European Metrology Research Programme

SI Broader Scope

An overview of the funded projects from the Targeted Programme SI Broader Scope

The SI system is not static but evolves to match the world's increasingly demanding requirements for measurement.

Measurements are made constantly in industry, healthcare, environmental monitoring and everyday life. The SI system of internationally agreed units underpins these measurements, giving us traceability and associated confidence in measurement consistency across the world. Since the units were first introduced, advances in science and technology have led to revisions to their definitions. Currently all of the units but one, the kilogram, are defined with respect to fundamental constants of nature, meaning that these units can be realised anywhere in the world and are not tied to any one artefact.

Now it is also time to redefine the kilogram in terms of fundamental constants, and to update the definitions of the other units so that they are the most accurate that modern science allows.

The seven SI units are:

second | metre | kilogram | ampere | mole | candela | kelvin

Direct measurements of extreme temperatures

Implementing the new kelvin (SIB01)

A new way to measure temperature

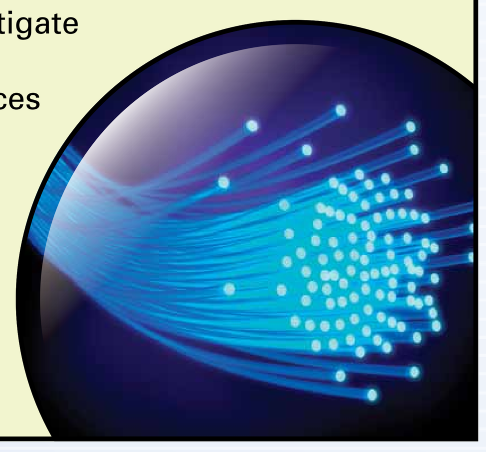
The upcoming redefinition of the kelvin will enable a fundamental change in the way we measure temperature. This project will improve primary thermometry and assign definitive thermodynamic temperatures to a set of high temperature fixed points, allowing extreme temperature measurements to be linked to a direct realisation of the kelvin.

Optical clocks across Europe

Accurate time/frequency comparison and dissemination through optical telecommunication networks (SIB02)

Using fibre rather than satellites

Optical atomic clocks could be used to redefine the second as they are more accurate than the microwave atomic clocks used today. This project will investigate techniques for comparing remote optical clocks separated by distances of up to 1500 km through optical fibre links in order to check their performance.

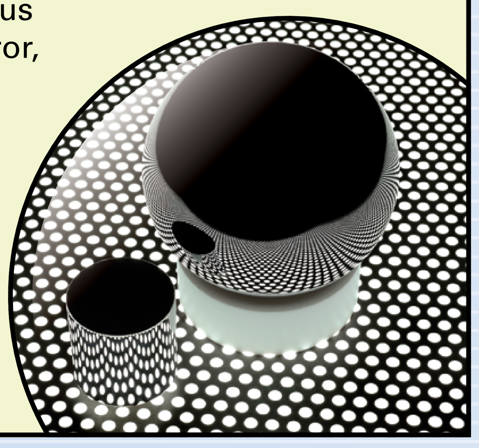


Fixing the kilogram

Realisation of the awaited definition of the kilogram – resolving the discrepancies (SIB03)

Fixing the Planck and Avogadro constants

There needs to be international agreement on the Planck and Avogadro constants in order to redefine the kilogram. This project aims to understand why there is a discrepancy between the values measured in two previous experiments and to remedy the error, leading to lower uncertainties and taking a step towards redefinition.

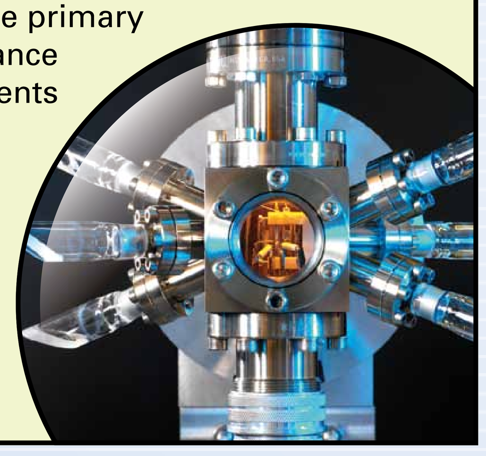


Trapped ion optical clocks

High-accuracy optical clocks with trapped ions (SIB04)

Improving the precision of optical clocks

The most advanced optical clocks now exceed the best clocks based on the current definition of the second in terms of reproducibility. This project will prepare a selection of optical clocks with the potential to become primary standards, evaluate their performance and provide frequency measurements for input to a redefinition of the second.



Next generation of mass standards

Developing a practical means of disseminating the redefined kilogram (SIB05)

Disseminating the new kilogram

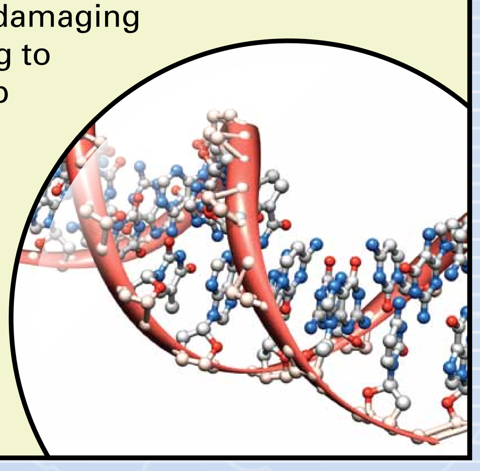
The current definition of the kilogram is realised in air, but the new definition will be under vacuum conditions. This project will produce new mass standards to enable traceability between the existing mass scale and the new experiments, linking the mass of the kilogram in air and in vacuum to enable the redefinition.

Better measurements for modern radiotherapy

Biologically weighted quantities in radiotherapy (SIB06)

Linking the physical properties of radiation with biological impact

Radiotherapy treatments work by damaging the DNA of cancerous cells, leading to cell death. This project will develop measurements to determine how the charged particles from radiotherapy interact as they pass through human tissue and compare the physical properties of the radiation with its impact on cancer cells to help improve cancer treatments.

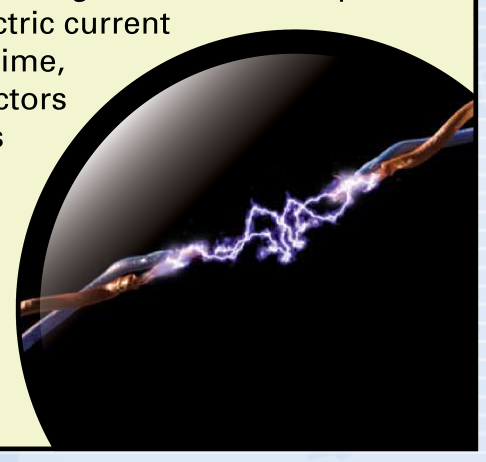


The new amp

Quantum ampere: Realisation of the new SI ampere (SIB07)

Technologies for a new definition of the ampere

It is necessary to control the number of electrons that flow over time in order to realise a new definition of the ampere. This project will develop state-of-the-art Single Electron Transport (SET) devices, which generate electric current by moving only one electron at a time, and by combining them with detectors to create quantum current sources for use as standards.

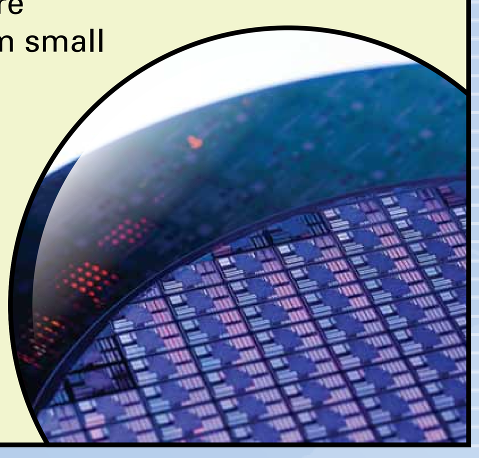


Traceable measurements under one nanometre

Traceability of sub-nm length measurements (SIB08)

Improving length and displacement measurements at the nanoscale

An error of less than one nanometre (one billionth of a metre) may seem small enough to be inconsequential, but some applications in metrology and industry require uncertainties to this level. This project will improve the traceability of high accuracy devices such as optical interferometers and capacitive sensors, which are used to make these measurements.



Improving chemical analysis

Primary standards for challenging elements (SIB09)

Pure chemical standards for measurements

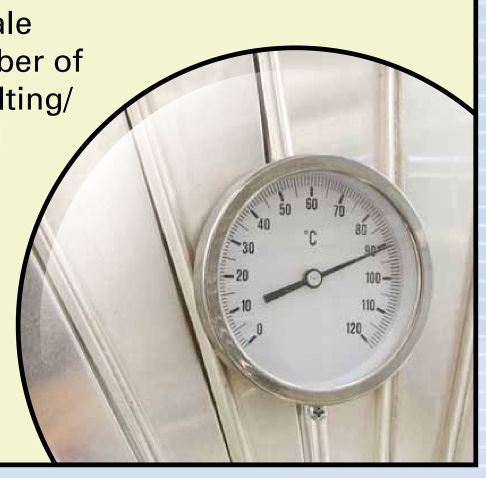
There is currently a lack of primary standards for some chemical analyses, which are important for comparing chemical measurement results and implementing EU directives. This project will develop methods to realise standards for challenging elements frequently used in chemical analysis, e.g. magnesium, zinc and molybdenum, and it will produce standards for these in the process.

Fixing discrepancies in the temperature scale

Novel techniques for traceable temperature dissemination (SIB10)

Reducing uncertainties in temperature measurements

The International Temperature Scale of 1990 (ITS-90) consists of a number of fixed points defined by known melting/freezing points of certain chemical elements (and water), and is used to calibrate temperature measurement equipment. This project will resolve discrepancies in the realisation of the fixed points, leading to a reduction in uncertainty.



Europe's National Measurement Institutes working together

The European Association of National Metrology Institutes (EURAMET) has implemented the European Metrology Research Programme (EMRP), a programme with a value of over 400 M€, organised by 22 NMIs and supported by the European Union.

Full details can be found at: **www.euramet.org**

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