 spectra with a frequency span of $78.125kHz$ (1601 frequency points) and a center frequency ranging from $1MHz$ to $10MHz$. This averaging allows to get the required sensitivity of about $5.10^{-23}V^2/Hz$ [2]. Given the capacitance of $200pF$ of the coaxial cables and the shunt resistors of 200Ω, the cut-off frequency is about $4MHz$. The calibration of each detection chain is achieved by means of the temperature dependence of the Johnson-Nyquist noise of the 200Ω resistors in the range 1.5-20 K. At the frequency of $2.221MHz$ where most measurements have been done, the total power gain attenuation of the noise setup is 0.75.

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