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Integer-Valued Physical Constants Based on Atomic-Hydrogen Physical Quantities

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Abstract

By using a set of universally invariable physical quantities derived from hydrogen atoms as basis for measurement units, key physical constants (e.g., C, h, and H) emerge as integers. This integer representation aligns well with physics equations and fundamental laws that primarily depend on integer values. Hydrogen is the simplest and most abundant element in the universe, making it a logical choice for such a primary role. These results may point to a direct link between the physical constants at the quantum scale and those at the cosmic level.

Keywords: physical constants, atomic hydrogen, integer values in physics

1. Introduction

Integer numbers play a crucial role in scientific understanding. Almost all physical laws and equations involve integer exponents for their parameters (Andrews). In quantum mechanics, various quantum numbers such as, angular momentum quantum number, the principal quantum number, and magnetic quantum number are expressed as integers and help describe the discrete (i.e., quantization of) energy levels and properties of atomic and subatomic particles. Quantum particles exhibit spin values that are restricted to integers, half-integers, or third integers (Eisberg, 1965). Furthermore, momentum along any axis is always expressed as an integer or half-integer multiple of the Planck constant (Feynman). The integer-valued quantities provide a mathematical framework for understanding phenomena such as the quantum Hall effect, where the material's conductivity exhibits distinct, quantized steps. Integer numbers are also crucial in group theory, which provides the basis for understanding symmetries and conservation laws in theoretical physics, particularly in particle physics and quantum mechanics.

Given the prevalence of integers in these fundamental scientific concepts, it is reasonable to postulate that key physical constants, such as the speed of light and Planck constant at the quantum scale, as well as the gravitational and Hubble constants at the cosmic level, might also be represented by integer values.

Applying the International System (SI) units to calculate or measure physical constants results in non-integer numbers because of the arbitrary assignment of values that were decided for length, mass, and time.

Hartree atomic units simplify calculations by setting fundamental physical constants of Bohr radius (atomic unit of length), reduced Planck constant, electron mass and the elementary charge where each may be represented by the numeric value one multiplied by a coherent unit of the system (Hartree, 1982). Similarly, Planck units follow a similar principle, defining measurement units based on universal physical constants, also assigning them a value of one [Wilczek, 2005]. At the Planck scale, it is expected that the predictions of general relativity, the standard model, and quantum field theory will not hold true; instead, quantum gravitational effects are predicted to dominate. The caesium-133 standard of time, which serves as the basis for the global frequency standard and as a substitute for the second, relies on a specific transition within its hyperfine structure in Cs atoms (Chen, 2018).

A universally accepted and standardized system of units could be developed using intrinsic physical properties of atomic hydrogen that remain invariant throughout the cosmos. This approach is exemplified by the derivation of fundamental physical constants from the intrinsic properties of atoms and molecules. Such a system would provide a consistent and reliable basis for scientific measurements across the universe, independent of local variations or human-defined standards.

2. Approach

In our new approach presented here, we propose using certain physical properties of atomic hydrogen as the basis for defining a set of measurement units. We make this choice due to hydrogen's position as the first and simplest element in the periodic table. We propose calling these units Atomic Hydrogen (AH) units. We utilize specific physical properties of hydrogen atoms as its foundational reference points.

Unit of length (H_L) – We propose using the Bohr radius as the AH unit of length, serving as its most crucial dimensional attribute (https://physics.nist.gov/cgi-bin/cuu/Value?bohrrada0). This key atomic parameter has been measured with high precision, and very small uncertainty.

Unit of time (H_T) – We propose using the radiative lifetime of atomic hydrogen as the AH unit of time, corresponding to a wavelength of 486.1 nm, (Ankudinov, Bobashev, & Andreev, 1965). Atomic hydrogen possesses multiple upper states, each with unique lifetimes and decay times. The selected time characteristic exhibits the greatest uncertainty compared to the other characteristics considered. Conflicting values for the radiative lifetime for the Balmer-beta upper-state can be found in the literature, many of which stem from unresolved hyperfine structure that yield varying lifetime values. Consequently, these values often represent averages of the lifetimes of the hyperfine states. Furthermore, most published lifetime data lack specified error margins, adding to the overall uncertainty.

Unit of mass (H_M) – We propose using the atomic hydrogen mass value as the AH unit of mass. Its mass was calculated by adding the mass of one proton (https://physics.nist.gov/cgi-bin/cuu/Value?mp) and one electron (https://physics.nist.gov/cgi-bin/cuu/Value?me).

Table 1 summarizes the selected hydrogen physical characteristic values and their uncertainties.

Table 1. Selected atomic hydrogen characteristics

Atomic Hydrogen Physical Constants		SI Unit	Uncertainty	Reference
Length (H_L) Bohr-Radius	5.29177210544E-11	m	(82)	NIST-Bohr Radius
Time (H_T) H_β Radiative Lifetime	3.4E-8	s	(0.15)	Ankudinov
Mass (H_M)	1.67352864321E-27	kg	0	NIST-proton NIST-electron

For example, to convert from the SI into the AH unit, the approximate value of the Bohr radius is $H_L = 5.29x10^{-11}$ m, therefore, m $=1.88x10^{10}$ (H_L). The approximate value for the Balmer upper-state radiative lifetime is $H_T = 3.5x10^{-6}$ s, and s = $2.82x10^5$ (H_T).

Given the above values, the speed of light (m/s) converts to ($2.99x10^8$) x ($1.88x10^{10}$) / ($2.82x10^5$) in units of H_L/H_T. Table 2 summarizes the conversion of some key physical constants from the SI to the AH units. This table calculates the AH-unit values based on the best atomic hydrogen values known to date.

Table 2. Conversion of the SI to AH (atomic hydrogen) units

H-Unit Substitutes for Length, Time, and Mass in SI Unit	**Value in AH Units** (within uncertainty range)	**Value in AH Units** (adjusted slightly outside the uncertainty range)
m = $1/H_L$	1.88972612590000E10	No change
s = $1/H_T$	2.8326282011519E7	No change
kg = $1/H_W$	5.975383104988E26	5.9855741440960E26

To ensure that the value of Planck constant (h) is an integer in the AH units, we had to slightly adjust its mass value outside the known uncertainty. The new value is very close to the unified-atomic-mass-unit, which is defined as 1/12 of the mass of an unbound neutral atom of carbon-12 in its ground-state.

3. Results

Table 3 shows conversion of certain key physical constants from SI to AH units. The values for the constants shewn in Table 3 are obtained from (NIST-C) for speed of light, (NIST-h) for the Planck-constant (Freedman, 2024) for the Hubble constant, (Workman, 2023) for the Cosmological constant, (Gentile, 2011) for the MOND gravitational acceleration, and (NIST-G) for the Gravitational constant.

Table 3. Conversion of key physical constants from SI units to atomic hydrogen units resulting in integer values for certain key physical constants, except for the gravitational constant

Physical Constants	Values (as of 2024)	Uncertainty Range	Values Selected within Uncertainty Range of Physical Constant	Physical Constant Values in AH Unit
C (Speed of light) m/s	2.99792458E8	0	No change	**2.000000000000 E+11**
h (Plank constant) m^2kg/s	6.62607015E-34	0	No change	**5.000000000000 E+6**
H (Hubble constant) s^{-1}	2.237108E-18 2.267247E-18	(0.056713) (0.048611)	2.266102560922E-18	**8.000000000000 E-26**
Λ (Cosmological constant) m^{-2}	1.088E-52	(0.028)	1.0713194492727E-52	**3.000000000000 E-73**
$\mathbf{a_0}$ (MOND Gravitational acceleration) ms^{-2}	1.2738E-10	(0.3)	1.27380085653517E-10	**3.000000000000 E-15**
G (Gravitational constant) $m3.kg^{-1}.s^{-2}$	6.67430E-11	(15)	No change	9.394147544E-22

We see here the surprising results that several well-known constants turn out to be exact integers in the AH system. The conversion of physical constants to AH units, as shown in Table 3, suggests a potential connection between the speed of light (c), Planck's constant (h), and the Hubble constant (H). If this connection is indeed valid, it implies a relationship between quantum-scale constants and H, a fundamental astrophysical constant, indicating a unified framework for matter and energy. Notably, the Gravitational constant stands out as it does not yield an integer value after this conversion. We have not yet attempted software optimization to obtain the most precise values for length, time, and mass. However, implementing such optimization might yield slightly more accurate values in AH unit while preserving the integer nature of the constants.

In Table 3, three examples (H, Λ, and a_0) feature negative exponents. This implies that despite having integer multiplication factors, these values would not be integer numbers without a normalization factor. Currently a common normalization factor that would convert these examples into full integers has not been determined or assigned.

The pursuit of a unified theory of quantum gravity has faced significant hurdles, akin to the apparent discrepancy in the AH units between the integer nature of key Quantum Mechanical Constants and the non-integer Gravitational Constant. This incongruity may underscore the difficulties in reconciling quantum mechanics with gravity. Assuming that certain key Quantum Mechanical Constants of nature are indeed integers while the Gravitational Constant is a non-integer, challenges in uniting gravity with quantum mechanics to develop a quantum gravity theory are highlighted. However, the MOND Gravitational Acceleration Constant does appear as integer.

Table 4 presents the computed values of dimensionless physical constants α and Z using the AH unit conversion. The fine structure constant (α) was calculated from the equation $\alpha = C\mu_0 e^2/2h$ where μ_0 represents the magnetic constant (vacuum permeability). The gravitational redshift (Z) (Bothwell, 2022) was calculated form the equation $Z = g\Delta_h/c^2$, with Δ_h denoting the change in height (set to 1), and g being $9.80665 m/s^2$. The fine structure constant referred to in Table 4 is based on more precise measurements of the electron magnetic modem (Fan 2023).

Table 4. Calculation of dimensionless physical constants a and Z based on AH Units

Physical Constants	2023 Measured Value	Value Calculated in AH Units Within the Uncertainty Range
Fine Structure Constant (α)	0.007297352565	0.007297352557
Gravitational Redshift (Z)	1.0900E-16	1.09114E-16

Temperature – We have not been able to select an appropriate thermal characteristic for hydrogen atom. Many properties ascribed to atomic hydrogen are in fact derived from measurements or analyses of molecular hydrogen (H_2).

4. Conclusion

The analysis presented above suggests that when using the intrinsic properties of the hydrogen atom as universal measurement units, several fundamental physical constants emerge as integers, aligning with the integer exponents found in physics equations. This observation potentially reveals a direct connection between quantum-scale and astronomical-scale physical constants. If the integer values derived from atomic hydrogen units are not coincidental, the proposed alternative unit system could be utilized to determine precise values for certain physical constants and measured properties that currently have significant uncertainties. This approach may also offer a new perspective on the fundamental relationships between physical quantities across different scales of the universe.

5. Future Steps

Certain numerical finding presented in this study regarding specific physical constants may be fortuitous rather than significant. Additional research and scrutiny would be necessary to confirm the validity and relevance of each identified integer value. A more rigorous analysis could help distinguish between meaningful patters and random occurrences in the data. The scope of this analysis was limited to a subset of physical constants, specifically those associated with the dimensions of length, mass, and time. Expanding the investigation to include additional atomic hydrogen properties, such as temperature characteristics, could potentially allow for the examination of a much broader range of physical constants. Furthermore, gaining deeper insights into the reasons why some fundamental constants manifest as integers while others do not may of scientific value.

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Authors' contributions

Dr. H. Hemmati was solely responsible for the concept and the analysis. All authors read and approved the final manuscript.

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References

Ankudinov, V. A., Bobashev, S. V., & Andreev, E. P. (1965). Measurement of Lifetimes of Excited States of the Hydrogen Atom. *Soviet Physics JETP, 21*, 26-32.

Bothwell, T., Kennedy, C. J., Aeppli, A., Robinson, J. M., Oelker, E., Staron, A., & Ye, J. (2022). Resolving the gravitational redshift across a millimeter-scale atomic sample. *Nature 602420-424*. https://doi.org/10.1038/s41586-021-04349-7

Chen, T.-J., *et al.* (2018). Absolute frequency of Cesium 6S1/2-6D3/2 hyperfine transition with a precision to nuclear magnetic octupole in interaction. *Optics Lett.,* 1954-1957. https://doi.org/10.1364/OL.43.001954

Eisberg, R., & Resnick, R. (1965). *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles* (2nd ed.). Wiley, pp. 272-273.

Fan, X., Meyers, T. G., Sukra, B. A. D., & Gabrielse, G. (2023). Measurement of the Electron Magnetic Moment. *Physical Review Letters, 130*(7). https://doi.org/10.1103/PhysRevLett.130.071801

Feynman Lectures in Physics. Retrieved from https://www.feynmanlectures.caltech.edu/II_35.html

Freedman, W., Madore, B. F., Jang, I. S., Taylor, J. H., Abigail J. L., & Owned, K. A. (2024). Status Report on the Chicago-Carnegie Hubble Program (CCHP): Three Independent Astrophysical determinations of the Hubble Constant Using the James Webb Space telescope. Arxiv, Astrophysics.

Gentile, G., Famaey, B., & de Blok, W. J. G. (2011). Things about MOND. *Astronomy and Astrophysics, 527*. https://doi.org/10.1051/0004-6361/201015283

Hartree, D. R. (1982). The Wave Mechanics of an Atom with a Non-Coulomb Central Field. Part I. Theory and Methods. *Mathematical Proceedings of the Cambridge Philosophical Society, 24*(1), Cambridge University Press, pp. 89-110. https://doi.org/10.1017/S0305004100011919

Retrieved from https://physics.nist.gov/cgi-bin/cuu/Value?bg

Retrieved from https://physics.nist.gov/cgi-bin/cuu/Value?bohrrada0

Retrieved from https://physics.nist.gov/cgi-bin/cuu/Value?me

Retrieved from https://physics.nist.gov/cgi-bin/cuu/Value?mp

Retrieved from https://www.andrews.edu/~rwright/physics/Physics%20Formula%20Sheet.pdf

Retrieved from https://www.nist.gov/physics/what-planck-constant

Retrieved from https://www.nist.gov/si-redefinition/meet-constants

Wilczek, F. (2005). On Absolute Units, I: Choices. *Physics Today, 58*, 12-13. https://doi.org/10.1063/1.2138392

Workman, R. L., *et al.* (2023). Review of Particle Physics, 2. *Astrophysical Constants and Parameters*.