The watt balance route towards a new definition of the kilogram

EURAMET
European Association of National Metrology Institutes

The need for the project

The kilogram is the last SI unit based on a material artefact, a Platinum-Iridium cylinder, kept at the Bureau International des Poids et Mesures (BIPM). However, the cylinder's mass is changing over time.

A promising way of supporting the redefinition of the kilogram is through the watt balance experiment, which links the kilogram to the Planck constant. Two European watt balance experiments are currently ongoing at the National Metrology Institutes in France and Switzerland (since 2002 and 1997 respectively).

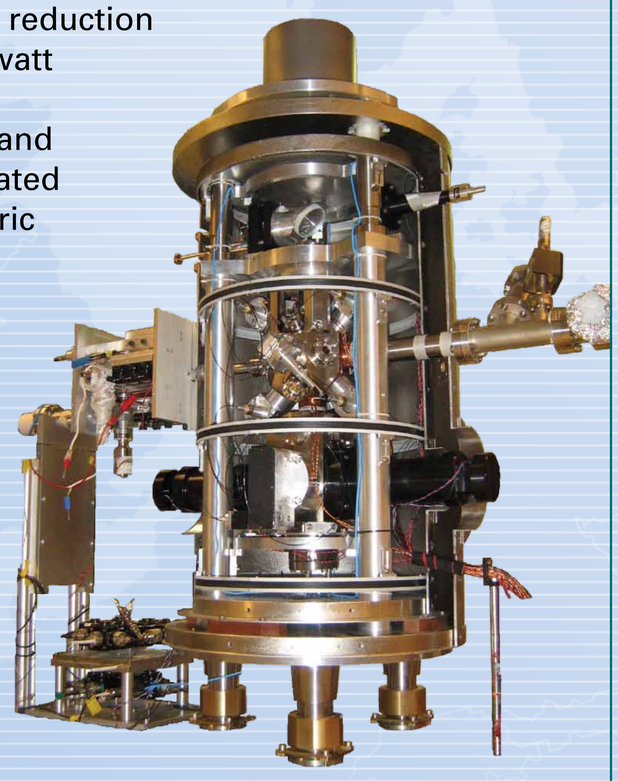
This project will produce methods and devices to improve these watt balance experiments and support the development of future experiments.

Technical achievements

To reduce alignment uncertainty, the project developed mechanical tools to adjust the magnetic circuit induction field horizontality and the watt balance's coil displacement verticality. Improved position detectors based on propagation properties of laser beams and heterodyne interferometers together with specific collimation methods were also studied to characterise the watt balance's coil movements. The resulting misalignment uncertainty, modelled for the French watt balance damped suspension was less than 1×10^{-8}.

The project developed noise reduction based on the control of the watt balance's coil velocity; three heterodyne interferometers and sources intended to be operated in close loop with piezoelectric actuators were produced.

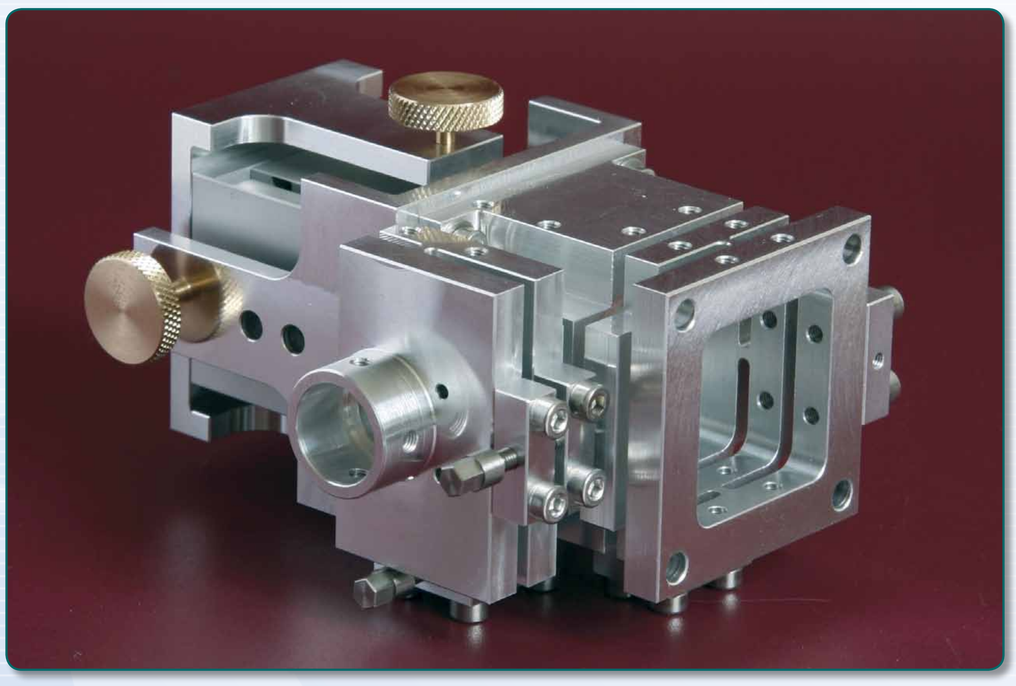
With the aim of improving the scattering of future values of the Planck constant, an *in situ* active compensation device was developed to reduce the disruptive external magnetic field effect on the effective watt balance magnetic field.



Absolute cold atomic gravimeter with the magnetic shields partially removed.

The acceleration of gravity can be measured with gravimeters based on different principles, such as atomic interferometer or falling corner-cube gravimeters. Three different gravimeters have been improved by the project and their uncertainty budget refined. To transfer the gravity acceleration value from the gravimeter to the standard mass of the watt balance, spatial variations were measured and modelled.

The watt balance in Switzerland determined a value of the Planck constant with a relative uncertainty of 2.9×10^{-7}.



Mechanical support of a position detector.

Improving watt balance experiments

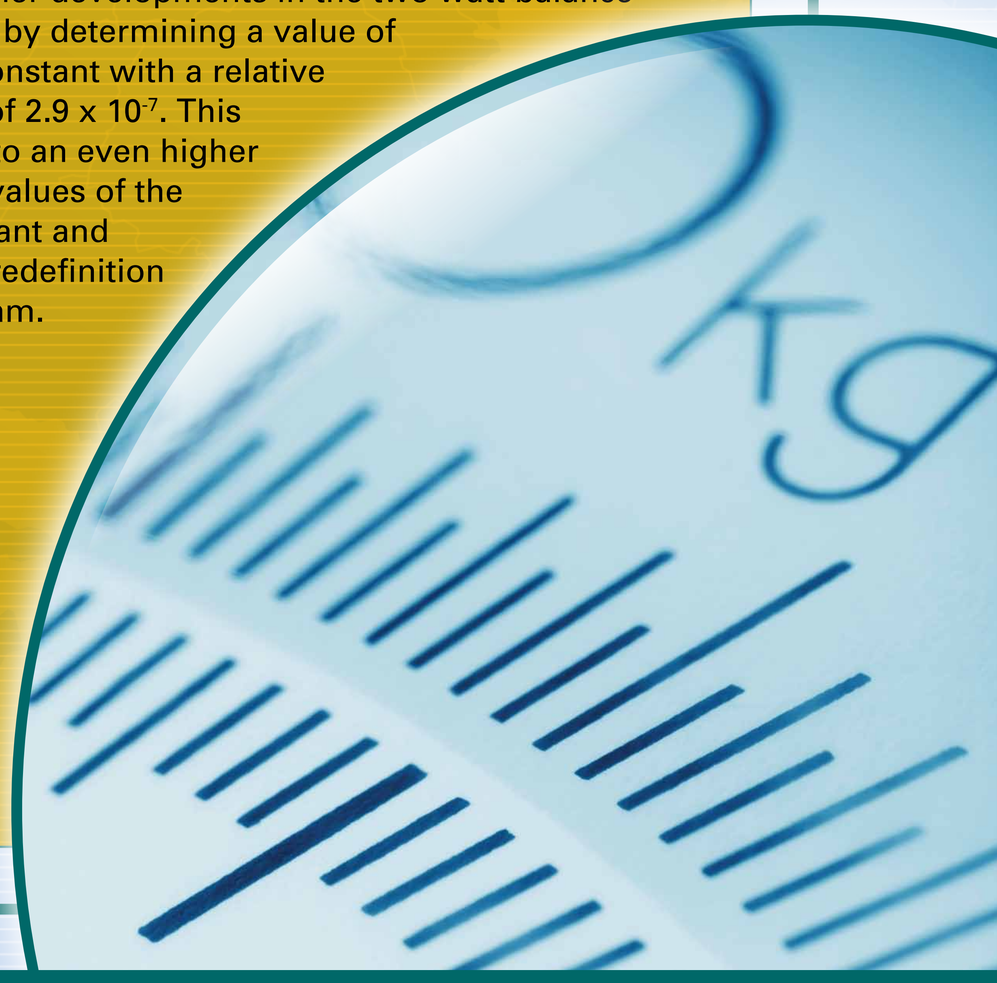
Supported the two current watt balance experiments through enhanced synergy and the development and sharing of new tools, techniques and methods. The project will also support future watt balance experiments through its improvements in:

- the alignment of the watt balance
- the magnetic field behaviour of the magnet
- the noise level in the electric measurements
- the measurement of the gravimetric field

Some of the devices developed during the project can also be used by other scientific and industrial sectors, such as geophysics, inclinometry and position monitoring.

Supporting a redefinition of the kilogram

Enabled further developments in the two watt balance experiments by determining a value of the Planck constant with a relative uncertainty of 2.9×10^{-7}. This should lead to an even higher accuracy of values of the Planck constant and support the redefinition of the kilogram.



Joint Research Project (JRP) Short Name: e-Mass • JRP-Coordinator: Gérard Genevès (LNE) • JRP-Partners: CNAM (France), CNRS (France), EJPD (Switzerland), INRIM (Italy), LNE (France)

The research within this EURAMET joint research project received funding from the European Community's Seventh Framework Programme, ERA-NET Plus, under the iMERA-Plus Project - Grant Agreement No. 217257

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union