S2-11: Quantum-based Johnson noise thermometry at NIST

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Abstract: Johnson noise thermometry utilizes the direct theoretical link between noise fluctuations and dissipation, where the power spectral density of the voltage fluctuations across a resistor are proportional to the temperature of the resistor and the resistance, with a proportionality constant equal to four times the Boltzmann constant. Measuring these small voltage fluctuations is challenging and is accomplished using custom, low-noise electronics which are calibrated over a 1 MHz bandwidth using a quantum-based Josephson arbitrary waveform synthesizer (JAWS), also known as a quantum voltage noise source (QVNS).

I will summarize the state of Johnson noise thermometry at NIST. We are currently focused on measuring the Boltzmann constant with a few parts in $10^6$ uncertainty using a resistor held at the triple point of water. After the redefinition of the SI in 2018, this project will pivot towards development of a compact primary thermometer and use the newly-defined Boltzmann constant to make precise temperature measurements over a wide range of temperatures. The redefinition will unlink the Kelvin from the triple point of water. However, a programmable and scalable primary thermometer will have the potential to revolutionize thermometry by reducing dependence of practical thermometry on the remaining fixed points of the ITS-90 temperature scale. A QVNS-JNT primary thermometer will increase understanding of the temperature scale and possibly reduce the uncertainty of temperature measurements at arbitrary temperatures, especially at temperatures away from these fixed points.