Planck's constant and the Elementary Charge

The 2019 GCWM changes to the fundamental constants

S. Smith Tuesday, January 21, 2020

Abstract

It appears that the current value for the Planck constant which took effect on the 20th May 2019 by the GCWM is erroneous resulting in seventeen errors. It is currently assumed that there exists a certain immutability of physical constants which may or may not be dimensionless quantities, for example ratios between quantities of like dimensions. Subsequent changes in physical constants cannot be considered meaningful if it results in a change of observational evidence.

Introduction

The recent changes effective the 20th May 2019 to the value of the Planck constant and the Elementary charge appears to have had unintended consequences as it would seem that the published values are inaccurate. By checking the value using other constants it was found that there are distinct correlation errors, indicating that the current published values are indeed erroneous.

The new values of fundamental constants which are of interest are as follows;

- Planck constant h $6.626\ 070\ 15 \times 10^{8}$ J s
- Elementary charge e $1.602\ 176\ 634\ \times 10^{-19}$C

Although other constants assume a new fixed value such as the Boltzmann and Avogadro constants the changes had no impact on other fundamental constants but rather on the unit definitions.

The problem arises in the Planck constant and the elementary charge, which are both elements used in the calculated value of the Fine Structure constant and the Compton wavelength. In particular the Fine Structure constant is not only measured but is also calculable to an exceptional degree of accuracy.

The proposed values which are consistent with all other values for the fundamental constants are;

- Planck constant h $6.626\ 070\ 11 \times 10^{8}$ J s
- Elementary charge e $1.602\ 176\ 625\ \times 10^{-19}$C

In order to establish a minimum set of reference variables from which many of the values of fundamental constants are arrived at, the following four were chosen for their obvious interdependence accuracy and commonality with the remaining fundamental constants.

§1. The Speed of Light [c]

The speed of light is used as the basic measurement of velocity throughout, the current agreed upon value being;

$$c = 2.997\ 924\ 58 \times 10^{8}\mathrm{m} \cdot \mathrm{s}^{-1} \qquad (1.0)$$

Clearly one of the most fundamental constants, the value and accuracy of which is hardly in dispute.

§2. The Mass of an electron [m_e]

It is currently thought that the mass of the electron is immutable and a universal value throughout the Universe. This being the case it is considered an ideal measure of mass;

$$m_e = 9.109\ 383\ 7015 \times 10^{-31}\mathrm{kg} \qquad (2.0)$$

Clearly, one of the more accurately measured constants, the value of which can be established by cross correlation with the Bohr model of the Hydrogen atom and also the Fine Structure constant.

§3. The Bohr Radius [a_0]

Even though the fine structure constant is a calculated value due to its relevance it is also used as a base value upon which other constants may be measured;

$$a_0 = 5.291\ 772\ 109\ 03 \times 10^{-11}\mathrm{m} \qquad (3.0)$$

As one of the more accurately measured constants the current method of establishing an accurate value being;

$$a_0 = \frac{h^2 e}{\varepsilon^2 \pi m} = 5.291\ 772\ 109\ 03 \times 10^{-11}\mathrm{m} \qquad (3.1)$$

The above equation is a somewhat simplified version of the method to establish the Bohr radius which nonetheless produces an identical value.

§4. The Fine Structure Constant [α]

Even though the fine structure constant is a calculated value, due to its relevance it is used as a base value upon which other constants may be validated;

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \frac{\omega}{c} = 7.297\,352\,527 \times 10^{-3} \qquad (4.0)$$

As one of the more accurately measured constants the current method of establishing a value is above including the original Sommerfeld definition as a ratio of quantities of like dimensions which results from simplification.

Having established the base from which other constants can be calculated an analysis of the 2019 changes can be performed.

§5. The Planck Constant [h]

The current agreed upon value of the Planck constant following the 2019 changes being;

$$h = 6.626\,070\,15 \times 10^{-34}\mathrm{J}\cdot\mathrm{s}^{-1} \qquad (5.0)$$

The fixing of the Planck constant at this value creates problems for other fundamental constants. There are however several alternative methods of establishing the Planck constant whereby the only value which satisfies all calculations being;

$$h = 6.626\,070\,11 \times 10^{-34}\mathrm{J}\cdot\mathrm{s}^{-1} \qquad (5.1)$$

It can be seen that the Planck constant has dimensions of physical action namely energy multiplied by time, or momentum multiplied by distance**.** Not coincidentally, this value can also be calculated from the ground state electron of a Hydrogen atom using the same interpretation and dimensions;

The orbital velocity of the electron can be calculated using the following;

$$\omega = \alpha c = 2.187\,691\,251 \times 10^{-34}\mathrm{m}\cdot\mathrm{s}^{-1} \qquad (5.2)$$

Furthermore, this value can be once more cross checked to ensure consistency;

$$\omega = \frac{h}{2\pi r m} = 2.187\,691\,251 \times 10^{-34}\mathrm{m}\cdot\mathrm{s}^{-1} \qquad (5.3)$$

Utilizing the result of the prior equations the correct value for the Planck constant can be obtained;

$$m_e a_0 \omega = 6.626\,070\,11 \times 10^{-34}\mathrm{J}\cdot\mathrm{s}^{-1} \qquad (5.4)$$

This value agrees exactly with the suggested value shown previously in (5.1) which differs from the currently published value, which is considered erroneous.

§6. The Elementary Charge [e]

The current agreed upon value of the Elementary charge following the 2019 changes being;

$$e = 1.602\,176\,634 \times 10^{-19}\mathrm{C} \qquad (6.0)$$

To perform an additional check if this value is correct requires nothing more than the equation actually used in CODATA to calculate the elementary charge, which itself yields an inaccurate value;

$$e = \sqrt{\frac{2ha}{\mu_0 c}} = 1.602\,176\,630 \times 10^{-19}\mathrm{C} \qquad (6.1)$$

It can be seen that the new value of the elementary charge does not coincide with the calculation suggesting that the new value for the Planck constant is indeed inaccurate as all remaining values are agreed constants. Being that this value affects several of the fundamental constants it is found that the only acceptable value for the elementary charge which satisfies the remaining constants is;

$$e = 1.602\,176\,625 \times 10^{-19}\mathrm{C} \qquad (6.2)$$

All that is required to obtain this value is to change the current value of the Planck constant to the value suggested in the prior section (5.4).

§7. The Compton Wavelength [λ_c]

The current agreed upon value of the Compton wavelength following the 2019 changes being;

$$\lambda_c = 2.426\,310\,238\,67 \times 10^{-12}\mathrm{m} \qquad (7.0)$$

This value for the Compton wavelength can be calculated using the current value of the Planck constant;

$$\lambda_c = \frac{h}{mc} = 2.426\,310\,238\,67 \times 10^{-19}\mathrm{C} \qquad (7.1)$$

Once more this value suggests that the currently published value for the Planck constant is indeed erroneous. If the Planck constant is taken to be the suggested value as shown in (5.4) it can be seen that the value of the Compton wavelength would then be;

$$\lambda_c = 2.426\,310\,224\,78 \times 10^{-19}\mathrm{C} \qquad (7.2)$$

The value of this constant in particular affects many of the atomic and nuclear fundamental constant values, including

the electron, muon, tau, proton and neutron when calculation includes the Compton wavelength.

Summary

It has been shown that the currently published values for the Planck constant and the elementary charge are inaccurate. It has also been shown that there are only two calculated values which satisfy the conditions of cross correlation with other published constants.

It is also clear that due to the two erroneous values for the Planck constant and the Elementary charge, the ultimate goal of the exercise has been compromised inasmuch as the very unit definitions as shown in the table below are also incorrect.

It is thought by the author that there is no option but to discard the recent changes and to republish the more accurate values as shown in the table below.

Property	Symbol	Base Values	
Speed of light in a vacuum	c	$2.997\,924\,580 \times 10^{8}$	
Electron mass	m_e	$9.109\,383\,702 \times 10^{-31}$	
Fine Structure constant	α	$7.297\,352\,528 \times 10^{-3}$	
Bohr radius	a_0	$5.291\,772\,109 \times 10^{-11}$	
		Calculated Values	Redefined Values
Elementary Charge	e	$1.602\,176\,625 \times 10^{-19}$	$1.602\,176\,634 \times 10^{-19}$
Planck constant	h	$6.626\,070\,112 \times 10^{-34}$	$6.626\,070\,150 \times 10^{-34}$
Planck constant reduced	$\hbar$	$1.054\,571\,812 \times 10^{-34}$	$1.054\,571\,818 \times 10^{-34}$
Josephson constant	K_J		
Compton wavelength	λ		
Ground state of Caesium atom		$9.192\,631\,770 \times 10^{9}$	
Units			
Second	s	$9.192\,631\,770 \times 10^{9}$	$9.192\,631\,770 \times 10^{9}$
Meter	m	$3.066\,331\,899 \times 10^{1}$	$3.066\,331\,899 \times 10^{1}$
Kilogram	kg	$1.475\,521\,408 \times 10^{40}$	$1.475\,521\,400 \times 10^{40}$
Joules per second	J/s	$1.509\,190\,188 \times 10^{33}$	$1.509\,190\,180 \times 10^{33}$
Joule	J	$1.641\,738\,978 \times 10^{23}$	$1.641\,738\,968 \times 10^{23}$
Watt	W	$1.785\,929\,230 \times 10^{13}$	$1.785\,929\,219 \times 10^{13}$
Newton	N	$5.354\,081\,136 \times 10^{21}$	$5.354\,081\,105 \times 10^{21}$
Ampere	A	$6.789\,686\,854 \times 10^{8}$	$6.789\,686\,817 \times 10^{8}$
Coulomb	C	$6.241\,509\,108 \times 10^{18}$	$6.241\,509\,074 \times 10^{18}$
Kelvin	K	$2.266\,665\,278 \times 10^{0}$	$2.266\,665\,265 \times 10^{0}$
Mole	mol	$4.361\,818\,797 \times 10^{46}$	$4.361\,818\,797 \times 10^{46}$
Candela	cd	$2.614\,830\,497 \times 10^{10}$	$2.614\,830\,482 \times 10^{10}$

References

SI Brochure of changes 2019