CCT member and observer Activity Report

Period: January to December 2021

Institute: Laboratoire commun de métrologie LNE-Cnam (Temperature and thermophysical quantities) and LNE-CETIAT (Humidity)

State economy: FRANCE

Number of persons involved in thermometry of the institute: 25 (thermometry),

Short summary of research and development:

Mise-en-pratique of the new definition of the kelvin:

We are improving and putting into application methods for thermodynamic temperature measurement and dissemination over a large temperature range, from the lowest temperatures with acoustic gas thermometry and single-pressure refractive index thermometry (SPRIGT, in collaboration with CAS-TIPC, China) to the highest temperatures using radiance-based thermodynamic temperature measurement technique and high-temperature fixed points up-to the WC-C point (3022 K).

Opto-mechanical temperature sensors:

In collaboration with two major French laboratories in this field: Laboratoire Kastler Brossel (LKB) and Centre de Nanosciences et Nanotechnologies (C2N), LNE-Cnam is developing and characterising quantum optomechanical temperature sensors for the low temperature range. Two Ph-D theses are devoted to this research subject and the first satisfactory results have been obtained in 2021.

Development of new temperature references for contact thermometry:

LNE-Cnam has a long experience in filling and producing fixed point cells for the calibration of SPRTs and radiation thermometers. We are currently studying new designs of open cells with improved characteristics for contact thermometry. The first cell design was completed in 2021 and should be tested at the zinc point and the aluminium point in 2022.

Improvement methods for high temperature calorimetric measurements:

Development of facility to measure enthalpy of fusion and specific heat of solid materials by drop calorimetry in the temperature range from 800 °C to 1500 °C. The uncertainty target is 0.5 % (k=2) and 1 % (k=2) for enthalpy and specific heat measurements, respectively.

Local probe thermal microscopy:

Improvement of the metrology associated with thermal conductivity measurement at nanoscale by local probe thermal microscopy. Development of protocols for thermal conductivity measurements at nanoscale and calibration of Scanning Thermal Microscopes (SThM).

Development in humidity and moisture measurement:

LNE-CETIAT follows up the JRP SIB64 METefnet by developing its capabilities in moisture measurement with reference methods [H1] and also, thanks to the support of the French Metrology, by developing moisture measurements based on dielectric permittivity [H2]. A PhD thesis related to this subject is in progress

Short summary of recent comparison activity:

- CCT-K10: Draft B of the comparison agreed. The results of LNE-Cnam are very satisfactory and show a noticeable improvement of the uncertainty level up to 2800 °C. New CMCs will be claimed following the publication of the results. A paper was published in Metrologia [RT 16] which fully analyses the uncertainty budget of the realisation of the scale by radiation thermometry above the silver point.

- CCT-K9 and Euramet-T-K9: LNE-Cnam has participated to the CCT-K9 comparison and is leading the work in Euramet-T-K9. Pending the final results of K9 publication, the Euramet comparison results have been analysed in 2021 and should be related to K9 and published in the nearest future.

- CCT-K7-2001: LNE-Cnam participates to this key comparison at the triple point of water. A TPW cell was compared to the TPW reference of LNE-Cnam and sent to NRC in 2021.

- Following the European project 14IND11 HIT, three European National Metrology Institutes (NMIs), VSL, LNE-CETIAT and INRiM, extended their relative humidity calibration capabilities to temperatures up to 170 °C, dew-point temperatures up to 150 °C and pressures up to 600 kPa . In order to test the equivalence of the respective calibration set-ups a comparison was performed between the three laboratories whose results can be consulted in [H3]

Short summary of other activities:

- JRP Project Real-K “Realising the new kelvin”: LNE-Cnam leads the work package on high temperatures in which a series of high-temperature fixed points will have a collective thermodynamic temperature assignment for future use as references for the mise en pratique of the kelvin. In this project, fast acoustic gas thermometry is trialled and new references to replace the Hg point are being studied in LNE-Cnam.

- JRP Projet PhotoQuanT “Photonic and Optomechanical Sensors for Nanoscaled and Quantum Thermometry” The objective of this European-funded joint research project coordinated by LNE-Cnam is to provide a quantum temperature standard for self-calibrated embedded optomechanical sensor applications, as well as optimised high-resolution and high-reliability photonic and optomechanical sensors to measure temperature at the nano and meso-scales.

- JRP Projet PrometH2O: LNE Cnam and LNE-CETIAT are involved in this project dedicated to trace water in ultra-pure process gases. Their involvement is mainly focused on provision of robust traceability to trace water measurements in real humid gas mixtures, and namely the measurement of the enhancement factor in selected humid gas mixtures by using quasi-spherical resonator. LNE CETIAT leads the work package impact of this project

- Key-Comparison of body temperature measurement: this comparison is lead by NIM and LNE-Cnam is one of the European NMIs involved. The capabilities of calibration of forehead thermometers and tympanic thermometers will be compared worldwide in the context of the Covid pandemic.

- JRP Emirim: LNE-Cnam coordination - This project addressed the needs of the standardisation group CEN/TC 89/WG 12 for improvement of the standard EN 16012. LNE-Cnam contributed to the improvement of the traceability chain of total hemispherical emissivity measurements to enable end-users to perform these measurements on low emissivity foils used in "reflective insulation" products with an uncertainty below 0.03.

- JRP MetroDecom II "In situ metrology for decommissioning nuclear facilities": LNE-Cnam has worked on the development of facilities and methods for the characterization of the metrological capabilities of Raman and Brillouin distributed temperature sensors.

- JRP Nanowires "High throughput metrology for nanowire energy harvesting devices": LNE-Cnam contributes to the improvement of method for traceable measurement of thermal properties of nanowires using scanning thermal microscopy.

- JRP Hi-TRACE "Industrial process optimisation through improved metrology of thermophysical properties": LNE-Cnam coordination – LNE-Cnam developed a laser flash apparatus for measuring the thermal diffusivity on solid materials from 23 °C to 3000 °C with an expanded uncertainty (k=2) lower than 5 %.

- JRP BiofMET: This project will research more accurate metrological methods and establish advanced traceable measurement standards for the determination of the calorific value, new methods for determining impurities and ash content, new moisture transfer standards and calibration facilities. LNE-CETIAT leads the work package related to the development of online traceability. More specifically LNE-CETIAT is currently developing a transfer standard based on RF/MW technique enabling on-site measurement.

Link to bibliography or list of bibliography (last 5 years):

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