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WILLIAM FREDERICK MEGGERS

1888—1966

A Biographical Memoir by

PAUL D. FOOTE

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WILLIAM FREDERICK MEGGERS was born in Clintonville, Wisconsin, on July 13, 1888, of German parents who came to Wisconsin from Pomerania before 1872. Most of his youth was spent on a farm two miles west of Clintonville. He attended the public schools in Clintonville and was graduated as valedictorian by the high school in 1906. In 1907 he entered Ripon College on a scholarship and earned most of his expenses by organizing a dance orchestra in which he played the slide trombone. He was awarded a B.A. degree in 1910 and remained another year as graduate assistant to Professor William H. Barber, head of the Physics Department. During the academic year 1911-1912 he served the University of Wisconsin as laboratory assistant and was a graduate student under the physicists Max Mason, C. E. Mendenhall, and L. R. Ingersoll.

In September 1912 Meggers moved to Pittsburgh where he became an instructor in physics at the Carnegie Institute of Technology. In March 1914, after reading the classical paper on "Constitution of Atoms and Molecules" by Niels Bohr, he decided to become a spectroscopist. He passed a two-day civil service examination and was appointed on June 12, 1914, at considerable financial sacrifice, a laboratory assistant with the National Bureau of Standards.

Here he served continuously for more than half a century in spectroscopy, photography, and atomic physics. He was officially retired in 1958 as Chief of the Spectroscopy Section but continued working until a few days before his death in 1966. By working a seven-day week and utilizing vacations and accumulated leave for academic studies, he earned the master's degree from the University of Wisconsin in 1916 and his doctorate from Johns Hopkins in 1917.

His lifework can be summarized under four general headings: (*a*) precision measurement of standard wavelengths, (*b*) detailed descriptions of photographed spectra, (*c*) quantum interpretation of these spectra, and (*d*) practical applications of spectroscopy.

Most atomic and ionic spectra embrace thousands of different wavelengths that for correlation and standardization purposes must be measured with a precision of one part in one to twenty million. Meggers holds the world's record for contributions to this program over the past fifty years. The first international standards of wavelength were taken in 1910 from an iron arc by measuring with interferometers selected spectral lines relative to the red cadmium line then adopted as the primary standard of wavelength. Since 1919 the work has been under the supervision of the International Astronomical Union, to which Meggers was the chief contributor. His iron lines from 2100 to 10,216 Angstroms are unique. In 1925 he initiated a program of interferometric measurement of absorption lines in the solar spectrum, the first modern spectroscopic standards in astrophysics.

In 1947 he developed a lamp utilizing mercury 198 transmuted from gold, demonstrated its superiority, and proposed its adoption as a primary standard of length, but so far it has not received international acceptance. He later suggested that better secondary standards could be derived from a mercury

198 electrodeless microwave-excited lamp containing thorium iodide. Using this source, in 1958 he published 222 wavelengths to eight significant figures, and in 1965 extended the range to 510 wavelengths. These thorium standards are ten times as accurate as the iron standards.

Spectra are usually measured at atmospheric pressure but must be corrected for the refractive index of air if employed for atomic interpretation. In 1960 Meggers provided a two-volume *Table of Wavenumbers* for converting wavelengths from 2000 to 10,000,000 Angstroms to wave numbers per centimeter *in vacuo* with an accuracy of one part in one hundred million.

In 1914 the characteristic spectra of atoms and ions were only partially and poorly described, partly because photographic emulsions were insensitive to long wavelengths, and also because satisfactory standards throughout the spectrum were still lacking. Consequently Meggers' second contribution to spectroscopy was to exploit photosensitizing dyes to record spectra in the long wave visible and near infrared. Thus with dicyanin-stained photographic plates he extended records of laboratory arc spectra and the sun's spectrum to 9600A in 1918. By 1934, using new infrared-sensitized emulsions prepared by the Eastman Kodak Company, he succeeded in observing laboratory spectra beyond 13,000A. Later he produced infrared spectral data for more than 70 elements and undertook the improvement of spectral descriptions throughout the entire photographic range (2000 to 13,000A) for all the recently discovered or refined elements such as hafnium, rhenium, technitium, promethium, actinium, niobium, vanadium, scandium, yttrium, lanthanum, thulium, and others. These descriptions are adequate and definitive for spectrochemical analysis and for structural analysis, but there is plenty of work remaining for the future, a single example being his 1966 paper with Corliss

on the spectra of YbI, II, III, IV. Possibly the thousands of lines he evaluated quantitatively for intensity relations may prove to be one of his most important achievements.

Meggers' third major activity involved the quantum theory interpretation of complicated spectra. Multiplets were discovered in 1922 and the vector model of the atom was proposed in 1924-1925 to explain multiplet structure and the anomalous Zeeman effect. During the next forty or more years he disentangled the spectra of some eighty heavy elements and ions, and determined their various quantized energy states and the binding forces on their electrons.

His fourth major activity was the laboratory application of spectra for the identification and quantitative analysis of chemical compositions. In this field he was a pioneer; in 1914 his was probably the only laboratory in the country that regarded spectrochemical analysis as practical and useful. Now there are over 3000 spectrochemical laboratories active in the United States and similar conditions exist in all the other technologically advanced countries of the world. Wavelengths, of course, uniquely identify chemical elements for qualitative analysis, but for quantitative analysis the relative intensities of the lines are required. Until recently the intrinsic intensities of relatively few spectral lines had been measured. In 1961, after twenty-eight years of intermittent investigation, Meggers published *Tables of Spectral-Line Intensities* containing relative energies of 39,000 spectral lines in the range 900 to 9000A characteristic of 70 metallic elements observed under standardized conditions. Such data are not only necessary for the chemical laboratory but are of great interest in interpreting the quantum probability theory of collision and reactions. In the early days, working jointly with Keiven Burns, Meggers constructed the first practical stigmatic grating mounting of the so-called

Wadsworth type, in a form that is now widely manufactured commercially.

Every scientist is familiar with the Welch charts of the periodic table of the elements that hang on the walls of every college and high school laboratory. These were first pictorially developed by Henry D. Hubbard and after his death were continually revised and extended by Meggers together with a descriptive booklet or explanatory key summarizing the physical properties of the elements.

Meggers was president of the Optical Society of America from 1949 to 1951, and its representative on the governing board of the American Institute of Physics from 1952 to 1958. Later he was made honorary member of the Optical Society. He received the Frederick Ives medal in 1947 and the C. E. K. Mees medal in 1964. He was awarded the Department of Commerce gold medal in 1949; the medal of the Society of Applied Spectroscopy in 1952; the Cresson medal of the Franklin Institute in 1953; and the Pittsburgh Spectroscopy award in 1963. He was elected to the National Academy of Sciences in 1954. At various times he was chairman of the National Research Council Committee on line spectra; president of the International Joint Committee for Spectroscopy; and president of the Wavelength Commission of the International Astronomical Union. He was a member of Phi Beta Kappa and Sigma Xi and was active in many of the technical societies and organizations.

William Frederick Meggers died November 19, 1966, after a brief illness, at the age of seventy-eight. He is survived by his wife, Edith Marie Raddant; a daughter, Betty Jane Evans, an archaeologist; a son, William Frederick Meggers, Jr., a physicist and electronic engineer; and three grandchildren. A second son, John Charles Meggers, an engineer, preceded him in death by only a few weeks.

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KEY TO ABBREVIATIONS

Anal. Chem. = Analytical Chemistry
Astrophys. J. = Astrophysical Journal
Internat. Critical Tables = International Critical Tables
J. Opt. Soc. Am. = Journal of the Optical Society of America
J. Opt. Soc. Am. Rev. Sci. Instr. = Journal of the Optical Society of America and Review of Scientific Instruments
J. Res. Nat. Bur. Std. = Journal of Research of the National Bureau of Standards
J. Wash. Acad. Sci. = Journal of the Washington Academy of Sciences
Nat. Bur. Std. Sci. Pap. = National Bureau of Standards, Scientific Papers
Nat. Bur. Std. Tech. News Bull. = National Bureau of Standards, Technical News Bulletin
Phil. Mag. = Philosophical Magazine
Phys. Rev. = Physical Review
Proc. ——— Summer Conf. Spectry. Applications = Proceedings of the ——— Summer Conference on Spectroscopy and Its Applications
Publ. Allegheny Obs. Univ. Pittsburgh = Publications of the Allegheny Observatory of the University of Pittsburgh
Publ. Astron. Soc. Pacific = Publications of the Astronomical Society of the Pacific
Rev. Mod. Phys. = Reviews of Modern Physics
Sci. Monthly = Scientific Monthly
Spectrochim. Acta = Spectrochimica Acta
Trans. Internat. Astron. Union = Transactions of the International Astronomical Union
Z. Physik = Zeitschrift fuer Physik

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