PROGRESS IN PRIMARY ACOUSTIC THERMOMETRY AT NIST: 273 K TO 505 K

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Abstract

Thermodynamic relationships are true only when the temperature that appears in them is the thermodynamic temperature T. With this in mind, the International Temperature Scale of 1990 (ITS-90) provides the temperature T_{90}, which is an excellent approximation to the thermodynamic temperature. However, ITS-90 can be improved. The NIST Acoustic Thermometer is designed to reduce the uncertainty of ITS-90 (by a factor of 5 near 800 K) by measuring the difference ($T - T_{90}$) throughout the temperature range 273 K to 800 K with uncertainties of only a few millikelvin. Acoustic thermometers exploit the proportionality: $c^2 \propto T$ where c is the speed of sound in a dilute monatomic gas. The NIST acoustic thermometer determines the speed of sound (and T) in dilute argon by measuring the frequencies of both the acoustic and the microwave resonances of an argon-filled, spherical cavity. The microwave resonances determine the thermal expansion of the cavity from 273.16 K to the operating temperatures while the acoustic resonances determine how the speed of sound in the argon changes with temperature. We report our progress in redetermining the thermodynamic temperature of three fixed points on ITS-90: the melting point of gallium (302.9146 K) and the freezing points of indium (429.7485 K) and tin (505.078 K). At these temperatures, we estimate the uncertainty of ($T - T_{90}$) by combining the uncertainties of the pressure-dependent acoustic measurements, the microwave measurements, the thermometry, and the purity of the argon.