

The constants they are a changin': NIST posts latest adjustments to fundamental figures

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2010

2006 CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL CONSTANTS OF PHYSICS AND CHEMISTRY

Values from: P. J. Mohr, B. N. Taylor, and D. B. Newell, Rev. Mod. Phys. 82(2):1515-1586 (2010) and J. Phys. Chem. Ref. Data 39(2):1-108 (2010). The number in parentheses is the one-sigma (1 σ) uncertainty in the last two digits of the given value.

Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	c	299 792 458 (exact)	m s^{-1}
gravitational constant	G	$6.674 08(46) \times 10^{-11}$	$\text{N m}^2 \text{kg}^{-2}$
electric constant $1/4\pi\epsilon_0$	k_e	$8.987 551 788(48) \times 10^9$	F m^{-1}
Newtonian constant of gravitation	γ	$7.408 4(41) \times 10^{-8}$	$\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$
Planck constant	h	$6.626 068 96(46) \times 10^{-34}$	J s
elementary charge	e	$1.602 176 634(94) \times 10^{-19}$	C
Fine-structure constant $\alpha^2/4\pi\epsilon_0\hbar c$	α^2	$7.297 352 5698(54) \times 10^{-5}$	
inverse fine-structure constant	α^{-1}	$137.035 989 794(86)$	
Rydberg constant $\alpha^2 m_e c^2/2\hbar^2$	R_∞	$10 973 731.568 539(65)$	m^{-1}
Bohr radius $a_0/4\pi\epsilon_0$	a_0	$0.529 177 234 763(21) \times 10^{-10}$	m
Bohr magneton $e\hbar/2m_e$	μ_B	$9.274 009 474(47) \times 10^{-24}$	J T^{-1}

Credit: Mohr, Talbott/NIST

The electromagnetic force has gotten a little stronger, gravity a little weaker, and the size of the smallest "quantum" of energy is now known a little better. The National Institute of Standards and Technology (NIST) has posted the latest internationally recommended values of the fundamental constants of nature.

The constants, which range from relatively famous (the [speed of light](#)) to the fairly obscure (Wien frequency displacement law constant) are adjusted every four years in response to the latest scientific measurements and advances. These latest values arrive on the verge of a worldwide vote this fall on a plan to redefine the most basic units in the International System of Units (SI), such as the [kilogram](#) and ampere,

exclusively in terms of the fundamental constants.

The values are determined by the Committee on Data for Science and Technology (CODATA) [Task Group on Fundamental Constants](#), an international group that includes NIST members. The adjusted values reflect some significant scientific developments over the last four years.

Often the biggest news in a fundamental constant value is a reduced uncertainty—scientists know the value better. The uncertainty in the value of the fine-structure constant alpha ($\alpha = 7.297\,352\,5698 \times 10^{-3}$), which dictates the strength of the [electromagnetic force](#), has been slashed in half to 0.3 parts per billion (ppb). Since alpha can be measured in a uniquely broad range of phenomena from the recoil of atoms to the magnetic properties of electrons, the consistency of the measurements acts as a barometer of scientists' general understanding of physics. Alpha will also be a critical constant after a redefinition of the SI: it will remain an experimentally determined constant, while quite a few others' values will be fixed to define the basic measurement units.

Also improved is the Planck constant h , which defines the size of the smallest possible "quantum" (packet) of energy, and is central to efforts to redefine the SI unit of mass. The latest value of h ($6.626\,069\,57 \times 10^{-34}$ joule seconds) takes into account a measurement of the number of atoms in a highly enriched silicon sphere. That value currently disagrees with the other fundamental method for determining h , known as the [watt-balance](#). Even so, when all the values are combined, the overall uncertainty of h (44 ppb) is smaller than in 2006, and the values from the two techniques are getting closer to each other.

The 2010 CODATA values incorporate two new experimental measurements of G , the Newtonian constant of gravitation, which dictates the strength of [gravity](#). The latest value of G ($6.673\,84 \times 10^{-11}$ $\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$) is about 66 parts per million smaller than the 2006 value.

Other adjustments have been seen in the constants such as the radius of the proton and other constants related to atoms and gases such as the Rydberg and molar gas constants.

The CODATA task group is preparing a full report on the 2010 adjustments (for now, there is a [brief overview](#)), and the report will include recommendations for future measurements. A plan to adopt a fully constant-based SI, being voted upon this October by the General Conference on Weights and Measures, is contingent upon the values of the fundamental constants such as h reaching certain levels of precision and accuracy that will require further measurement advances in the coming years.

More information: physics.nist.gov/constants

Provided by National Institute of Standards and Technology

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