----- Forwarded message from ian704mills@btinternet.com -----
Date: Mon, 30 May 2011 23:45:59 +0100 (BST)
From: Ian Mills <ian704mills@btinternet.com>
Subject: Re: SV: Redefinition of the kilogram
To: hill@math.gatech.edu
Cc: Terry Quinn-gmail <tjqfrs@gmail.com>, "Barry N. Taylor"
<barry.taylor@nist.gov>, Peter Mohr <peter.mohr@nist.gov>,
"michael.kuehne@bipm.org" <michael.kuehne@bipm.org>,
"cthomas@bipm.org" <cthomas@bipm.org>

Dear Ted,

Thanks for sending me the reprint. Two other things while I am writing.

Perhaps I can help to explain why the CCU and the CIPM prefer to redefine the
kilogram by fixing the numerical value of h rather than by fixing the
numerical
value of m(12C), or m(28Si). There is of course a choice in this
matter, and of
course the CCU is aware of this and has discussed it. I appreciate that you
would prefer to define the kilogram in terms of the mass of an atom,
because it
is conceptually easier to understand. However the CCU voted
unanimously at our
meeting last September in favour of redefining the kilogram in terms of h.
There are two main reasons why the definition in terms of h was preferred.

The first concerns the metrology of electromagnetic measurements. Precise
measurements in this field are performed today using the Josephson effect to
measure emf in terms of the value of the Josephson constant K_J =
2e/h, and the
quantum hall effect to measure electrical resistance in terms of the value of
the von Klitzing constant R_K = h/e^2. These effects are highly reproducible,
with lower uncertainty than the values of K_J and R_K can be determined in the
current SI. To escape this contribution to the uncertainty of measurement the
CIPM adopted fixed conventional values denoted K_J90 and R_K90 in
1990, fixed to
the best estimates of the constants at that time. In this way everyone could
use the same electrical units, and this is still how precise electrical
measurements are made today. But the result is that the electrical units used
are not actually SI units. However if we were to redefine the
kilogram to fix h
and the ampere to fix e, as currently proposed, then we would know the
vales of
2e/h and h/e^2 exactly, and the effect would be to bring electrical metrology
into the SI. The world of precise electrical metrology is a very important
field today, and the CCEM (consultative committee for electricity and
magnetism)
strongly recommend the choice to fix e and h.

The second reason concerns the fact that c and h are perhaps the most
important
fundamental constants in basic physics today, c in relation to

relativity theory
and h in relation to quantum mechanics. There is a strong preference
to base our
system of units on the most important and most fundamental constants
of nature.
By this argument h wins over m(12C) - or m(28Si) - which refer to particular
nuclides which are somewhat arbitrarily chosen, rather than h which is one of
the most fundamental constants of nature.

Your preference for redefining the kilogram in terms of the mass of an atom is
based on a preference for a definition that is easy to comprehend. But many
would say that we have lost that battle already. The experiments to
realise the
definition of the second and the metre are already too complicated for many
students to understand, and that applies also the other base units.
There is no
point in pretending that we can meet the desire for simplicity today
at the same
time as satisfying the requirements of modern precise quantum metrology. That
is why the CCU voted to fix h.

Of course the difference between these two definitions is small; we
are talking
about parts in 10^9. See equations (5) and (6) on p.13 in our recent paper of
which I sent you a preprint.

Kind regards. Ian

===========================
Ian Mills FRS
President of the CCU
School of Chemistry
University of Reading
Reading RG6 6AD, U.K.

office email: i.m.mills@reading.ac.uk
office phone: +44 (0)118 378 8456
mobile: 07770 227678
home email: ian704mills@btinternet.com
home phone: +44 (0)118 987 2335

From: "hill@math.gatech.edu" <hill@math.gatech.edu>
To: ian704mills@btinternet.com
Cc: "barry.taylor@nist.gov" <barry.taylor@nist.gov>; "i.m.mills@reading.ac.uk"
<i.m.mills@reading.ac.uk>; "Mohr, Peter J." <mohr@nist.gov>;
"terry.quinn@physics.org" <terry.quinn@physics.org>;
ingvar.johansson@philos.umu.se; "Williams, Edwin R. Dr."
<edwin.williams@nist.gov>; "michael.kuehne@bipm.org"
<michael.kuehne@bipm.org>;
"cthomas@bipm.org" <cthomas@bipm.org>; "miller@lbl.gov" <miller@lbl.gov>;
"himbert@cnam.fr" <himbert@cnam.fr>; "alfornow@sbcglobal.net"
<alfornow@sbcglobal.net>; "paul.de.bievre@skynet.be"
<paul.de.bievre@skynet.be>;
"athor@mech.kth.se" <athor@mech.kth.se>; "Marcus.Foster@csiro.au"
<Marcus.Foster@csiro.au>; "walter.emerson@wanadoo.fr"
<walter.emerson@wanadoo.fr>; "b.hibbert@unsw.edu.au" <b.hibbert@unsw.edu.au>;
"gcooper@pairmetrics.com.au" <gcooper@pairmetrics.com.au>;
"stephen.humphry@uwa.edu.au" <stephen.humphry@uwa.edu.au>;
"Ulrich.Feller@metas.ch" <Ulrich.Feller@metas.ch>
Sent: Monday, 30 May, 2011 1:59:19

Subject: Re: SV: Redefinition of the kilogram

Dear Ian,

I am glad to send you a pdf of our Metrologia paper; see attached.

Please note that Russian metrologists have also concluded that the
Planck-based
definition of the kilogram has serious problems, and that an atom-counting
definition is preferable (our article refers to one of their articles, which I
have also attached for your convenience).

best regards,

Ted

Quoting Ian Mills <ian704mills@btinternet.com>:

> Dear Ted,
>
> Just for my convenience, could you send me a pdf copy of your paper in
> Metrologia, 2011, vol 48, pp. 83-86.
> I would be grateful.
>
> Ian
> ==========================
> Ian Mills FRS
> President of the CCU
> School of Chemistry
> University of Reading
> Reading RG6 6AD, U.K.
> ________________________________
> From: "hill@math.gatech.edu" <hill@math.gatech.edu>
> To: barry.taylor@nist.gov; i.m.mills@reading.ac.uk
> Cc: "Mohr, Peter J." <mohr@nist.gov>; "terry.quinn@physics.org"
> <terry.quinn@physics.org>; "Williams, Edwin R. Dr."
> <edwin.williams@nist.gov>;
> "michael.kuehne@bipm.org" <michael.kuehne@bipm.org>; "cthomas@bipm.org"
> <cthomas@bipm.org>; "miller@lbl.gov" <miller@lbl.gov>; "himbert@cnam.fr"
> <himbert@cnam.fr>; "alfornow@sbcglobal.net" <alfornow@sbcglobal.net>;
> "paul.de.bievre@skynet.be" <paul.de.bievre@skynet.be>; "athor@mech.kth.se"
> <athor@mech.kth.se>; "Marcus.Foster@csiro.au" <Marcus.Foster@csiro.au>;
> "walter.emerson@wanadoo.fr" <walter.emerson@wanadoo.fr>;
> "b.hibbert@unsw.edu.au"
> <b.hibbert@unsw.edu.au>; "ingvar.johansson@philos.umu.se"
> <ingvar.johansson@philos.umu.se>; "gcooper@pairmetrics.com.au"
> <gcooper@pairmetrics.com.au>; "stephen.humphry@uwa.edu.au"
> <stephen.humphry@uwa.edu.au>; "Ulrich.Feller@metas.ch"
> <Ulrich.Feller@metas.ch>
> Sent: Friday, 27 May, 2011 3:16:12
> Subject: RE: Redefinition of the kilogram
>
>
> --Dr. Theodore P. Hill
> http://people.math.gatech.edu/~hill/
>
>
>
> Dear Ian and Barry,
>
> Thank you for your two messages and three papers.
>
> Unfortunately, none of them answers the basic question I asked you four years
> ago, repeated in my email last week:
>

>> 4. What is your proposed introductory-level textbook definition of a
>> kilogram? (including all the necessary pre-definitions, such as de Broglie,
>> Planck, photon frequency etc)
>
> Do you have a clean, precise definition suitable for college chemistry and
> physics students (let alone "students in all disciplines", as you say)?
>
> If so, please tell us what it is.
>
> Thank you for your time.
>
> Kind regards, Ted
>
> P.S. In his email below, Barry wrote, "the thinking of the international
> community concerning the "New SI" has evolved considerably over the last 5
> years". Has it now suddenly stopped evolving?
>
>
> Quoting Ian Mills
> <ian704mills@btinternet.com><mailto:ian704mills@btinternet.com>>:
>
>> Dear Ted,
>>
>> Perhaps I can add a few words to Barry Taylor's reply to you.
>> First, to make
>> life easier for you I attach a copy of our third paper which is currently in
>> press, and also a copy of the FAQs that we prepared to aid
>> understanding, and
>> which are available on the BIPM website.
>>
>> As you will see from our paper, we do of course recognize that a definition
of
>> the kilogram in terms of the mass of something (such as the mass of a
> specified
>> number of silicon atoms) would be easier to comprehend for many readers.
>> However the definition to fix the numerical value of h has other advantages
>> which the CCU and the CIPM believe outweigh the arguments for fixing the
>> numerical value of the mass of a silicon atom. Also these two definitions
are
>> very nearly equivalent, because of the relation between h and m(28silicon)
>> which
>> is presented in equation (6) on p.13 of our paper. Because all the factors
on
>> the right hand side of that equation are either known exactly or
>> are known to
>> about a part in 10^9 in the new SI, the mass of a silicon 28 atom is
>> effectively
>> exactly related to the Planck constant in the new SI. Thus if you ask "how
>> will
>> the definition in terms of h be realised?", two possible answers are either
> by
>> using a watt balance, or by measuring the mass of a silicon 28 atom
>> using the
>> XRCD experiment. The results should agree.
>>
>> In practice we shall not actually make the change from the current SI to the
>> new
>> SI until the results of the experiments to determine h from a watt balance
and
>> to determine m(28Si) from the xrcd experiment are in adequate
>> agreement. But
>> we
>> do believe that the proposed new definitions are the best way to go.
>>
>> If you have more specific questions about the new SI proposals I would be

> happy
>> to try to be of help.
>>
>> Kind regards, Ian
>> ===========================
>> Ian Mills FRS
>> President of the CCU
>
> Quoting "Taylor, Barry N."
> <barry.taylor@nist.gov><mailto:barry.taylor@nist.gov>>:
>
>> Dear Ted,
>>
>> Thank you for your email. You may not be aware of the fact that the
>> thinking of
>> the international community concerning the "New SI" has evolved considerably
>> over the last 5 years since our 2006 article was published in Metrologia.
>> Please see the Web site of the BIPM at the following link, and also
>> have a look
>> at the various documents available through that link. Have a look at the
>> attachments as well. (Note that the preprint by Mills, Quinn,
>> Mohr, Taylor, and
>> Williams will appear latter this year in an issue of the Philosophical
>> Transactionas of the Royal Society A).
>>
>> http://www.bipm.org/en/si/new_si/
>>
>>
>> With regard to teaching people about the New SI, in particular how
>> to show how
>> fixing the numerical value of the Planck constant defines the kilogram, I
>> believe it can be done relatively easily by comparing the energy of
>> quanta of
>> light, that is, photons, given by the equation E = hnu, and the
>> energy of a body
>> of mass m. This energy can be the kinetic energy of a macroscopic body, E =
>> (1/2)mv^2, its potential energy above the earth, E = mgh, or its
>> "equivalent
>> energy," E = mc^2.
>>
>> Kind regards,
>>
>> Barry
>>
>> Barry N. Taylor
>> NIST, Bldg. 221, Rm. A255
>
>> From: hill@math.gatech.edu<mailto:hill@math.gatech.edu>
>> [hill@math.gatech.edu<mailto:hill@math.gatech.edu>]
>> Sent: Thursday, May 19, 2011 5:12 PM
>> To: i.m.mills@reading.ac.uk<mailto:i.m.mills@reading.ac.uk>; Mohr, Peter J.;
>> terry.quinn@physics.org<mailto:terry.quinn@physics.org>; Taylor, Barry N.;
>> Williams, Edwin R. Dr.
>> Cc: michael.kuehne@bipm.org<mailto:michael.kuehne@bipm.org>;
>> cthomas@bipm.org<mailto:cthomas@bipm.org>;
>> miller@lbl.gov<mailto:miller@lbl.gov>;
>> himbert@cnam.fr<mailto:himbert@cnam.fr>;
>> alfornow@sbcglobal.net<mailto:alfornow@sbcglobal.net>;
>> paul.de.bievre@skynet.be<mailto:paul.de.bievre@skynet.be>;
>> athor@mech.kth.se<mailto:athor@mech.kth.se>;
>> Marcus.Foster@csiro.au<mailto:Marcus.Foster@csiro.au>;
>> walter.emerson@wanadoo.fr<mailto:walter.emerson@wanadoo.fr>;
>> b.hibbert@unsw.edu.au<mailto:b.hibbert@unsw.edu.au>;
>> ingvar.johansson@philos.umu.se<mailto:ingvar.johansson@philos.umu.se>;
>> gcooper@pairmetrics.com.au<mailto:gcooper@pairmetrics.com.au>;

>> stephen.humphry@uwa.edu.au<mailto:stephen.humphry@uwa.edu.au>;
>> Ulrich.Feller@metas.ch<mailto:Ulrich.Feller@metas.ch>
>> Subject: Redefinition of the kilogram
>>
>> Dear Drs. Mills, Mohr, Quinn, Taylor and Williams,
>>
>> Your 2006 Metrologia article declared (p 228)
>>
>> "since it is important that the basis of our measurement system be
>> taught in schools and universities, it is preferable, as far as modern
>> science permits, that the definitions of base units be comprehensible
>> to students in all disciplines."
>>
>> Shortly thereafter, four years ago this month, physicist Ron Fox and I
>> sent you an email asking
>>
>> "What is your proposed introductory-level textbook definition of a
>> kilogram (cf your Table 1)? (including all the necessary
>> pre-definitions, such as de Broglie, Planck, photon frequency etc)"
>>
>> Your exact response (from Barry Taylor, see email below) was
>>
>> "I am not in the business of writing introductory textbooks -- I will
>> leave that to others. All I will say is that we do not believe any of
>> the proposed new definitions are any more complex than the current
>> definitions of some of the SI base units."
>>
>> Is that still your position?
>>
>> Thank you for your time.
>>
>> Sincerely
>>
>> Ted Hill
>> Professor Emeritus of Mathematics
>> Georgia Institute of Technology
>> Atlanta, GA 30332 USA
>>
>> --
>> Dr. Theodore P. Hill
>> http://people.math.gatech.edu/~hill/
>>
>>
>>
>> -------- Begin forwarded message --------
>> Subject: Re: Redefinition of kilogram
>> Date: 5/4/07 8:54:54 PM
>> From: "Barry Taylor"
>> To: "Ted Hill" , i.m.mills@reading.ac.uk<mailto:i.m.mills@reading.ac.uk>,
>> mohr@nist.gov<mailto:mohr@nist.gov>,
>> terry.quinn@physics.org<mailto:terry.quinn@physics.org>,
>> edwin.williams@nist.gov<mailto:edwin.williams@nist.gov>
>> Cc: ron.fox@physics.gatech.edu<mailto:ron.fox@physics.gatech.edu>
>>
>>
>>
>> Dear Ted,
>>
>> I will try to answer your questions, but perhaps you are making the
>> whole business more complex than necessary. Further, a telephone
>> conversation may be more useful than written exchanges. See the
>> interspersed red text, which I hope you find helpful.
>>
>> Regards,
>>

>> Barry
>>
>> At 04:50 PM 5/4/2007, Ted Hill wrote:
>> Gentlemen,
>>
>> I just returned from an extended truip abroad and am re-reading your
>> 2006 Metrologia article (Vol 43, p
>> 227-246). I still find it confusing in places, and perhaps some of you
>> do also - one author told me that kappa
>> is changing in time while another told me it is NOT changing in time,
>> and at one point in my conversation with
>> Dr. Mohr, he told me that the same symbol N_A might mean different
>> things in different parts of that paper.
>>
>> Your paper stresses the importance of communication between scientists
>> and metrologists, and it is in that spirit
>> that I am asking for further explanations. If the proposal detailed in
>> your paper contains significant shortcomings
>> or errors, that should be brought to the attention of both
>> communities, especially the readers of Metrologia.
>>
>> Perhaps I am wrong, but if you could answer the following basic
>> questions, that might be a good place to start.
>>
>> 1. Exactly what does the symbol N_A mean in that paper?
>>
>> [BT] Imagine the following. The SI is as currently defined, it is 1
>> January 2011, and the 2010 CODATA constants adjustment has just been
>> completed. At its meeting in October 2011 the CGPM decides to adopt
>> new definitions of the kilogram, ampere, kelvin and mole that links
>> these four units to exact values of h, e, k, and N_A, respectively.
>> The actual wordings of the definitions are unimportant -- they can be
>> explicit unit definitions like the present definition of the meter,
>> which links the meter to a fixed value of c, or an explicit constant
>> definition, which for the meter might read "The meter, the SI base
>> unit of length, is such that the speed of light in vacuum c is exactly
>>   299 792 458 meters per second."
>>
>> [BT]Now, what values of h, e, k, and N_A should the CGPM choose?
>> Obviously, to maintain continuity with the current kilogram, ampere,
>> kelvin, and mole, they should choose the 2010 CODATA recommended
>> values of h, e, k, and N_A since these values are the most accurate
>> available in SI units based on our knowledge as it existed on 31
>> December 2010. However, the CGPM will take these values to be exact,
>> i.e., with no uncertainty, and hence these values will never change
>> forever more, just like the current value of c is exact and will never
>> change. Of course, the values chosen will have to have enough digits
>> to keep any discontinuity introduced by using truncated values to a
>> negligible level, which for the sake of argument we will assume to be
>> 11 digits (10 may be adequate or 12 may be needed; it really doesn't
>> matter). The symbols for these constants will remain the same,
>> because the value of a quantity is independent of the unit in terms of
>> which its value is expressed. However, the numerical value of a
>> quantity depends on the unit, and the newly defined kilogram, ampere,
>> kelvin, and mole are actually different units from the currently
>> defined kilogram, ampere, kelvin, and mole. Hence in principle, they
>> should have some distinguishing mark (i.e., a different symbol).
>> Nevertheless, this was not done when the meter was redefined in terms
>> of c, and hence the current symbols for the kilogram, ampere, kelvin,
>> and mole, that is, kg, A, K, and mol, will be retained for the newly
>> defined units just as the symbol m was retained for the newly defined
>> meter in 1983.
>>
>>
>>   (Is it perhaps the 2002 NIST range of values for Avogadadro's

>> constant (i.e., a variable with that specified
>>   mean and standard deviation), or is it the central value of that
>> range (i.e., a constant fixed in 2002), or is it the
>>   current best experimental estimate of one of those? Or something else?)
>>
>> 2. By your definitions, would the exact mass (in grams) of one atom of
>> carbon-12 be changing in time?
>>
>> [BT] The mass of an atom of carbon-12 is an invariant of nature and
>> hence its value does not change. What does change is our knowledge of
>> that value when expressed as a number times a unit. In the new SI
>> where c, h, e, k, and N_A have exactly known values, one can show that
>> the mass of the carbon-12 atom is given by
>>
>> m(12^C) = (24R_inf h)/[c alpha^2 A_r(e)], (1)
>>
>> where R_inf is the Rydberg constant, alpha^2 is the square of the
>> fine-structure constant, and A_r(e) is the relative atomic mass of the
>> electron. Now h and c are exactly known but R_inf, alpha, and A_r(e)
>> are not, hence their numerical values will change as new experimental
>> and theoretical results become available. Thus, the numerical value
>> of m(12^C) expressed in the new kilogram will change. Based on the
>> 2006 CODATA recommended values, if the SI were redefined today as we
>> propose, the relative uncertainty of m(12^C) would be approximately
>> 1.4 parts in 10^9 due to the uncertainties of R_inf, alpha^2, and
>> A_r(e).
>>
>> 3. Isn't kappa essentially a new fundamental constant?
>>
>>   (it seems to be the crucial link between your new proposed
>> numerical definitions of
>>   fundamental constants and the physical world of real atoms - e.g.
>> via amu/carbon-12)
>>
>> [BT] I suppose one could call (1 +kappa) a new fundamental constant if
>> one wishes to do so, but one should keep in mind that it is really
>> just a combination of well known constants and writing the combination
>> as (1 + kappa) is for convenience. Note that in the new SI we have
>>
>> (1 + kappa) = (2R_inf N_A h/)[c alpha^2 A_r(e) M_u],   (2)
>>
>> where N_A is the Avogadro constant and M_u is the molar mass constant,
>> equal to 10^-3 kg/mol exactly. Thus, the relative uncertainty of (1 +
>> kappa) is the same as that of m(12^C) since both N_A and M_u have no
>> uncertainty in the new SI. Note that its numerical value of (1 +
>> kappa) will be zero at the time of adoption of the New SI, but this
>> will change with time.
>>
>>
>> 4. What is your proposed introductory-level textbook definition of a
>> kilogram (cf your Table 1)?
>>
>>   (including all the necessary pre-definitions, such as de Broglie,
>> Planck, photon frequency etc)
>>
>> [BT] I am not in the business of writing introductory textbooks -- I
>> will leave that to others. All I will say is that we do not believe
>> any of the proposed new definitions are any more complex than the
>> current definitions of some of the SI base units.
>>
>> [part deleted]
>>
>> Thank you for your feedback in the past - I look forward to your
>> responses to these questions.
>>

>> Regards
>>
>> Ted Hill
>>
>>
>> ************************************
>> Barry N. Taylor
>> NIST, Bldg. 221, Rm. A255
>> 100 Bureau Drive, Stop 8420
>> Gaithersburg, MD 20899-8420
>> USA
>> Tel.: 301-975-4220
>> Fax: 301-990-1350
>> Web: <http://physics.nist.gov/cuu>
>>   <http://physics.nist.gov/cuu>
>> http://physics.nist.gov/cuu <http://physics.nist.gov/cuu>
>> ***********************************
>
> --Dr. Theodore P. Hill
> http://people.math.gatech.edu/~hill/
>
>
>
>
>
>

----- End forwarded message -----