Changing constants: Measuring progress

Constant	Recommended value	Uncertainty (ppm)
Elementary charge, e	$1.60217733 \times 10^{-19}$ C	0.30
Planck constant, h	$6.6260755 \times 10^{-34}$ J·s	0.60
Electron rest mass, m_e	$9.1093897 \times 10^{-31}$ kg	0.59
Avogadro constant, N_A	6.0221367×10^{23} mol^{-1}	0.59
Faraday constant, F	9.6485309×10^{4} C·mol^{-1}	0.30
Josephson frequency-voltage ratio, $2e/h$	4.8359767×10^{14} Hz·V^{-1}	0.30

Recommended values for selected fundamental constants

Source: CODATA

The values of fundamental physical constants, such as the elementary charge and the mass of an electron, are only as good as the techniques used to measure them. When measurement accuracy improves, then the numerical values of these constants change. The publication this month of new values for a range of fundamental constants represents the first major revision of the numbers since 1973. At least one decimal place has been added to many of the constants. Several values had to be adjusted by larger-than-expected margins.

"The advances [in measurement] across the board were amazing," says physicist Barry N. Taylor of the National Bureau of Standards in Gaithersburg, Md. "There were a lot of new results that had to be taken into account."

Taylor and E. Richard Cohen of the Rockwell International Science Center in Thousand Oaks, Calif., spent almost six years gathering information, reviewing measurements and analyzing data to come up with recommended values. Their report was adopted last summer by the Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions, and the final numbers appear in CODATA "Bulletin 63," recently published by Pergamon Press, Inc., in Elmsford, N.Y.

"Nothing else needs to be done except to get the information out to the troops," says Taylor, "and for everyone to start using the numbers." This also means changes in tables found in textbooks and reference works. "It takes some time for [the adjustment] to diffuse through the system," he says.

Changes in the values of fundamental constants won't affect the definitions of the seven basic units of measurement — the meter, kilogram, second, ampere, kelvin, mole and candela — in the International System of Units (SI). They may, however, alter the practical, laboratory methods used to represent certain units.

Although the volt, for example, is derived from the meter, kilogram, second and ampere, it's more convenient to define a practical voltage standard in terms of an electrical measurement on a Josephson junction. That measurement depends on how accurately the Josephson frequency-voltage ratio is known. The recent change in its value means that current practical representations of the volt are about eight parts per million too small.

Researchers measuring wavelengths in spectroscopy, computing energy levels in atoms or working with high-precision instruments may also find the higher degree of accuracy helpful. But in general, the changes in the fundamental constants will have little impact on everyday life or on normal laboratory work.

"It's the testing of physical theory where it's most critical," says Taylor. If two measurements, done in different ways, produce slightly different results for some constant, then there may be a problem in either or both measurements, or the theory may be incorrect.

"The overall consistency of the whole structure tests how well we can measure," Taylor says. This type of analysis brings inconsistencies to the attention of the scientific community, "and all the people involved then have a renewed motivation to go back and look harder and to try and understand," he says. "That's how science progresses." *— I. Peterson*

Bringing up baby: Emotion's early role

Three-month-old infants may not be able to walk and talk, but by that age they appear able to differentiate among several of their mothers' emotional expressions, according to psychologists at Rutgers — The State University, in New Brunswick, N.J. This is the youngest age at which such discriminations have been shown, say investigators Jeannette M. Haviland and Mary Lelwica, and it suggests that the regulation and shaping of emotional responses begins in the early weeks of life.

"The infants respond as if the presented emotional expression contains meaningful information," report the researchers in the January DEVELOPMENTAL PSYCHOLOGY, "leading to an emotional expression and an emotional state in the infant." While each emotional display had a specific effect on the infants, their behavior was not merely an imitation of the mothers' expressions.

A number of studies have shown that by 6 months most infants can tell the difference between posed versions of several facial expressions, and that they preferentially look at happy poses rather than sad, neutral or angry poses.

Haviland and Lelwica tested 12 infants (6 boys and 6 girls) at 10 weeks old. The infants' mothers were trained to display happy, sad and angry facial expressions. Each expression was presented to the infants in four 15-second periods, with the mother turning her head away for 20 seconds between periods. While facing their babies, mothers were instructed to speak continuously, saying, "You make me [happy, sad or mad]" and matching their voices to the facial expressions.

Videotapes of mothers and infants were independently analyzed by the researchers for second-by-second changes in behavior and emotional expression.

The researchers were easily able to identify each mother's emotion display over a 15-second interval, although most mothers did not continuously hold to the precise expression they were trained on. Nevertheless, consistent patterns of infant responses to the three emotional displays were apparent within 1 second following the mothers' presentation of an expression.

Infants initially reacted to their mothers' happy presentations by matching the joyful expression. Over the four presentations, however, infants' facial movements and the amount of time they gazed at their mothers became increasingly expressive of interest and less expressive of happiness. Infants faced forward continuously during these sessions.

Anger expressions increased and physical movement and expressions of interest decreased over the mothers' four angry presentations. Infants frequently looked toward the side during these sessions. Crying was rare, except in four infants who were not included in the final sample because the anger display caused intense crying.

In response to mothers' sad expressions, infants predominantly engaged in "mouthing" behavior that included lip and tongue sucking and pushing the lips in and out. This appears to be a "self-soothing" response to the sad expressions, note the researchers. Infants tended to gaze down during these sessions. *— B. Bower*