Contribution ID: **233** Type: **Poster Presentation**

Determination of thermodynamic temperature between 4.2K and 24.5 K by a new constant pressure refractive index gas thermometer

A new constant pressure refractive index gas thermometer (CPRIT) is proposed that measures the thermodynamic temperatures T from 4.2 K to 24.5 K with a quasi-spherical microwave resonator. The pressure fluctuation plays the essential entry for the measurement uncertainty by traditional refractive index gas thermometers operating above the triple point of water and constant volume gas thermometers running from 4.2K to 24.5K. We present a new method with the proposed CPRIT for stabilizing gas pressures in the fractional differences within one part of million in the temperature from 4.2 K to 24.5 K. The gas pressure stabilization promote the stability of measurement temperature so to decrease the measurement uncertainty. In addition, we propose a new procedure to minimize the deformation of the quasi-spherical cavity, and a new feature of gas fill ducts to decrease their disturbance for microwave resonances in the cavity. We report in this paper the theoretical model for the CPRIT and the analyses for all the imperfection disturbances for microwave resonant measurements. The theoretical analysis shows that the proposed CPRIT is anticipated to achieve a temperature measurement fluctuation bound with 25μK with helium as the working gas.

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Track Classification: CEC-11 - Safety, Reliability, and Standards