Report on the Meeting of the CODATA Task Group on Fundamental Constants
Document TGFC-22-03

10:00 - 17:00 (UTC), 12 September 2022
10:00 - 17:00 (UTC), 13 September 2022
10:00 - 12:30 (UTC), 14 September 2022

Hybrid Meeting

Prepared by

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1. Opening of the meeting and introductions

The meeting opened at 10:00 AM (UTC) Monday and introductions were made. Members of the Task Group on Fundamental Constants in attendance: Krzysztof Pachucki (chair), Eite Tiesinga (vice-chair), Kenichi Fujii, Savely Karshenboim, Helen Margolis, Peter Mohr, David Newell, François Nez, Randolf Pohl, Andrey Surzhykov, Barry Wood, Barry Taylor (emeritus member), Franck Bielsa (BIPM liaison) Toshihiro Ashino (CODATA liaison) and Richard Hartshorn (CODATA liaison).

The following members sent their regrets: Jifeng Qu, Meng Wang.

Present as observers: Simon Hodson (CODATA), Richard Davis (BIPM retired), Stephan Schlamminger (NIST), Michael Stock (BIPM), Hans-Werner Hammer (TU Darmstadt), Jean-Philippe Karr (LKB), Jeroen Koelemeij (VU Amsterdam), Hans Hepach (University of Vienna), Nadine De Courtenay (Université Paris Diderot), Robert Hanisch (NIST), Giovani Mana (INRIM), Hao Fang (BIPM), Connor Kapahi (University of Waterloo), Dusan Sarenac (University of Waterloo), Dimitry Pushin (University of Waterloo), Joachim Ullrich (CCU President), Enrico Massa (INRIM), Qing Li (HUST), Gabriele Rosi (Istituto Nazionale di Fisica Nucleare, INFN, LENS), Markus Aspelmeyer (University of Vienna), Daniel Hussey (NIST), Riccardo Decca (IUPUI), Stephan Schiller (Heinrich-Heine-Universität Düsseldorf), Mike Huber (NIST) and Clive Speake (University of Birmingham).

Two open scientific sessions on the gravitational constant G and HD^+ spectroscopy took place during the CODATA meeting, and they attracted a lot of interest in the scientific community.

2. Review of the agenda

One point was added to the Wednesday session concerning a discussion of the CCU Task Group on angle and dimensionless quantities in the SI Brochure (presented by P. Mohr). The agenda, TGFC-22-01, was reviewed and accepted.

3. Task Group administration

a. membership
No change in the membership.

b: membership contact information for posting
Members have been requested to check and update contact information.

4. Review of the report of the Task Group meeting held in September 14/15, 2021
It was suggested that the minutes be written and distributed with only a short delay after the meeting in the future. The minutes of the last meeting, (TGFC-21-03), were approved (one vote against, one abstention) without change and will be posted on the unrestricted website.

5. CODATA TGFC website at the BIPM: accessing and login information
Franck Bielsa described how to get access to and use the TGFC website hosted by the BIPM.

6. Comments and suggestions regarding publication of the CODATA 2022 adjustment of the fundamental constants: possible additions, deletions, and improvements
K. Pachucki stated in the introduction that inclusion of data considered for the adjustment had to be decided during this meeting, because it is the last meeting before the deadline of the 2022 adjustment.

The task group initiated a discussion on how to efficiently provide input and feedback from E. Tiesinga during the writing of the CODATA paper. The task group decided to regularly organize online sub-meetings to discuss specific points concerning the adjustment and the writing of the paper. The first sub-meeting will be held 4.00 P.M. (UTC) January 9, 2023. An online version of the paper and working documents will be shared with the task group using the overleaf platform.

The task group had a lively discussion on the clarification of the definition of the energy levels in the CODATA paper. In relation to this, it was proposed and agreed to add to the CODATA paper notes on the basis of hyperfine splittings (as a first step that can be extended in the future):

- Definition of energy levels: center of gravity versus hfs coupling constants.
- Nuclear recoil corrections of order (m/M)^2 depending on the nuclear spin.
- Definition of the charge radius dependence on the nuclear spin.

It was also proposed that a separate paper be written on the comprehensive theory of the Lamb shift in: muH, muD, mu^3He, mu^4He, and to present values for the nuclear charge radii. E. Tiesinga pointed out the workload added by this proposition. R. Pohl and K. Pachucki agreed to write this paper.

Some corrections to the CODATA paper have been suggested:
K. Pachucki: Misprint in uncertainties of magnetic moments.
S. Karshenboim: Possible changes to the muonic hydrogen section. To be discussed in sub-meetings.
S. Karshenboim: Include the magnetic moment of the muon? Should we include the theory of muon g-2?
S. Karshenboim: Add rules for public use of a word file containing results of the adjustment (does not concern the paper).
R. Pohl: Missing 1S – 2S transition in Deuterium.
S. Karshenboim: Proposed use of the original result for the triton charge radius
K. Pachucki: Suggested including the magnetic moment of ^3He in the adjustment

7. Proton charge radius from the e-p scattering measurements

Concerning the proton charge radius determination, the task group discussed the best way to consider the results provided by e-p scattering experiments which appear to be difficult to interpret. It was proposed to:

- Include short comments on form factors and Friar radius r^3.
- Add a more extensive description of the proton polarizability (a paragraph could be proposed by S. Karshenboim or by R. Pohl and K. Pachucki).
- Include in the adjustment all the new results on the determination of the proton charge radius based on the dispersion theory.
- Add a figure with the proton charge radius.

8: Masses of light nuclei

Four new values for the proton and deuteron mass have been reported:

- Fink and Myers, PRL **124**, 013001 (2020)
- Rau et al., Nature **585**, 43 (20)
- AME 2020 has been published including data up to Oct. 2020 (Sec 6.1 of Chin.Phys. C **45**, 030002 (2021)
- Molecular-ion spectroscopy of HD+.

9: Update of new or unexpected results concerning:

a. Hydrogen and deuterium energy levels.
b. Nuclear charge radii from muonic hydrogen, deuterium, and helium Lamb shifts.
   Three new determinations since the last adjustment: PRAD 2019, Garching 2020, Colorado 2021. Preliminary results on helium3.
   See slides presented by R. Pohl.
c. Nuclear charge radii from electron-proton and electron-deuteron scattering.
   New determinations based on dispersion theory.
d. Atomic g-factors in hydrogenic ions.
e. Electron and muon magnetic moment anomalies.
f. Atom recoil measurement for the determination of α.
   Results published by LKB in 2020. New result expected at LKB after 2022.
g. Electromagnetic moments of p, d, t, and helion.
h. Gravitational constant G.

10: Discussion and vote regarding inclusion of HD+ in 2022 adjustment

Concerning the HD+ spectroscopy results for e/p and e/d mass ratios, the task group decided to include in the adjustment the raw experimental data without detailed theory because of its complexity. A separate paper with details will be written by Jean-Philippe Karr and Jeroen Koelemeij.

11: Discussion regarding writing the publication of the CODATA 2022 adjustment of the fundamental constants

It was suggested, that CODATA 2022 paper should be written as soon as possible, with the help of CODATA TGFC members.

12: Other topics

a. Upcoming workshops to endorse.
   - S. Karshenboim informed TGFC about the next FFK, which will take place in Vienna, in May 2023.
   - A workshop might be organized in Mainz in June 2023 by R. Pohl and endorsed by CODATA-TGFC.
b. Several candidates have been proposed as possible new members representing the molecular physics community. This proposition will be discussed once again

during the next TGFC meeting.
The members from atomic mass community did not attend the meeting. In the future, if the members representing a community cannot attend the meeting, they should nominate a representative.

c. P. Mohr proposed an opinion of the CODATA Task Group on Fundamental Constants to the CCU Task Group on angle and dimensionless quantities in the SI Brochure (CCU TG-ADQSIB). TGFC voted: 5 votes in favor of the suggestion, two votes against the suggestion and 4 abstentions. The task group decided to present the opinion to the CCU TG-ADQSIB and to point out that it has no consensus in the CODATA-TGFC.

13: Date and location of the next Task Group meeting

As a primary suggestion, the next Task Group meeting will be held 12-13 September 2023 at the BIPM. It will be updated as soon the date of next CCU meeting will be known.

14: Adjournment

The meeting was adjourned at 12:30 UTC on September 15.