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Noise Thermometry : Getting Temperature from Electrical Johnson Noise and Shot Noise

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Among fundamental physical units, the temperature unit Kelvin is not well connected to other physical units. Noise thermometry is the tool to link electrical unit to thermodynamic temperature unit. Here I introduce our major activities in noise thermometry research; the Johnson noise thermometry and the shot noise thermometry. Johnson noise is the spontaneous thermal fluctuation in electrical circuits. From the Nyquist's theorem, the noise power spectral density across a resistor is proportional to the temperature of the resistor. Therefore, we can infer temperature from electrical noise. Thank to the invention of Josephson arbitrary waveform synthesis technology, we are now able to synthesize arbitrary waveform (including noise) with quantum mechanical accuracy. Here I will show the principle and operation of our Josephson waveform synthesis system, and how it can be applied to Johnson noise thermometry. On the other hand, if we measure the noise in a metal-insulator-metal tunnel junction, the noise is analogous to Johnson noise at zero bias, therefore it reflects the temperature. At finite voltage bias, however, shot noise will dominate in the junction, which arises from the discreteness of electron tunneling. This bias-dependent tunneling noise in a tunnel junction can be used to extract temperature from pure electronic noise signal. I will briefly introduce our shot noise thermometry results from sample fabrication technique to measurement results, and our recent research on the influence of the tunneling properties on the errors in shot noise thermometry.