TC Thermometry
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Euramet GA, Bucharest
Wed 30 May 2018

Thermometry

Overview

- Introduction to TC-T
- Annual meeting + technical workshops
- Some EURAMET contributions to the kelvin redefinition
- Plans for 2018-2019
  - Tempmeko-Tempbeijing ’19
  - First EURAMET Summer School in Thermal Metrology

TC-T overview

- Main field – thermometry (NPL)
- Sub committee on humidity (INRIM)

- Working groups on
  - Cmc review (NPL)
  - Strategy (CEM)
  - Best practice and guides (SMD)
  - Thermophysical quantities (CNAM-LNE)

Annual meeting 24-27 April 2018

Hosted by RISE, Sweden – around 70 delegates

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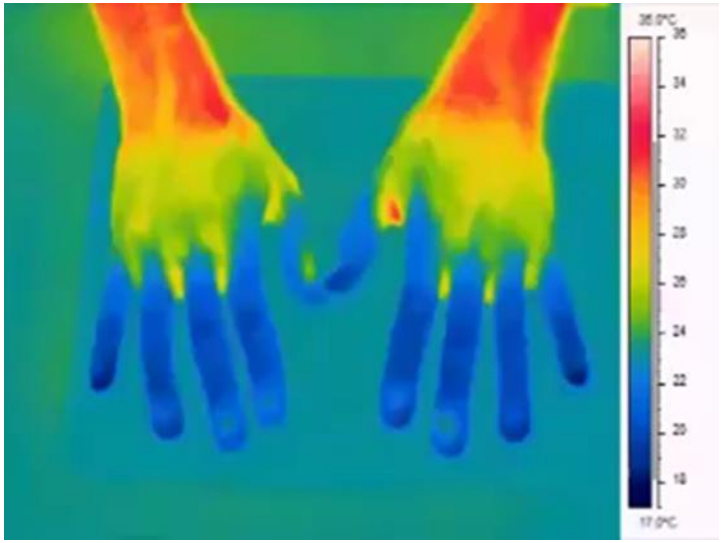
Including COOMET TCT chair – Anatolii Pokhodun

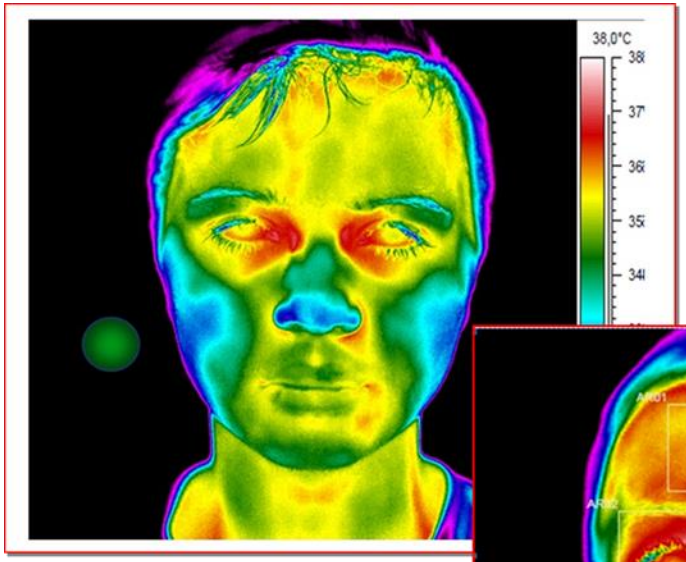
Technical workshop at TC-T plenary on thermal imaging

- Organised by Igor Pušnik (UL LMK), Rob Simpson (NPL)
- 7 presentations; NMIs, manufacturers, users

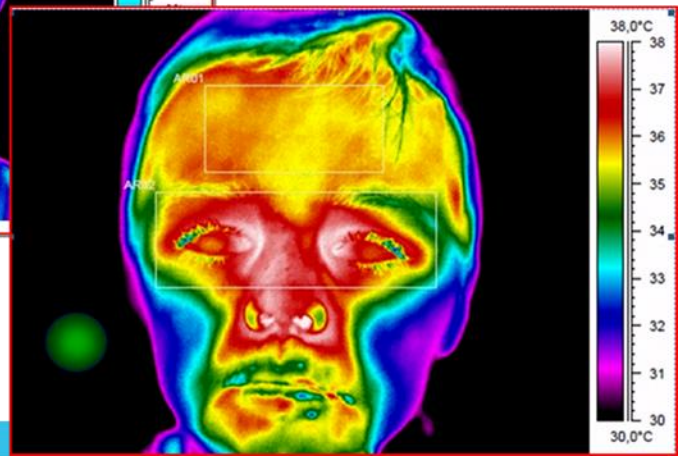
Cold challenge for identifying vasospastic conditions



Fever detection through inner canthus measurement



Study confirms **Inner canthi** temperatures closely correlate with **core temperature** & can be used for fever detection



Technical workshop at TC-T plenary on sea water metrology

- Organisers: Andrea Merlone (INRIM), Steffen Rudtsch (PTB)
- 7 presentations

- Marc Le Menn (SHOM):*State of the art and needs in ocean temperature measurements*
- Paola Fisicaro (LNE): *Chemical metrology for sea water*
- Fernando Sparasci (LNE-CNAM): *Progress on salinity measurements by refractive index.*
- Steffen Rudtsch (PTB):*High-precision speed of sound measurements in pure and ocean water as a function of temperature and pressure.*
- Nair, Rajesh (OGC): *Towards a "user-centered" marine metrology paradigm: JPI Oceans & The European Marine Sensors Calibration Network*
- Andrea Peruzzi (VSL): *Pressure effect on sea water thermometers.*
- Carmen Garcia Izquierdo (CEM): *Fiber optics characterization for underwater temperature measurements*

TC-T – plenary meeting+

- Sub committee on humidity & all four working groups met
- Leadership changes
  - Dolores del Campo (CEM) chair of TCT from May 2018
  - Steffen Rudtsch (PTB) new chair of Strategy Group

  (succeeds DdC)
  - DdC (CEM) new chair of CMC review Group

  (succeeds Helen McEvoy [NPL])
- Next meeting hosted by INRIM, Torino, 9-12 April 2019

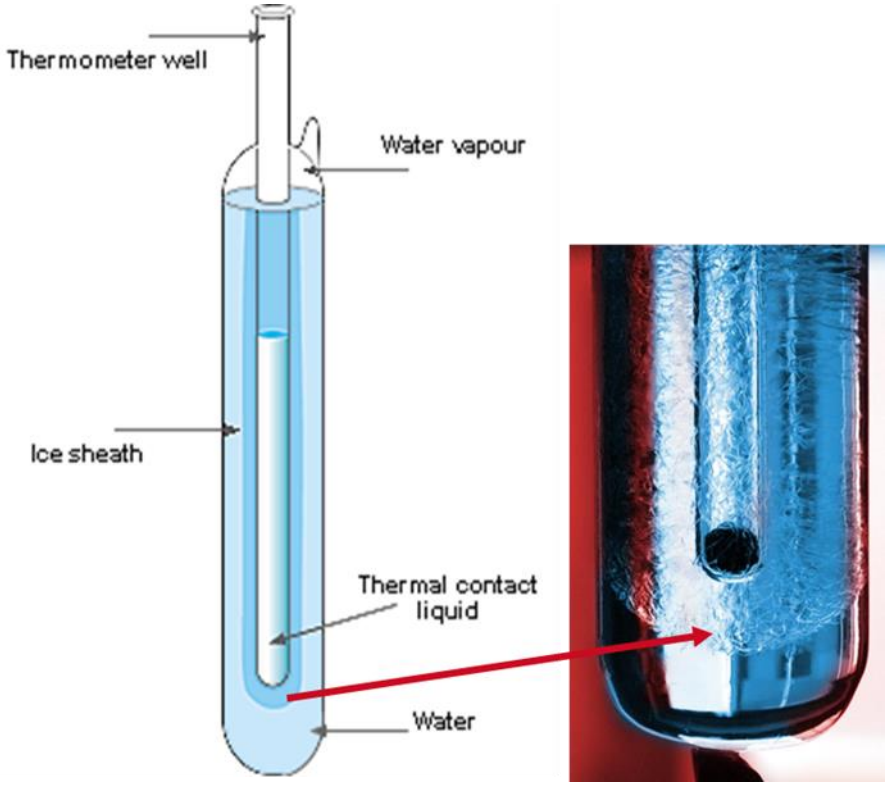
  Workshop on challenges and opportunities arising from *MeP*-K-19 (GM, NPL)

  Workshop on contemporary humidity and moisture measurement challenges (Stephanie Bell, NPL and Vito Fernicola, INRIM)

EURAMET CONTRIBUTIONS TO THE KELVIN REDEFINTION

Thermometry

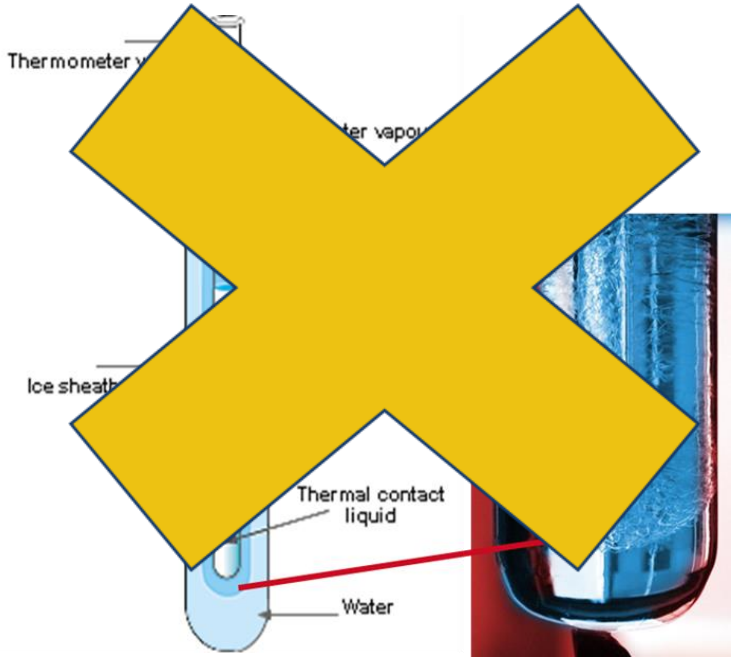
The current kelvin: “The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water”



Lord Kelvin
Belfast Botanical Gardens

Thermometry

The redefined kelvin: “The kelvin, symbol K, is the SI unit of thermodynamic temperature; its magnitude is set by fixing the numerical value of the Boltzmann constant to be equal to exactly $1.380\,649 \times 10^{-23}$ when it is expressed in the unit $s^{-2} \cdot m^2 \cdot kg\ K^{-1}$, which is equal to $J \cdot K^{-1}$”



→ k

A coordinated approach to redetermining the Boltzmann constant – started 2007

- Euramet 885 and then EMRP Joint Research Project "New Determinations of the Boltzmann constant"

- Partners: PTB (Coordinator), NPL, LNE-INM/Cnam, INRIM, University of Paris North, Second University of Naples, Polytechnic of Milan, CEM (UVa)

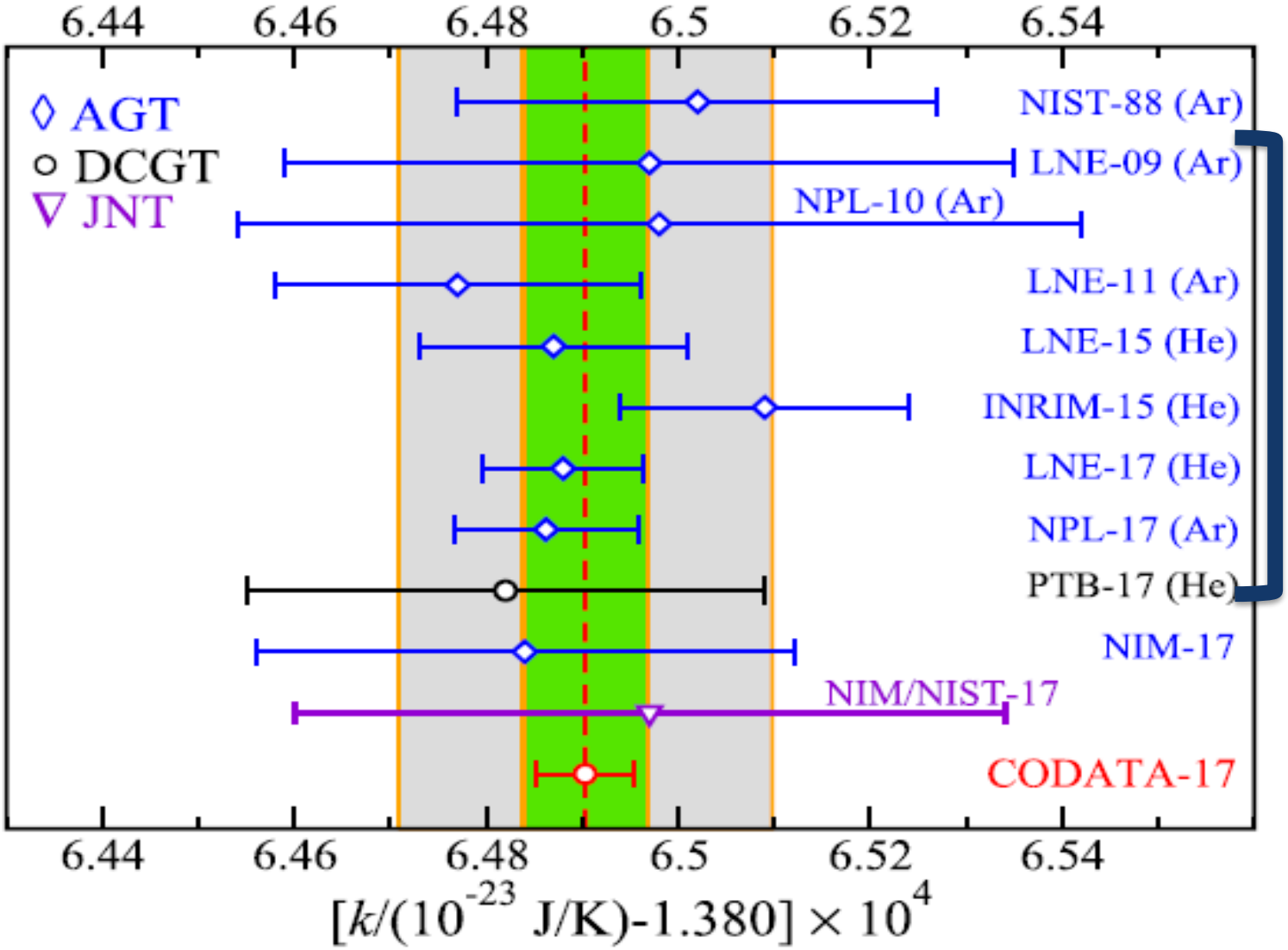
- **Goal was to achieve *k*~1ppm by at least two different approaches by <u>end 2010</u>**

A coordinated approach to re-determining the Boltzmann constant – started 2007

- Goal was to achieve k ~1 ppm by at least two different approaches by end 2010

HOPELESSLY AMBITIOUS – NO ONE ENVISAGED THE TECHNICAL CHALLENGES TO BE SO SIGNIFICANT

Boltzmann constant values included in the CODATA evaluation for the unit redefinition



EURAMET contribution to *k*

- Work inspired by Moldover's great paper
- J. Res. NBS, **93**, No 2 Mar-Apr 1988

- "… if by any chance our value is shown to be in error by more than 10 parts in 10^6, we are prepared to eat the apparatus, drink the mercury and breathe the argon"

- Mike is safe….!

Thermometry

PREPARING FOR THE KELVIN REDEFINITION - THROUGH THE EMRP/EMPIR InK PROJECTS

Thermometry

The main aims of the InK projects

- Two sequential projects InK1&2: 2012-2019
- To prepare the international thermometry community for the kelvin redefinition and ensure a smooth transition to the new arrangements through the *MeP*-K-19

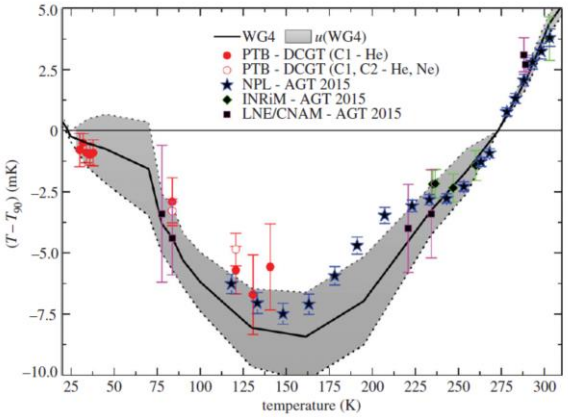
- Achieved through:
- Develop primary thermometry methods some of which could *supplant* the defined scales *(i.e.* ITS-90 *and* PLTS-2000*)* at high (>1300 K) and low (<20 K) temperatures
- Determine new values of $T - T_{90}$ with the world's lowest uncertainties (≤ 1mK) between approximately 1K to 1000 K
- Determine new values for $T - T_{2000}$ over whole range to address the discrepancy in the background data of the PLTS-2000

…bringing together most major primary thermometry institutes in the world

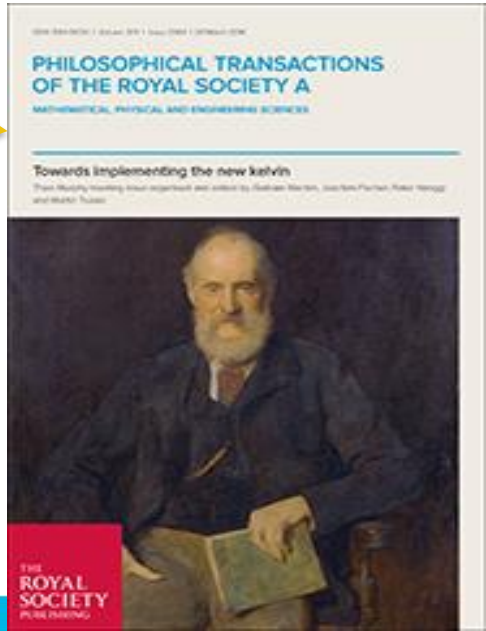
InK1 Summary of contribution to world thermometry

- Significant contributions to world thermometry
  - First *reliable T* values for high temperature fixed points (to ~2800 K)
  - Definitive recommendations to CCT about possible dissemination mechanisms for high temperatures (>1300 K)
  - Lowest uncertainty values for $T - T_{90}$ ever determined (<303 K)
  - Practical sensors for ULT dissemination and new values for $T - T_{2000}$ from 0.02 K to 1 K
  - Outcomes of InK-1 project published in:

Phil. Trans R. Soc. A. **374:** 20150048 (2016)



Ultra low uncertainty $T - T_{90}$ values measured in InK-1



Beyond the redefinition of the kelvin….

- InK2 and Implementation phase of redefined SI complete – May ’19
- Next larger phase begins – realisation and dissemination of redefined kelvin
- Promotion of primary thermometry detailed in *MeP*-K-19
- In the longer term could lead to:
  - Defined scales superseded by primary thermometry (especially at extremes of temperature <20 K and >1300 K)
  - The rise of practical *in-situ* primary thermometry not requiring calibration – facilitation of autonomous production future factories
- EURAMET plans to make major contribution to this next phase beginning with EMPIR project Realising the redefined kelvin (Real-K) [proposed – 2019-2022]

Plans for 2018 - 2019

- Transition to new chair of TCT – today!
- Preparation of new JRPs; e.g. Realising the redefined kelvin (Real-K)
- Begin planning for EMPIR 2019 e.g. Energy and Environment
- Major EURAMET involvement in Tempmeko/TempBeijing 2019
- Hold Inaugural Summer School for next generation of thermal metrologists

- International Symposium on Temperature and Thermal Measurements in Industry and Science
- Metrology for Meteorology and Climate

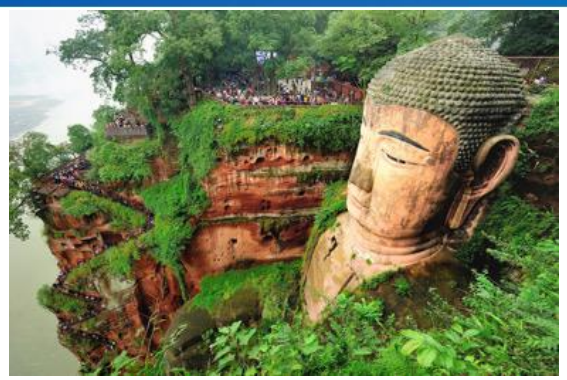
TEMPMEKO & TEMPBEIJING 2019

Chengdu, China

June 10-14, 2019

Organized by:

- National Institute of Metrology, China
- Chinese Society for Measurements


EURAMET Summer School in Thermal Metrology

- First Euramet Summer School
- Venue and host EIM, Greece, Thessaloniki
- Dates: 17 -21 September 2018
- Leading EURAMET experts in temperature, humidity and thermophysical quantities
- Lectures and hands on laboratory demonstrations
- >40 students
- Unique peer-to-peer networking opportunity for all those new to the field of thermal metrology
- We will work the students very hard….

Thermometry


Mythos
Mythos
Mythos
Mythos
Ψητοπωλείο

Welcome to EIM, Thessaloniki

au revoir from TC-T