日独交流150周年 Jahre Freundschaft Deutschland – Japan

DFG

16th Japanese-German Symposium

Japan-German Science Cooperation: Past-Present-Future

jointly organized by

Japan Society for the Promotion of Science
Deutsche Gesellschaft der JSPS-Stipendiaten e.V.
Deutsche Forschungsgemeinschaft

May 20 and 21, 2011 in Berlin

Leibniz-Saal, Berlin-Brandenburgische Akademie der Wissenschaften

日独交流150周年

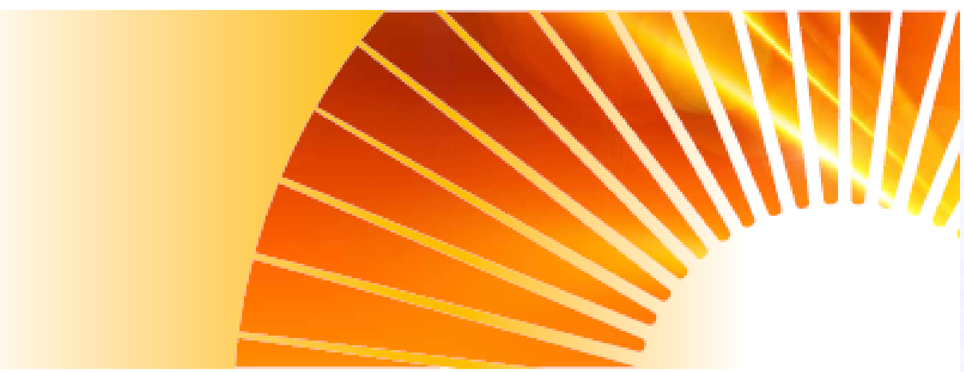
Jahre Freundschaft

Deutschland – Japan

SOLAR ENERGY FOR SCIENCE

An initiative by DESY

BUILDING BRIDGES



SOLAR ENERGY FOR SCIENCE

A joint energy/science partnership between Europe and MENA to promote sustainable development in view of global challenges.

International Advisory Board
Chair: Prof. Dr. Dr. h.c. mult. Klaus Töpfer, Executive Director of the Institute for Advanced Sustainability Studies, former Director UNEP

SYMPOSIUM
19/20 MAY 2011
DESY HAMBURG

DFG

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE · FOUNDED 1932 ·

Alumni Association JSPS Club

16th Japanese-German Symposium

Japan-German Science Cooperation: Past-Present-Future

jointly organized by

Japan Society for the Promotion of Science
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Deutsche Forschungsgemeinschaft

May 20 and 21, 2011 in Berlin

Leibniz-Saal, Berlin-Brandenburgische Akademie der Wissenschaften

Friday, May 20, 2011

10:30-	Eugen und Ilse Seibold Prize award ceremony
12:30	

13:30	W… …pan …chung… …y for the … …ience • … Gesellschaft d… …tipendiaten e.V.

Ceremonial Session

14:00	*Collaboration in High Energy Physics* **Prof. Dr. Makoto Kobayashi** (KEK, Executive Director, JSPS)
14:30	*Nobel Prizes, Fundamental Constants and Metrology* **Prof. Dr. Klaus von Klitzing** (Max Planck Institute for Solid State Research, Stuttgart)

METROLOGY
The science of measurements

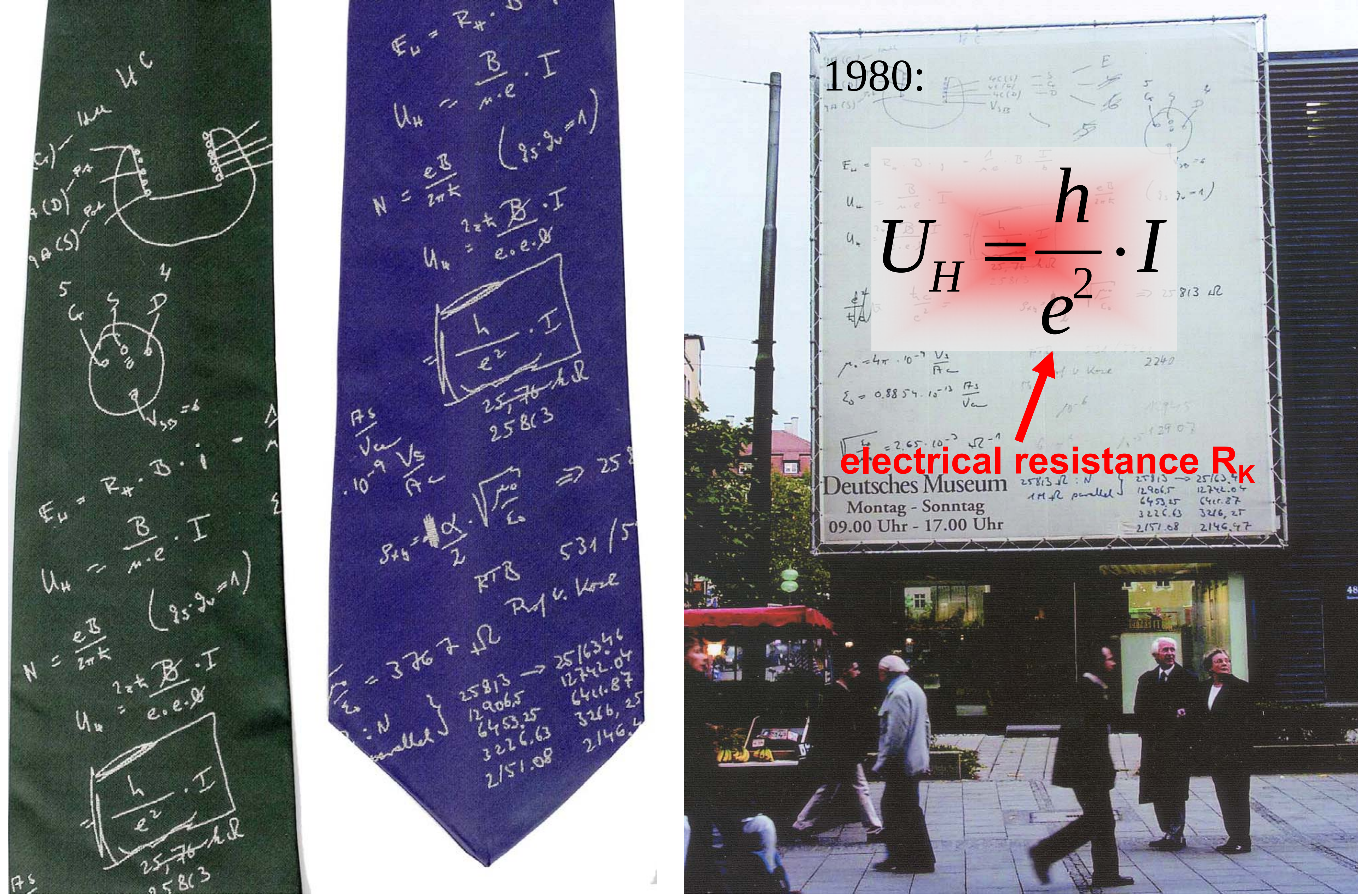
125 years ago:

Lord Kelvin (William Thomson) 6.May 1886

..I often said that when you can measure what you are speaking about, and can express it in numbers, you know something about it.

…So therefore, if science is measurement, then without metrology there can be no science

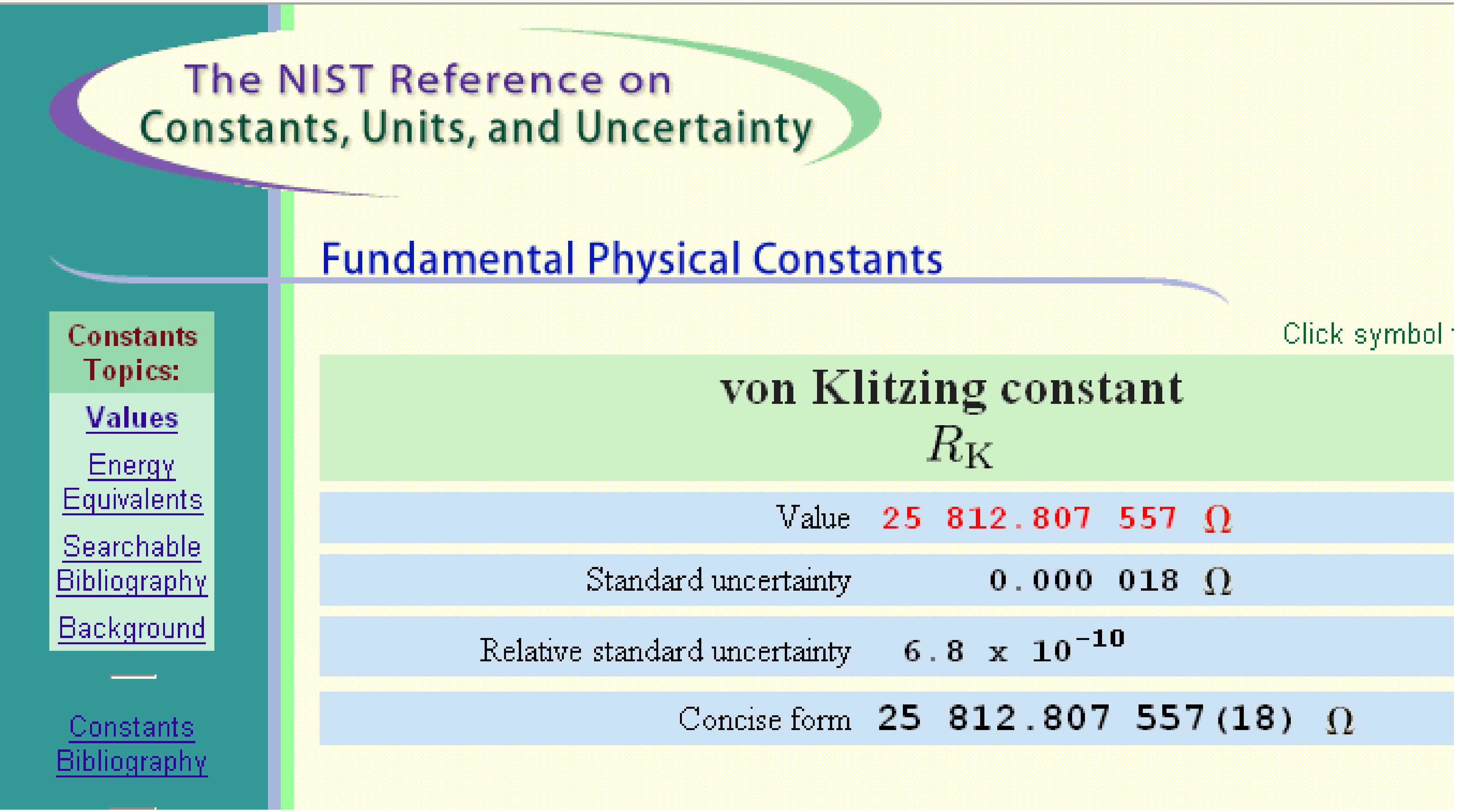
Integer Quantum Hall Effect (Nobel Prize in Physics **1985**)



DEUTSCHES MUSEUM BONN

(Science museum in Germany)

http://physics.nist.gov/cuu/Constants/index.html



The NIST Reference on Constants, Units, and Uncertainty

Constants Topics:

Values

Energy Equivalents

Searchable Bibliography

Background

Constants Bibliography

Fundamental Physical Constants

Click symbol

von Klitzing constant
R_K

Value	25 812.807 557 Ω
Standard uncertainty	0.000 018 Ω
Relative standard uncertainty	6.8×10^{-10}
Concise form	25 812.807 557(18) Ω

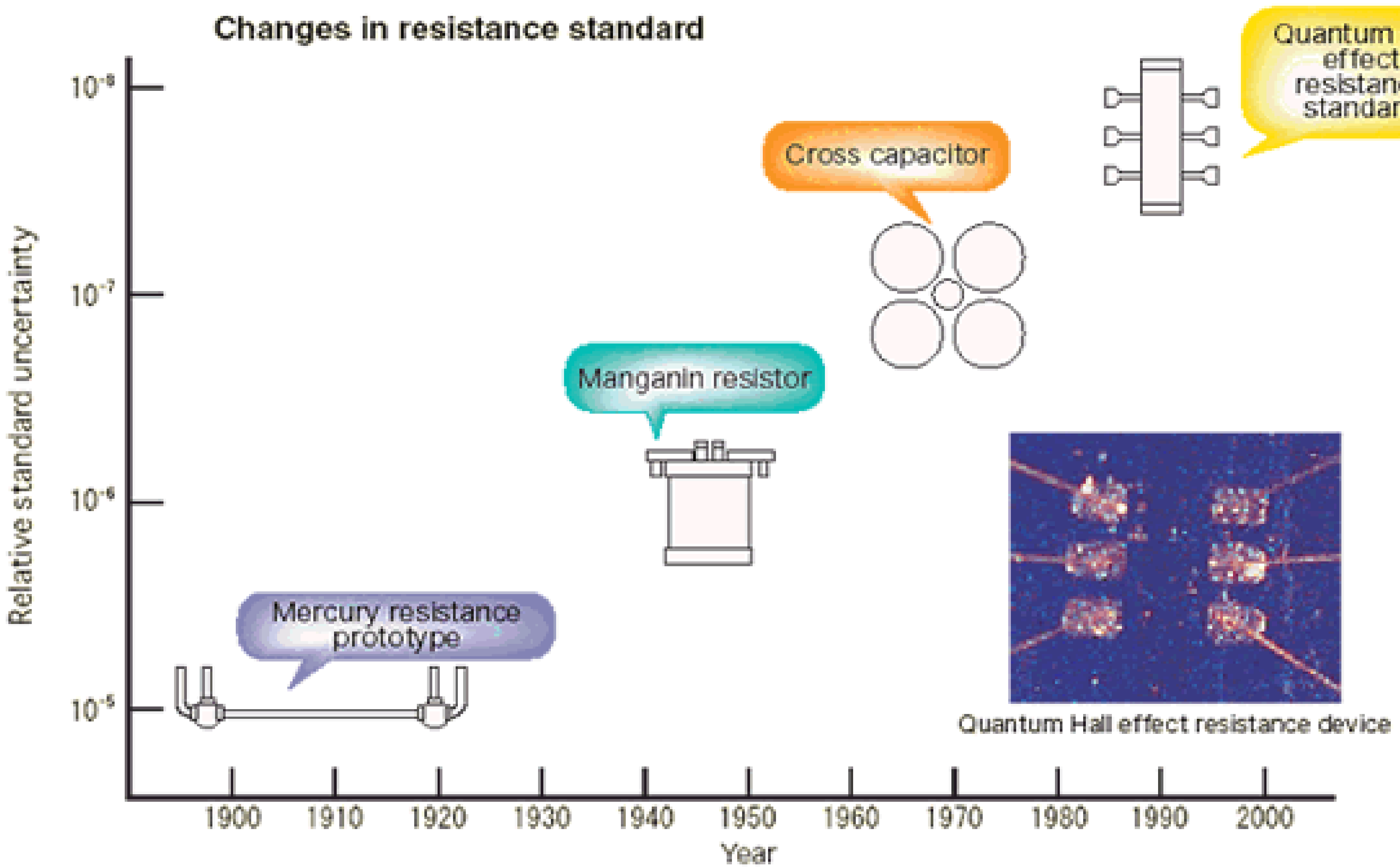
QUANTIZED HALL RESISTANCE IN SI OHM

(data collected until 1988)

CSIRO, Australia	25 812.809 (2) Ω
NPL, UK	25 812.809 (1) Ω
BNM-LCIE, France	25 812.802 (6) Ω
ETL, Japan	25 812.806 (6) Ω
NIST, USA	25 812.807 (1) Ω
VNIIM, Russia	25 812.806 (8) Ω
VSL, Netherland	25 812.802 (5) Ω
NRC, Canada	25 812.814 (6) Ω
EAM, Switzerland	25 812.809 (4) Ω
PTB, Germany	25 812.802 (3) Ω
NIM, China	25 812.805 (16) Ω
CSIRO/BIPM	25 812.809 (2) Ω
CSIRO/Japan	25 812.813 (2) Ω

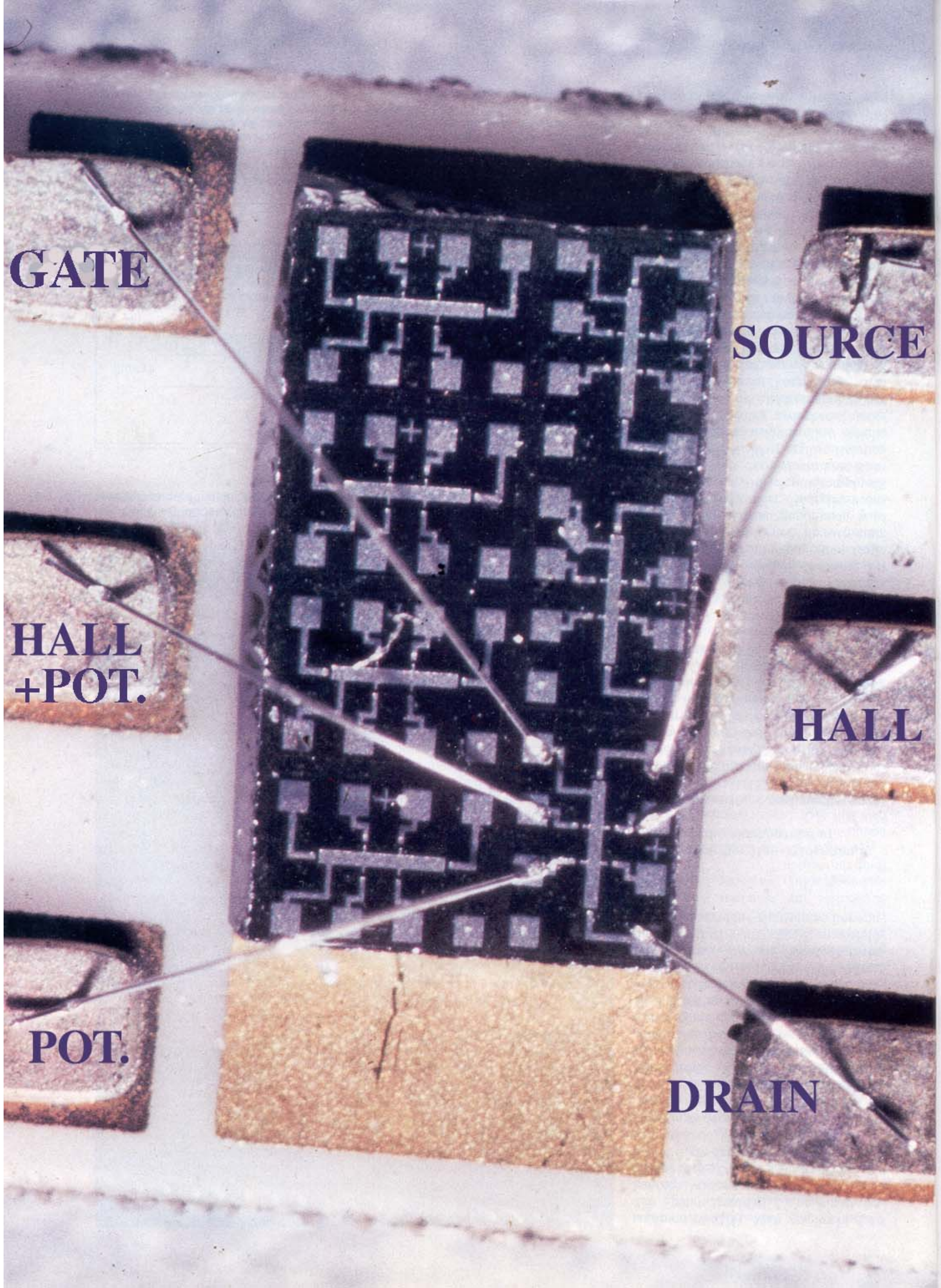
BEST VALUE (1990): R_K=25 812.807 (5) Ω

limitations due to calibration of reference resistor


Changes in resistance standard
Relative standard uncertainty
10^{-8}
10^{-7}
10^{-6}
10^{-5}
Quantum Hall effect resistance standard
Cross capacitor
Manganin resistor
Mercury resistance prototype
Quantum Hall effect resistance device
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

Si MOSFET

basic research on such a device led to the discovery of the quantum Hall effect



http://physics.nist.gov/cuu/Constants/index.html

The NIST Reference on Constants, Units, and Uncertainty

For applications in metrology

Fundamental Physical Constants

Constants Topics:
- **Values**
- Energy Equivalents
- Searchable Bibliography
- Background

Constants Bibliography

Constants, Units & Uncertainty home page

conventional value of von Klitzing constant

$R_{\mathrm{K}-90}$

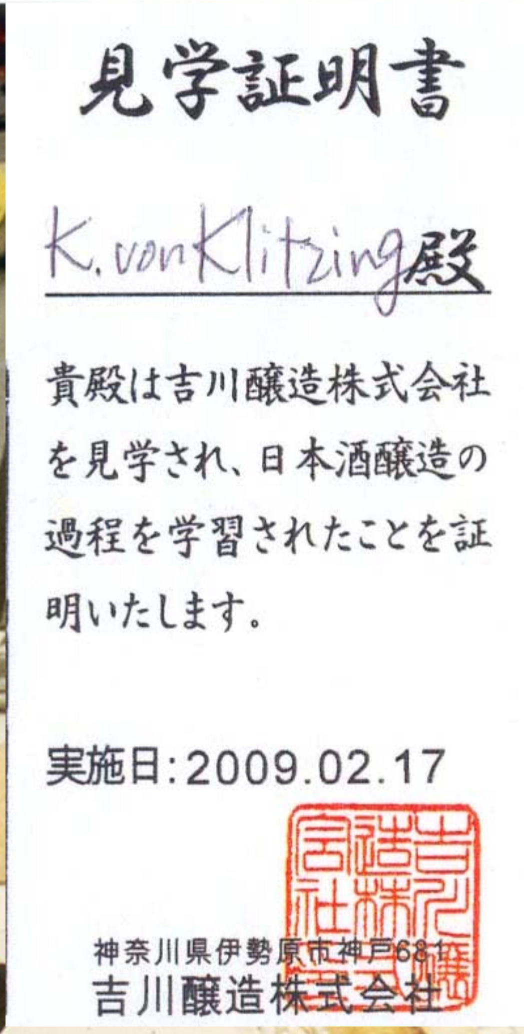
Value	25 812.807 Ω
Standard uncertainty	(exact)
Relative standard uncertainty	(exact)
Concise form	25 812.807 Ω

Click here for **correlation coefficient** of this constant with other constants

Source: 2006 CODATA recommended values

Definition of uncertainty

Correlation coefficient with any other constant



見学証明書

K. von Klitzing殿

貴殿は吉川醸造株式会社を見学され、日本酒醸造の過程を学習されたことを証明いたします。

実施日：2009.02.17

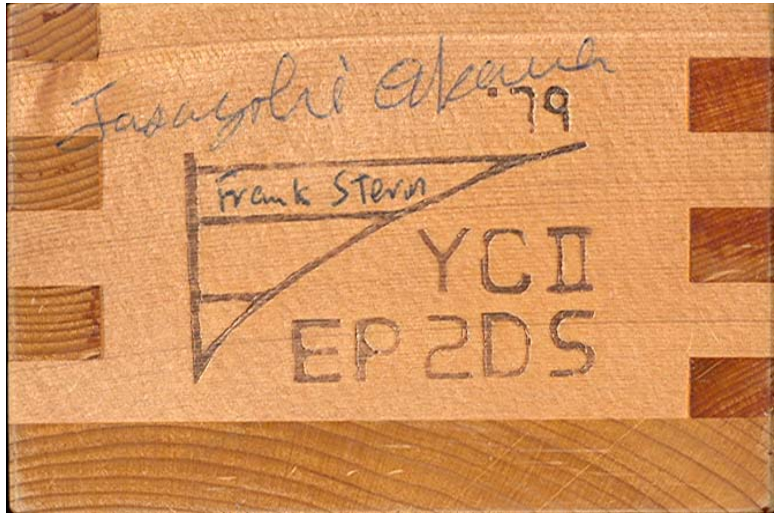
神奈川県伊勢原市神戸681
吉川醸造株式会社

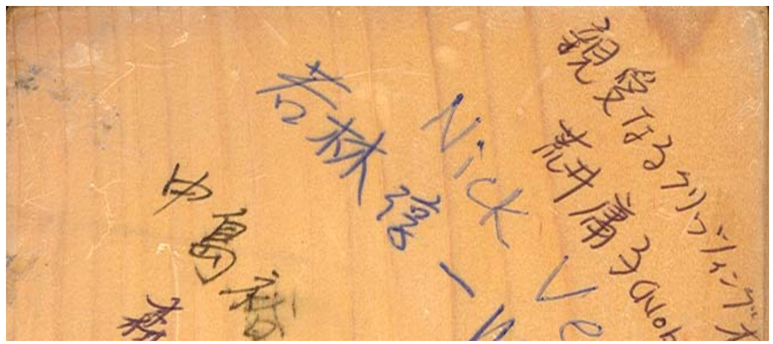
it may work also with sake

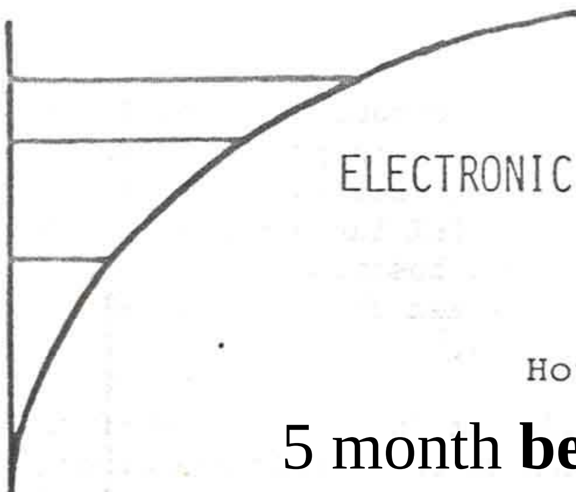
5.2.1980 at 2:05 a.m. in Grenoble: The birth of the QHE

Typical Exercise in Japan

Yamada Conference
1979







YAMADA CONFERENCE
ON
ELECTRONIC PROPERTIES OF TWO-DIMENSIONAL SYSTEMS
(THIRD INTERNATIONAL CONFERENCE)

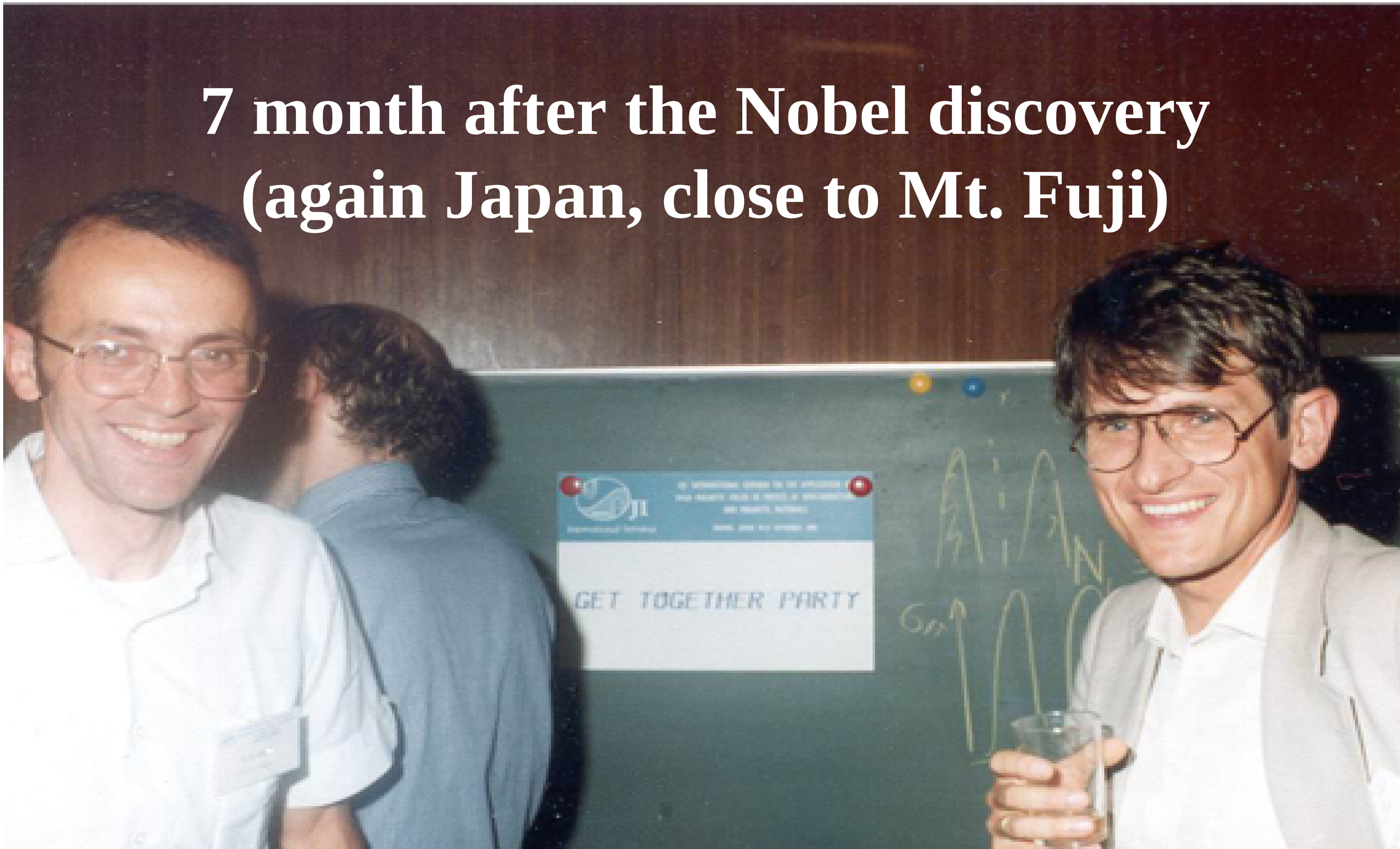
September 3 - 6, 1979

Hotel Mt. Fuji, Lake Yamanaka, Japan

5 month **before** the Nobel Prize discovery

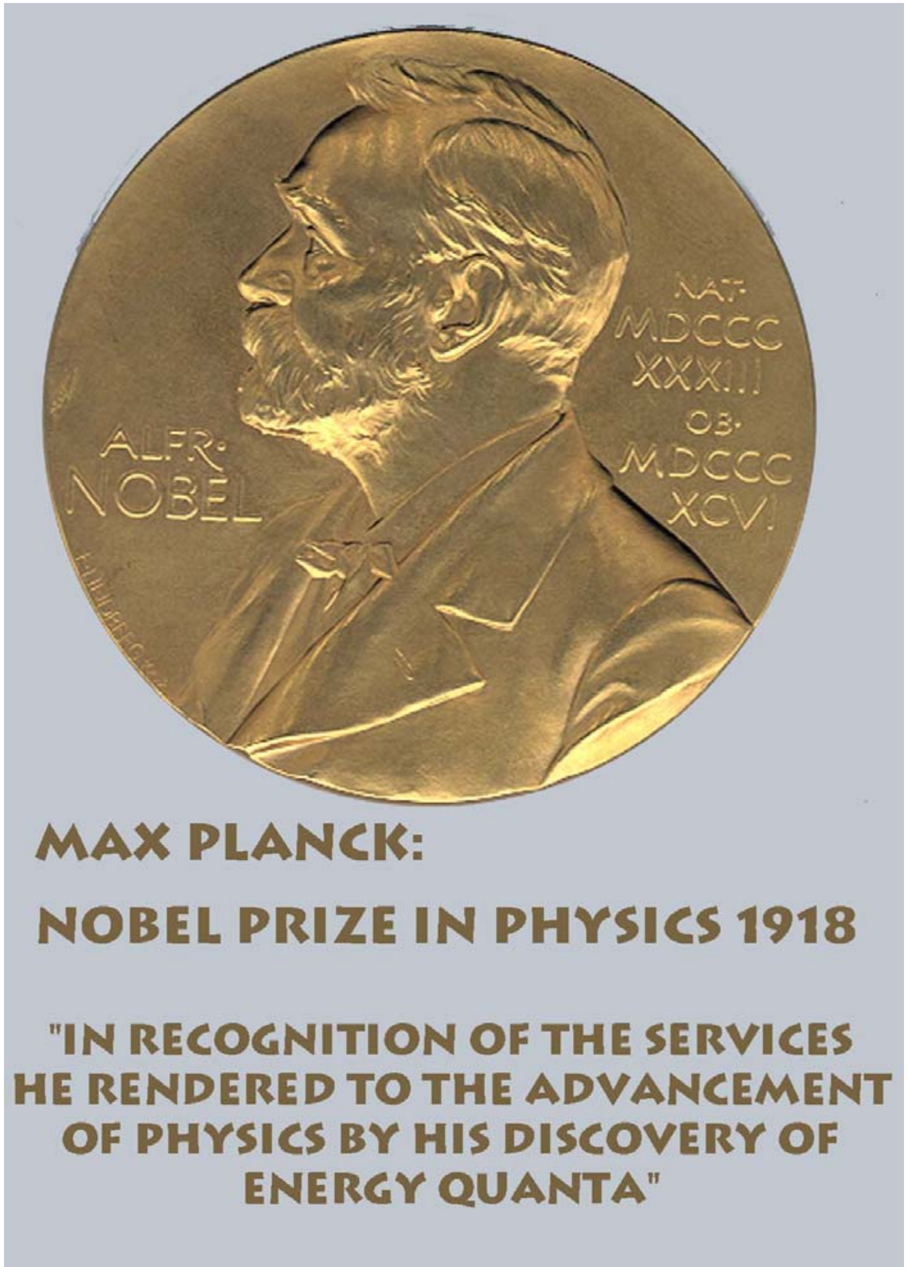
Physics in High Magnetic Fields

Hakone, Japan, 10.-13.9.1980



7 month after the Nobel discovery (again Japan, close to Mt. Fuji)

NOBEL PRIZES, FUNDAMENTAL CONSTANTS AND METROLOGY



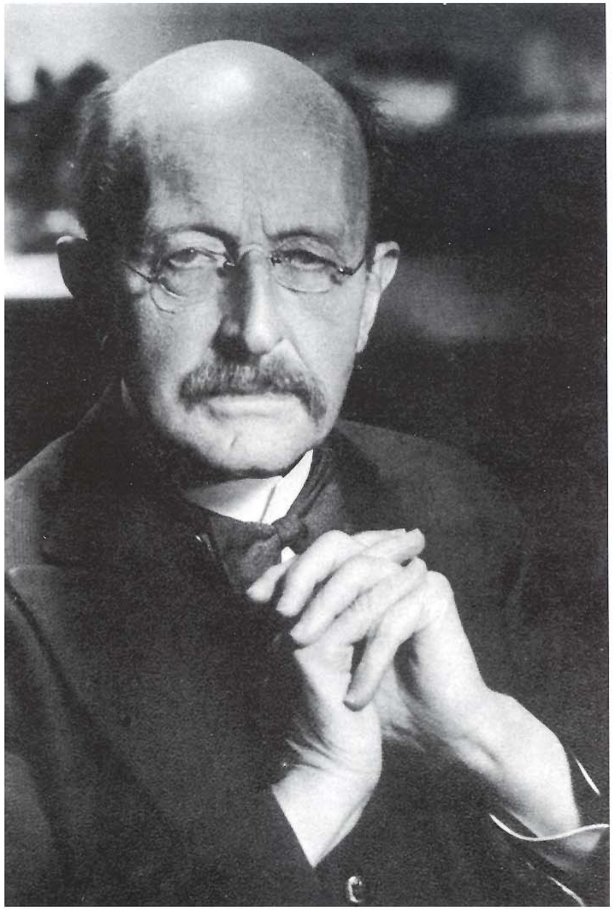
Klaus v. Klitzing

Max Planck Institute for Solid State Research

Stuttgart, Germany

MAX PLANCK

(initiator of *QUANTUM THEORY*)



14.12.1900

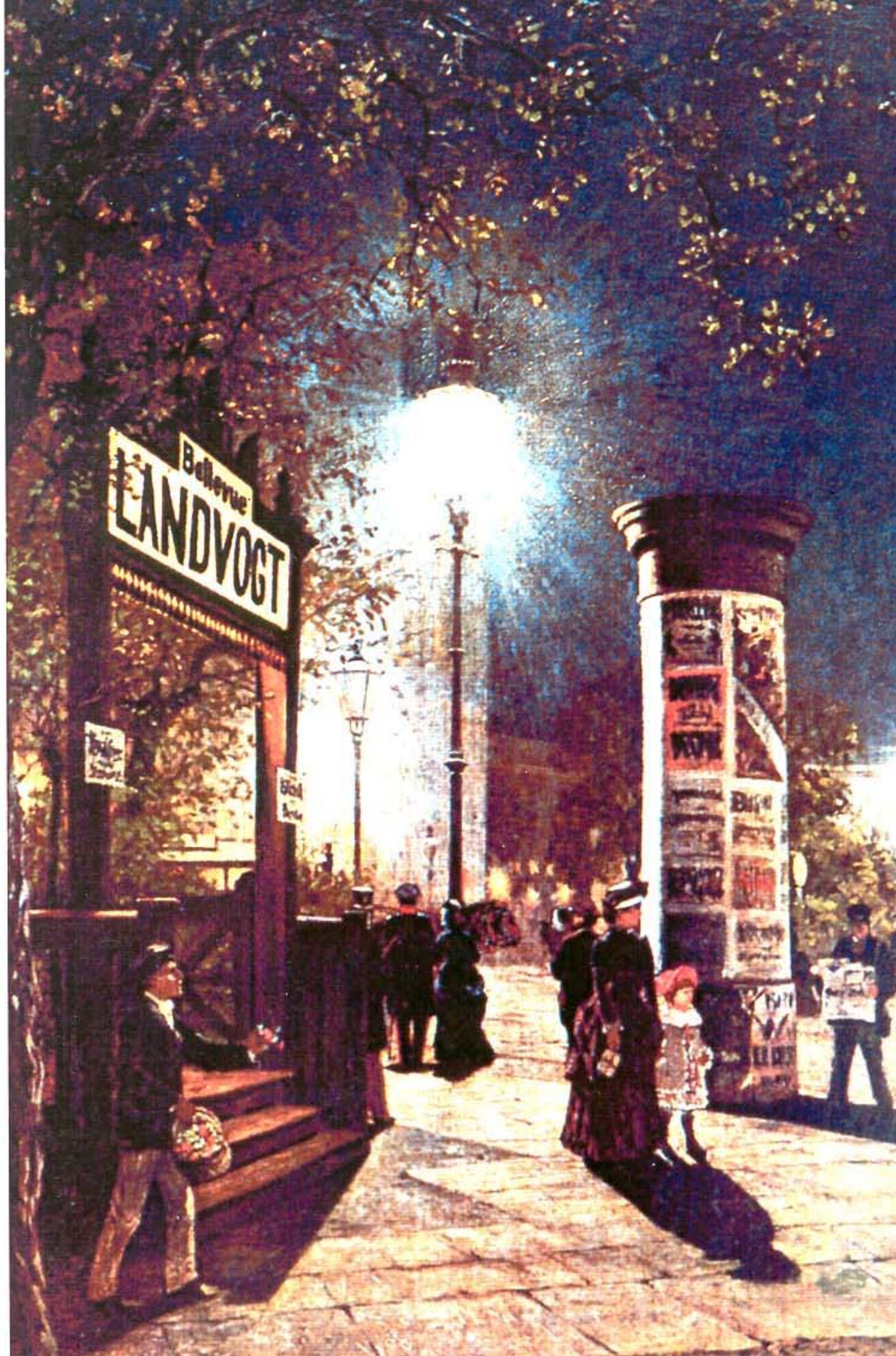
BIRTHDAY OF QUANTUM MECHANICS

A result of the cooperation with a METROLOGICAL INSTITUTE in Berlin (PTR)

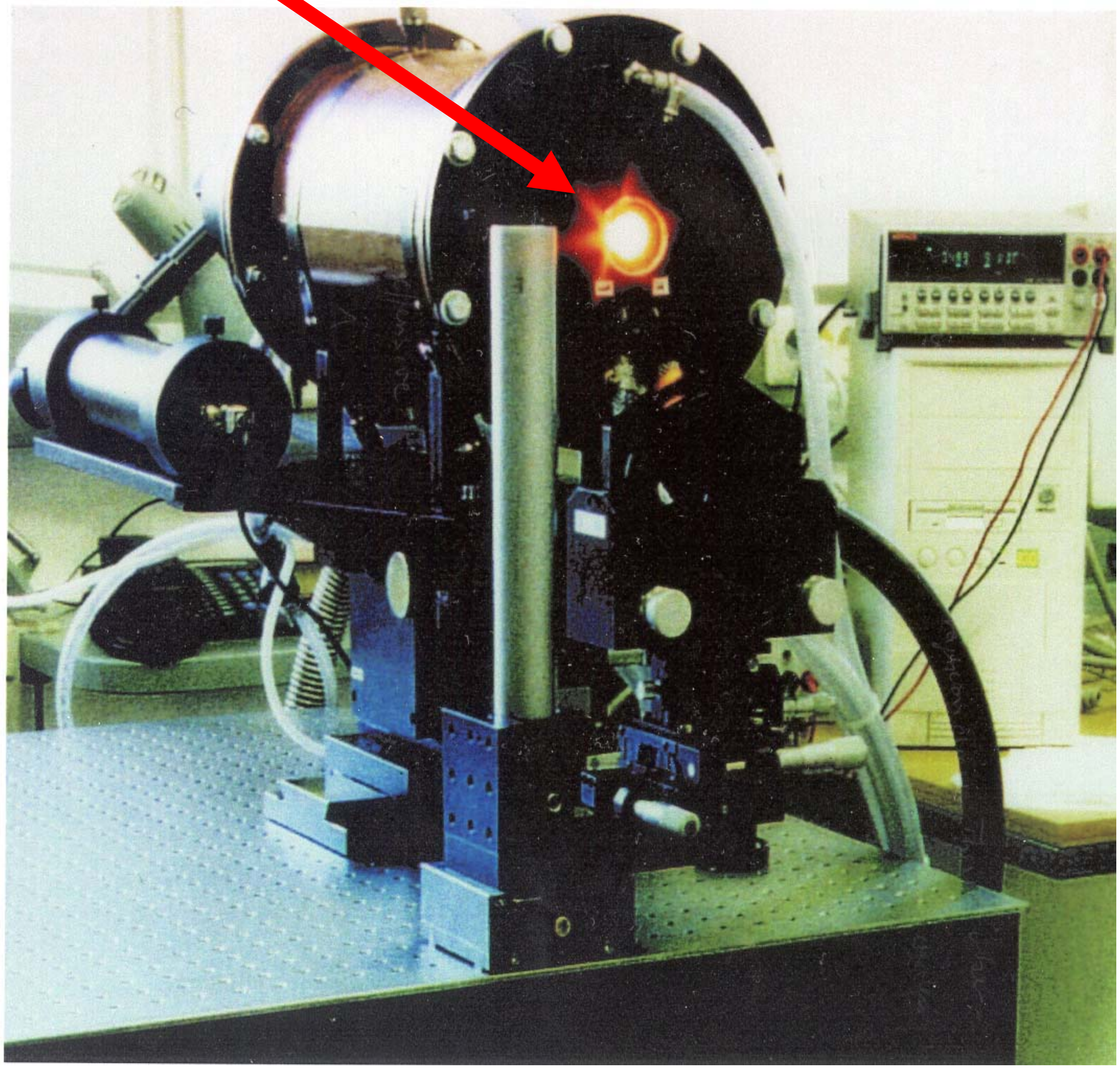
BERLIN 1882

(Potsdamer Platz)

FIRST ELECTRICAL ILLUMINATION

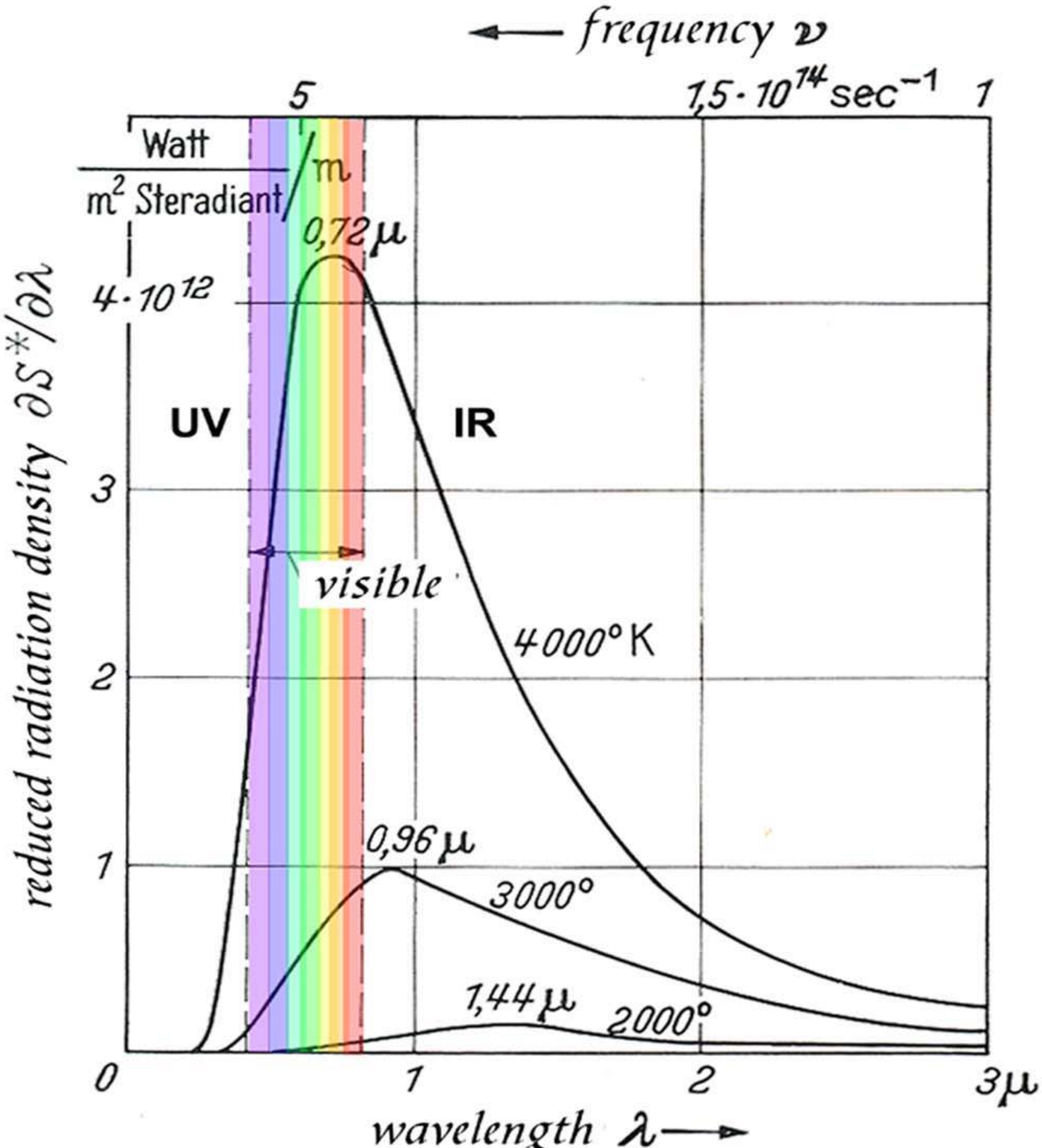


BLACKBODY RADIATION AT HIGH TEMPERATURES

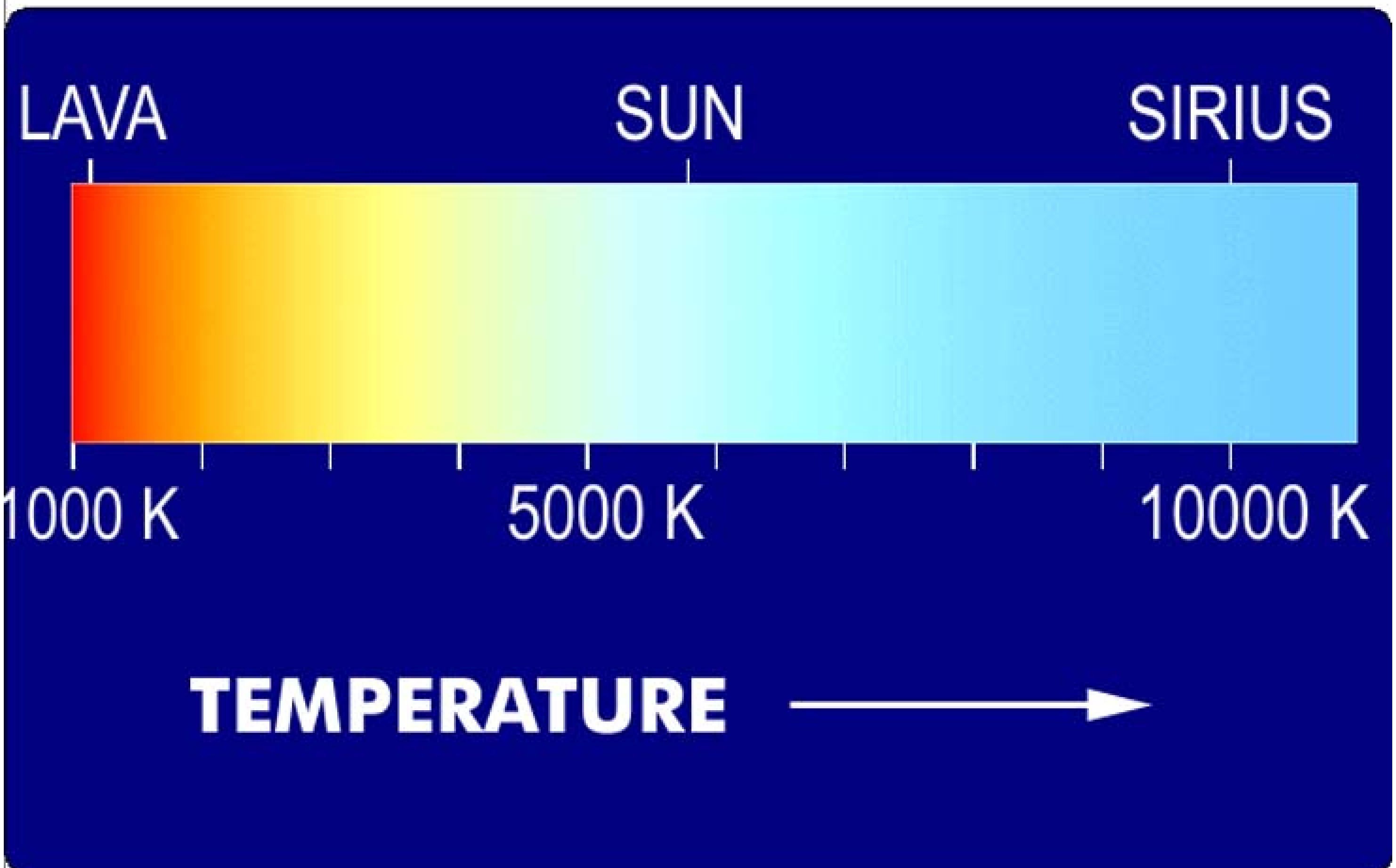


Black body radiation

at 3 different temperatures



COLOUR OF PLANCK RADIATION



Planck's formula: $$u(\nu,T)=\frac{8\pi}{c^3}\cdot\frac{h\nu^3}{e^{h\nu/kT}-1}$$

contains two different energies:

RADIATION ENERGY $h\nu$

THERMAL ENERGY kT

$$E=h\nu$$

FUNDAMENTAL CONSTANTS:

c = velocity of light

h = Planck constant

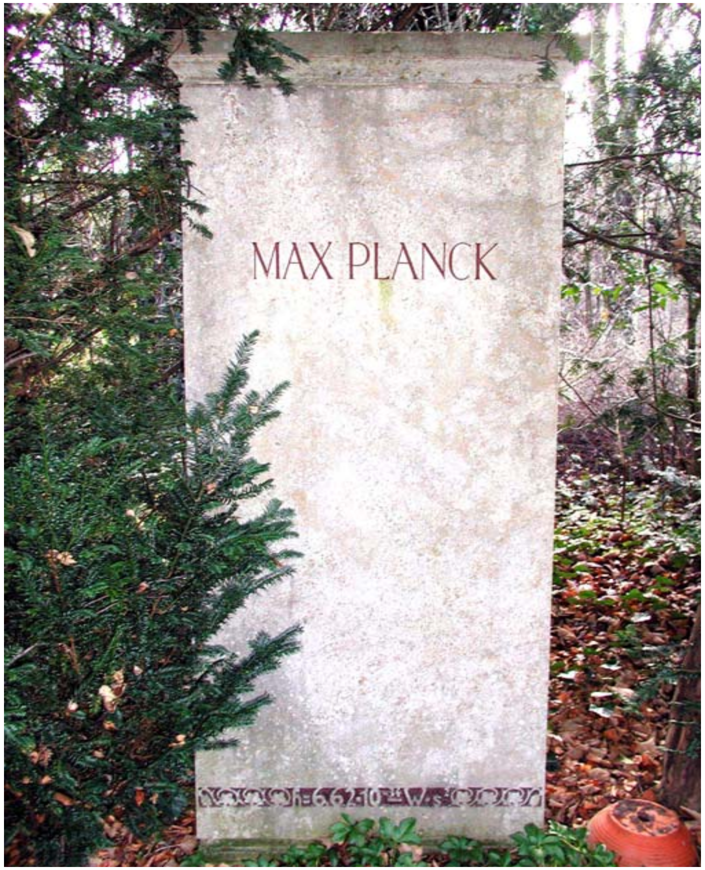
k = Boltzmann constant

Planck Constant h at the Entrance Door of our Max Planck Institute

MAX PLANCK

Kiel 1858

Göttingen 1947



GRAVE OF MAX PLANCK IN GÖTTINGEN

Max Planck:

“....with the help of fundamental constants we have the possibility of establishing units of length, time, mass, and temperature, which necessarily retain their significance for all cultures, even unearthly and nonhuman ones.“

Ann.Physik 1, 69-122 (1900)

NATURAL UNITS

(introduced by Max Planck in 1899)

unit of length: $\sqrt{\frac{h \cdot f}{c^3}} = 4{,}13 \cdot 10^{-33}\, cm$

unit of mass: $\sqrt{\frac{h \cdot c}{f}} = 5{,}56 \cdot 10^{-5}\, g$

unit of time: $\sqrt{\frac{h \cdot f}{c^5}} = 1{,}38 \cdot 10^{-43}\, s$

unit of temperature: $\sqrt{\frac{h \cdot c^5}{k^2 \cdot f}} = 3{,}50 \cdot 10^{32}\, K$

h **= Planck constant**

f **= gravitational constant**

c **= velocity of light**

k **= Boltzmann constant**

Realization of Planck's idea?

RECOMMENDATION OF THE
INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES

h *e* *k*

Preparative steps towards new definitions of the kilogram, the ampere, the kelvin and the mole in terms of fundamental constants

RECOMMENDATION 1 (CI-2005)

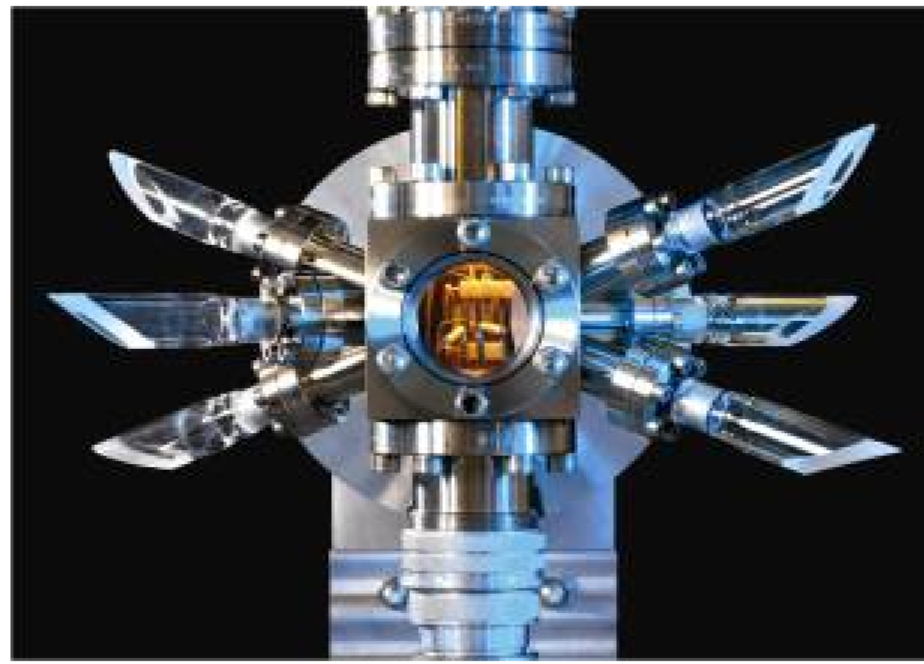
approve in principle the preparation of new definitions and *mises en pratique* of the kilogram, the ampere and the kelvin so that if the results of experimental measurements over the next few years are indeed acceptable, all having been agreed with the various Consultative Committees and other relevant bodies, the CIPM can prepare proposals to be put to Member States of the Metre Convention in time for possible adoption by the 24th CGPM in 2011;

The new SI: units of measurement based on fundamental constants

Starts: 9.00am on 24 January 2011

Finishes: 5.00pm on 25 January 2011

Venue: The Royal Society, London

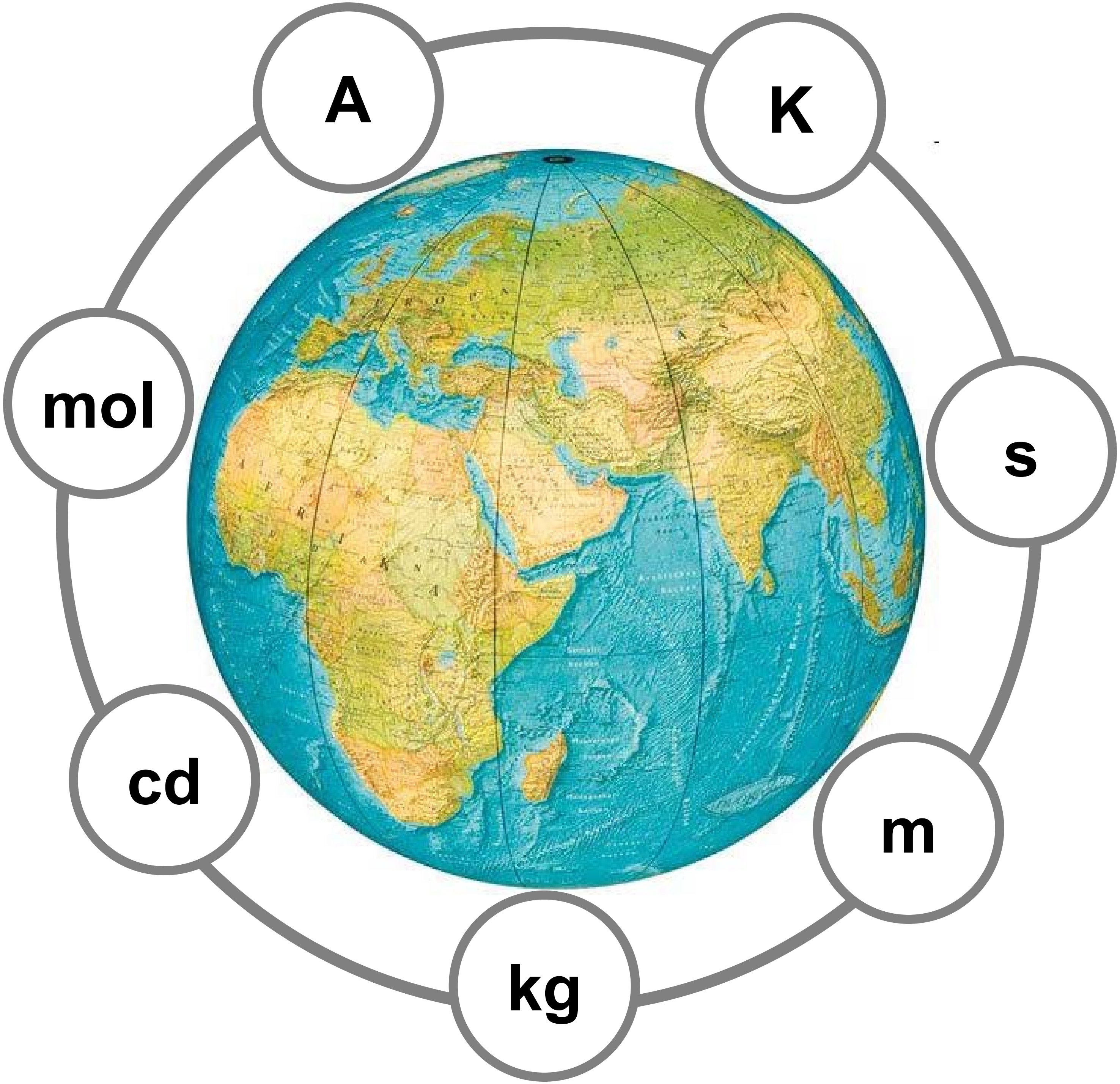


Organised by Dr Terry Quinn CBE FRS, Professor Ian Mills FRS and Professor Patrick Gill

Registration for this event is now open - click here to register.

From the origins of the metric system,
when the metre was a fraction of the arc of the Paris meridian and the kilogram the weight of a cubic decimetre of water, the ultimate goal has been a system of measurement based on invariant quantities of nature.

SI Base Units




Ton Kinsbergen/Science Photo Library

Metrology in the balance

The world's leading metrologists are keen to redefine the seven SI units in what is billed as the system's biggest overhaul since the French Revolution. **Robert P Crease** reports from a recent meeting that discussed the proposed changes

Originally:

TIME, LENGTH, MASS

related to properties of the earth

Today:

4 BASIC UNITS FOR MECHANICAL AND ELECTRICAL UNITS

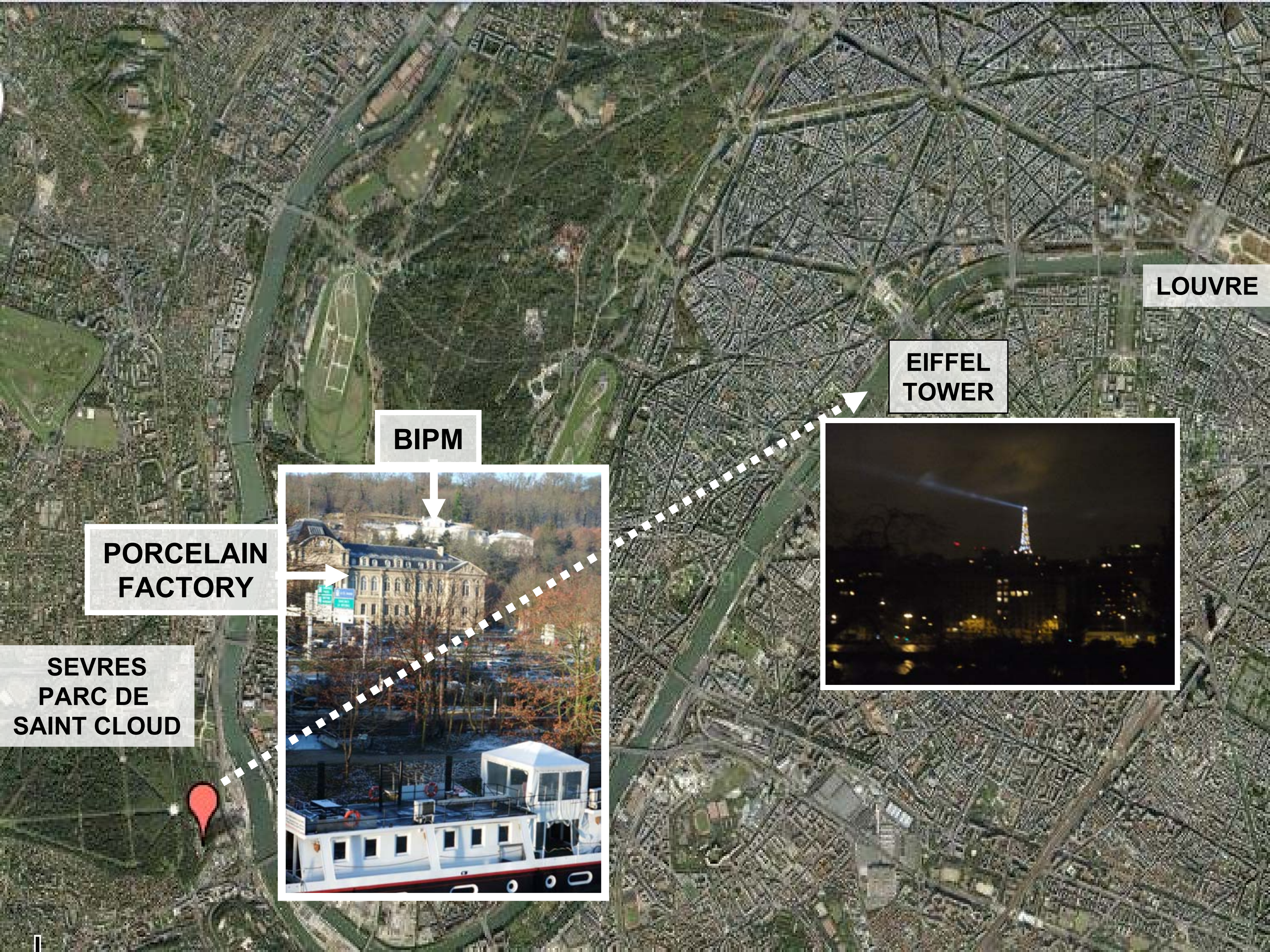
1 second: atomic clock

1 meter: velocity of light (fixed value for c)

1 kilogram: prototype

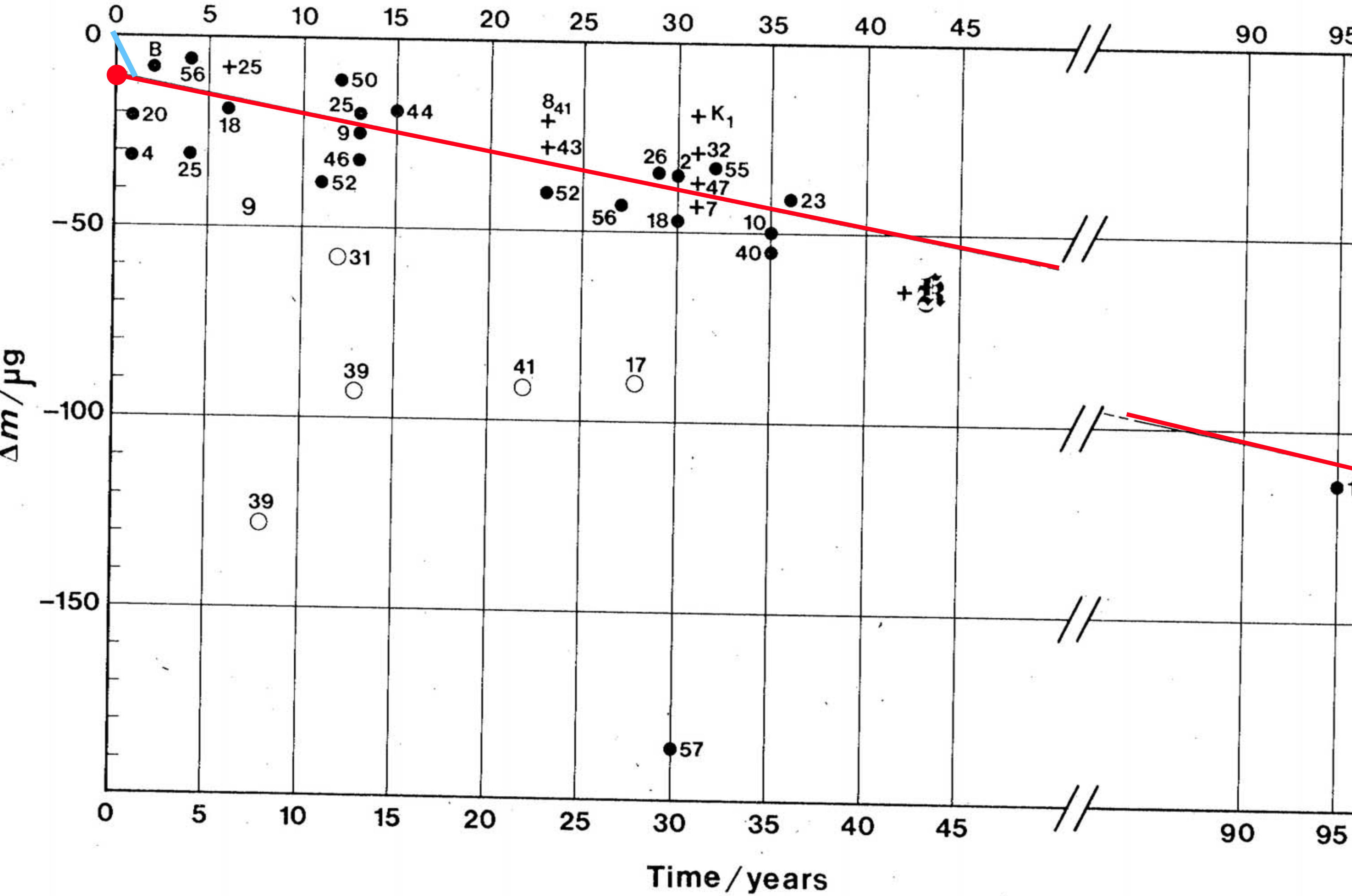
1 Ampere: electromagnetic force (fixed value for μ_0)

The unit of mass kept in a safe at the BIPM in Paris


LOUVRE
EIFFEL TOWER
BIPM
PORCELAIN FACTORY
SEVRES PARC DE SAINT CLOUD


3sat

mass change after cleaning



Dump the lump

Radical plans to overhaul SI units deserve to be approved

If there is one topic guaranteed to get *Physics World* readers hot under the collar, it is units – and SI units in particular. Hardly surprising, given that a joule is a joule whether you are a particle physicist or an astronomer. Moreover, the kelvin and the ampere – not to mention many "derived" SI units such as the farad, hertz, newton and watt – are tangible links with great physicists of the past.

BIPM

But change is in the air. At a recent meeting at the Royal Society in London, the world's top metrologists gathered to discuss plans to overhaul the SI system. If implemented in full, the "new SI" would see every SI unit (bar the second) defined in terms of a fundamental constant of nature (the second will remain defined in terms of a particular atomic transition). That, its proponents claim, would be the most radical overhaul of metrology since the French revolution (p39).

For the metre, the rebranding is rather subtle. It is currently defined as the distance travelled by light in a vacuum during 1/299 792 458th of a second, from which one infers that the speed of light in a vacuum, c, is 299 792 458 m s^{-1} exactly. Metrologists want to turn this argument on its head. First, they want to say that c is equal to exactly 299 792 458 m s^{-1}, from which one infers that the metre is the length of path travelled by light in a vacuum during 1/299 792 458th of a second.

INSTITUTE OF PHYSICS PUBLISHING METROLOGIA
Metrologia **42** (2005) 71–80 doi:10.1088/0026-1394/42/2/001

Redefinition of the kilogram: a decision whose time has come

Ian M Mills[1], Peter J Mohr[2], Terry J Quinn[3], Barry N Taylor[2] and Edwin R Williams[2]

Electrical metrology may be important for the redefinition of the kilogram!!

Metrologia 42 (2005) 431–441 doi:10.1088/0026-1394/42/5/014

Towards an electronic kilogram: an improved measurement of the Planck constant and electron mass

Richard L Steiner, Edwin R Williams, David B Newell and Ruimin Liu

National Institute of Standards and Technology (NIST), 100 Bureau Dr Stop 8171, Gaithersburg, MD 20899-8171, USA

Abstract

The electronic kilogram project of NIST has improved the watt balance method to obtain a new determination of the Planck constant h by measuring the ratio of the SI unit of power W to the electrical realization unit W_{90}, based on the conventional values for the Josephson constant $K_{J\text{-}90}$ and von Klitzing constant $R_{K\text{-}90}$. The value $h = 6.626\,069\,01(34) \times 10^{-34}$ J s verifies the NIST result from 1998 with a lower combined relative standard uncertainty of 52 nW/W. A value for the electron mass $m_e = 9.109\,382\,14(47) \times 10^{-31}$ kg can also be obtained from this result.

Towards a new SI

Base unit	Reference constants used to define the unit in the current SI	Reference constants used to define the unit in the proposed "new SI"	Exact value of constant in the "new SI"
s, second	hyperfine splitting in Cs-133	hyperfine splitting in Cs-133	9 192 631 770 Hz
m, metre	speed of light in vacuum, c	speed of light in vacuum, c	299 792 458 m s^{-1}
kg, kilogram	mass of International Prototype of the Kilogram, $m(\kappa)$	Planck constant, h	6.626 068...× 10^{-34} J s
A, ampere	permeability of free space, μ_0	elementary charge, e	1.602 176...× 10^{-19} C
K, kelvin	triple point of water, T_{tpw}	Boltzmann constant, k	1.380 65...× 10^{-23} J K^{-1}
mol, mole	molar mass of carbon-12, $M(^{12}C)$	Avogadro constant, N_A	6.022 141...× 10^{23} mol^{-1}
cd, candela	luminous efficacy of a 540 THz source	luminous efficacy of a 540 THz source	683 lumen W^{-1}

The seven SI units with the reference constants that are currently used to define the unit and those in the proposed "new SI". The second, metre and candela remain unchanged, while the kilogram, ampere, kelvin and mole will all now be related to fundamental constants.

Physics World March 2011

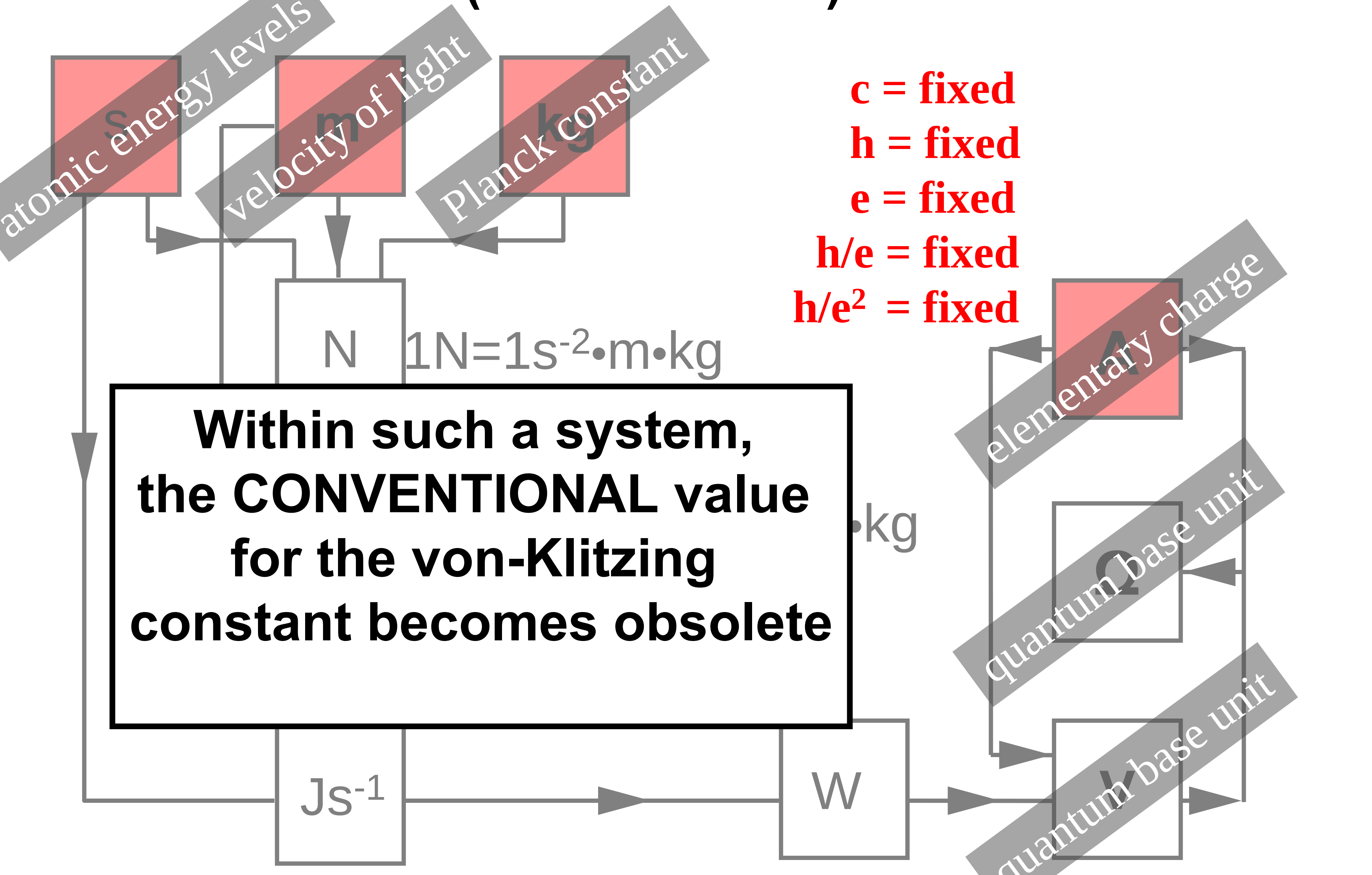
connection between m and h

$$E = mc^2$$ (EINSTEIN)

$$E = hv$$ (PLANCK)

$$m = hv/c^2$$

International System
(basic SI units)



Within such a system, the CONVENTIONAL value for the von-Klitzing constant becomes obsolete

NOBEL PRIZES AND METROLOGY

Max **Planck**	1919
Charles **Guillaume**	1920
Robert **Millikan**	1923
Willis **Lamp**	1955
Brian **Josephson**	1973
Klaus **v. Klitzing**	1985
Norman **Ramsey**	1989