Measurement of Thermodynamic Temperature Between 5 K and 24.5 K with Single-Pressure Refractive-Index Gas Thermometry

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We will describe measurements of thermodynamic temperature in the range 5 K to 24.5561 K (the triple point of neon) using single-pressure refractive-index gas thermometry (SPRIGT) with ^{4}He. The main purpose of the work is to provide values of T-T_{90}, the discrepancy between thermodynamic temperature and that of the International Temperature Scale of 1990 (ITS-90). The link to ITS-90 is made via calibrated rhodium-iron resistance thermometers. Innovations required to reach the level of accuracy required for meaningful measurements (uncertainty in T-T_{90} less than the expected deviation) include the suppression of temperature oscillations in a cryogen-free cryostat, a pressure stabilization scheme based on a non-rotating piston balance, modelling of the hydrostatic head correction and refinements of the measurement of microwave resonances in a quasi-spherical copper resonator. The accuracy of measurements varies from 0.05 mK to 0.17 mK and is competitive with that of all previous ones in this temperature range using other techniques. The improvement stems partly from the new techniques used for the new definition of the kelvin as well as *ab initio* calculations of the thermophysical properties of gaseous ^{4}He. In addition to confirming the validity of SPRIGT as an accurate, easier-to-implement alternative to other low-temperature primary thermometry techniques (*e.g.* acoustic gas thermometry) yet with scope for improvement, the results should provide important input data for any future revision of ITS-90.