Time Line for the Definition of the Meter

By: William B. Penzes

1791 The International System (formerly called the Metric System) is the decimal system of weights and measures based on the meter and the kilogram. The essential features of the system were embodied in a report to the French National Assembly by the Paris Academy of Sciences.

1799 Originally intended to be one ten-millionth part of the quadrant of the earth, the so called *Meter of the Archives* was based on a measurement of a meridian between Dunkirk and Barcelona. A platinum bar with a rectangular cross section and polished parallel ends was made to embody the meter. The meter was defined as the distance between the polished end faces at a specified temperature and it was the international standard for most of the 19th century. It was compared to other bars with optical comparators as a means of disseminating the unit.

1859 J.C. Maxwell suggested choosing as a natural standard, the wavelength of the yellow spectral line of sodium.

1866 By act of the U.S. Congress, the use of the metric system was legalized in this country, but was not made obligatory.The International Commission of the Meter made the Meter of the Archives the official definition of the meter and the standard of length. It was admitted that its relationship to a quadrant of the earth was tenuous and of little consequence anyway. The Commission had 30 prototype meters made using the Meter of the Archives as the reference.

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1875 On May 20, the *Treaty of the Meter* was signed by seventeen countries, including the United States, at the International Metric Convention. As a result, the International Bureau of Weights and Measures (Bureau Intérnational des Poids et Mésures, BIPM) was established.

1889 A new modified Xshaped cross-section graduated platinum-iridium line standard was developed and adopted as the *International Prototype Meter*. The meter was defined as the distance between the two graduation lines at 0 °C. Each member country in the International Metric Convention received two copies of the standard with calibration reports relating them to the prototype. All meter bar calibrations were done by comparisons in optical comparators.

Prototype Meter No.27 served as the U.S. primary standard from 1889 to 1960. Its length is known in terms of the international prototype, having been returned to BIPM for recomparison four times during that period. It is now on exhibit in the NIST Museum at Gaithersburg, Maryland.

1890 A.A. Michelson found that the red spectral line of natural cadmium was exceptionally coherent.

1892 Michelson used an interferometer that he developed to determine the length of the International Prototype Meter in terms of the cadmium red line wavelength. His measurements gave the meter a value of 1,553,164.13 times the wavelength of cadmium red in air, at 760 mm of atmospheric pressure at 15 °C.

1921 A. Perard began a systematic study of the radiations of cadmium, mercury, helium, neon, krypton, zinc and thallium, to determine which might best serve as defining lengths.

1925 The Michelson interferometer was in regular use at BIPM for measuring length.

1950 Cadmium 114, mercury 198, and krypton 86 were candidates to be a new definition of the meter based on the wavelength of light.

1960 On October 14, the Eleventh General Conference on Weights and Measures redefined the International Standard of Length as 1,650,763.73 vacuum wavelengths of light resulting from unperturbed atomic energy level transition $2p_{10}$ $5d_5$ of the krypton isotope having an atomic weight of 86. The wavelength is

$$\lambda = 1 \text{ m} / 1{,}650{,}763.73 = 0.605{,}780{,}211 \ \mu\text{m}$$

At different times some national laboratories used light sources other than krypton 86 as length standards. Mercury 198 and cadmium 114 were among these and they were accepted by the General Conference as secondary length standards.

1964 Helium-Neon stabilized laser wavelengths were coming into use as length standards. Although the laser wavelength was generally accepted as a secondary standard, its widening use was mainly based on its remarkable coherence. Long distances could be measured by laser interferometry that would be impossible with atomic light sources. Line scales of length are measured by dynamic (fringe counting) laser interferometry at NIST.

1980 The iodine stabilized Helium-Neon laser wavelength was accepted as a length standard. It had a wavelength uncertainty of 1 part in 10^{10} at the time.

1983 On October 20, the meter was redefined again. The definition states that *the meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second*. The speed of light is

$$c = 299{,}792{,}458 \text{ m/s}$$

The second is determined to an uncertainty, U = 1 part in 10^{14} by the Cesium clock. The General Conference made the iodine stabilized Helium-Neon laser a recommended radiation for realizing the meter at this time. The wavelength of this laser is

$$\lambda_{HeNe} = 632.99139822 \text{ nm}$$

with an estimated relative standard uncertainty (U) of ± 2.5 x 10^{-11}.

In all of these changes in definition, the goal was not only to improve the precision of the definition, but also to change its actual length as little as possible.

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