EMPIR Call 2015 – Health, SI, Normative and Research Potential

Selected Research Topic number: **SRT- s14**
Version: 1.0

Title: Implementing the new kelvin 2

Abstract

The International Committee for Weights and Measures (CIPM) aims to redefine the kelvin in terms of the Boltzmann constant in 2018. Therefore, it is essential that the required primary thermometry methods and results are put in place to facilitate an effective redefinition. In addition, over the next decade, current temperature scales (ITS-90 and PLTS-2000) are likely to be replaced by a combination of a new temperature scale (ITS-xx) and practical primary thermometry. Consequently, the need exists to work on primary thermometry in the difficult scale areas, developing an understanding as to the cause of the discrepancies currently found and stimulating highly novel primary thermometry approaches.

Keywords

New SI, new kelvin, primary thermometry, *mise en pratique*, temperature scale, *MeP*-K, ITS-90, PLTS-2000, ITS-xx

Background to the Metrological Challenges

A redefinition of the kelvin in terms of the Boltzmann constant requires a soundly founded *mise en pratique* and reliable primary thermometry methods (i.e. those that are thermodynamically based). The *mise en pratique* for the definition of the kelvin (*MeP*-K) and the establishment of a new temperature scale require the robust determination of the differences between the thermodynamic temperature (T) and the defined scales currently in use, ITS-90 (T_{90}) and PLTS-2000 (T_{2000}), the understanding of method dependent systematic uncertainties and a lower overall uncertainty in the estimates of thermodynamic temperature.

Over the last years, significant improvements have been made in the assignment of definitive radiometric temperatures to some high temperature fixed points with robust uncertainties and significantly improved T-T_{90} values over some temperatures; particularly around the triple point of water (273 K down to ~150 K). However, much work has yet to be done to extend the temperature range and uncertainty capability, and overcome the technical challenges that remain in establishing a complete low uncertainty data set of T-T_{90} and T-T_{2000}. Improvements are required in particular in the ranges ~1 K to ~200 and ~ 500 K to ~ 1337 K.

Current state-of-the-art for T-T_{90} and T-T_{2000} shows that further work is required in specific ranges, such as in the lower part of PLTS-2000 (which is based on data discrepant by 6 %), where there is a paucity of new data for low temperatures (e.g. from ~1 K to ~100 K) and confirmatory data for high temperatures (above approximately 500 K).

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement of thermodynamic temperatures and on the support of emerging primary thermometry techniques, with optional emphasis on the high temperature range.

The specific objectives are

1. To determine T-T_{90} in the range from ~ 500 K to ~ 1337 K using a variety of techniques and with a standard uncertainty of 5 mK;

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2. To determine T-T_{90} in the range ~1 K to ~200 K using a variety of techniques and with a standard uncertainty of 0.5 mK;

3. To establish novel primary thermometry approaches to re-determine T and T-T_{90}, to identify and minimise systematic uncertainties;

4. To perform research in the ultralow temperature thermometry regime (0.9 mK to around 1 K) – so as to demonstrate primary thermometer dissemination of T and identify the cause of the PLTS-2000 background data discrepancy (6 % at lowest temperatures);

5. To facilitate the take up of the technology and measurement infrastructure developed by the project by the measurement supply chain (other NMIs, accredited laboratories, instrumentation manufacturers, etc.).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the iMERA-Plus joint research project for determinations of the Boltzmann constant and the EMRP SIB01 project (InK - Implementing the new kelvin) and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.8 M€, and has defined an upper limit of 2.1 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 21 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the instrumentation industry and the metrology, thermometry, radiometry, and low-temperature physics sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”.

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.