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FREDERIC HANLEY SEARES

1873—1964

A Biographical Memoir by

ALFRED H. JOY

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Biographical Memoir

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FREDERICK HANLEY SEARES

May 17, 1873–July 20, 1964

BY ALFRED H. JOY

THE FIRST YEARS of the twentieth century were marked by a rapid growth of interest in the physical sciences. Fundamental investigations of the structure of matter and the properties of the distant heavenly bodies were developing at the same time with the aid of improved devices and methods in both areas.

Of the basic data needed in various lines of astrophysical research, none was more exacting or more significant than knowledge of the intrinsic luminosities of the stars. During an exceptionally long period of time and with highly concentrated activity, Frederick H. Seares was an outstanding leader and zealous contributor to advances in this field, both in the observational procedures involved and in the application of results obtained by himself and other observers to the various problems of astronomy. His goal was always the highest possible precision obtainable both in observation and in analysis.

At the invitation of George E. Hale, Seares came to the Mount Wilson Observatory in its early years and had a major part in its program until his retirement in 1940. For thirty-one years he gave uninterrupted effort to the work of the Observatory and to the essential, though often baffling, program of photometric investigations that he had set for himself.

Frederick Hanley Seares was born May 17, 1873, on a farm

near Cassopolis, Michigan, and died in Honolulu, July 20, 1964, at the age of ninety-one. The history of the Seares family, which was of British ancestry, dates back as far as 1633 in America to Richard Seares of the Plymouth Colony. His sons were Paul (1637-1707) and Silas (1639-1698). The family was not immune to the great western movement of those days and Frederick's great-great-grandfather, Richard Seares (1771-1838), who was born in Connecticut, moved to Dutchess County, New York, then to Pennsylvania, and died in Michigan. His son Isaac (1794-1839) with his family moved west from Erie County, Pennsylvania, between 1821 and 1836. They cut their way through surrounding forests and built a home two miles from Cassopolis in southwestern Michigan. One of Isaac's eleven children was Frederick's grandfather, William Seares (1816-1894), who remained there on the farm as long as he lived. After his father died, at the age of twenty-three he became the head of the pioneer family of twenty-one persons. He taught school, became County Treasurer, and founded the first church in Cassopolis. His son, Isaac Newton Seares (1847-1922), was Frederick's father. On account of the austere conditions prevailing during his youth, Isaac had little opportunity for formal schooling but by his own studies he managed to attain a considerable education.

In 1870 he married Ella Ardelia Swartwout, who was of Dutch descent but whose family had been in America for 200 years. Frederick was born three years later.

In 1878 Isaac with his family left Michigan and set forth to the west, this time to the unsettled prairie 18 miles from LeMars in the very northwest corner of Iowa. Frederick retained vivid recollections of the blizzards, prairie fires, and the loneliness that he experienced as a small boy on the great plains. After a short stay there the family took up residence in the nearby town of Ireton, and later in Rock Rapids, where his

father was the land agent for an English syndicate. In 1887 Isaac again turned west and came to Pasadena, California, where he engaged in real estate and insurance until 1896. He later moved to Long Beach, and to Corona where he had charge of large orange groves.

While they were in Pasadena, Frederick made good use of his educational opportunities and in 1890 was one of six members of the first graduating class of the Pasadena High School. During the summers he worked as a carpenter and acquired considerable skill which he made use of after his retirement, in rebuilding and refinishing a number of pieces of fine furniture that he had acquired in earlier years.

One summer he sailed with Steven Cutter Clark to Honolulu, Tahiti, and islands of the South Pacific. As a result of this long voyage he became very fond of the sea stories of Conrad and Stevenson, which he frequently read with great enjoyment to his son Richard.

For his college course Seares went to Berkeley, graduating with high honors from the University of California in 1895. Evidently during his studies there he became interested in astronomy and joined the Astronomical Society of the Pacific while he was still an undergraduate. He was a member of the Beta Theta Pi fraternity and an officer in the Military Training Cadet Corps. Although the graduate department of astronomy had not yet been organized, he remained in Berkeley for four years after graduation. (The first doctorate in astronomy at Berkeley was not awarded until 1901.) As Fellow and Assistant he continued his studies with Professor A. O. Leuschner and achieved great skill in computing orbits of comets—an accomplishment that intrigued him for some ten years.

On May 28, 1896, Seares married Mabel Urmy of Berkeley, who was a teacher in Miss Head's School for Girls. After they came to Pasadena some years later she founded and edited for

ten years the beautifully illustrated home and garden magazine, *California Southland,* which in 1928 was merged with the *Pacific Coast Architect.* She was also interested in civic and philanthropic activities, especially the Assistance League.

The family enjoyed outdoor trips by horseback in the mountains and explored as far as Santa Cruz. At home, they shared musical evenings with some of the well-known musicians of the neighborhood, Seares playing the violin with considerable skill.

In the summer of 1899 Mr. and Mrs. Seares went to Europe, where he studied for a year in Munich and a year in Paris. They took several bicycle trips together in different countries. Their only child, Richard Urmy Seares, was born in September 1900 during their stay in Paris.

Returning to America in 1901, Seares accepted a position as Professor of Astronomy in the University of Missouri and Director of the Laws Observatory at Columbia. The 7½-inch telescope there was one of the earliest to be mounted in the United States. It was reconstructed and new auxiliary instruments were obtained. With this modest equipment he succeeded in developing a fruitful program of observations of many variable stars and comets in addition to organizing the department of astronomy.

When the observational program for the new 60-inch reflector on Mount Wilson was inaugurated in 1909, Hale invited Seares to come to the Mount Wilson Observatory and take advantage of the opportunities opened up by the enlarged staff and powerful equipment.

In Pasadena, Seares was asked to take charge of the Computing Division and the editorial work on publications by the members of the staff. He was also largely responsible for building up a working library. For stellar research, he proposed to investigate the feasibility of using the increased light-

gathering power of the 60-inch telescope to extend accurate photometry to the faintest observable stars. Previously reflectors had not been used to any great extent for stellar photometry.

At that time great interest in the system of the stars had been aroused by the studies of stellar motions by the Dutch astronomer J. C. Kapteyn. Over the years many of the brighter stars had been observed with meridian circles for changes in position in the sky with respect to other stars—a parameter known as proper motion. For these stars velocities in the line of sight (radial velocities) were under observation by W. W. Campbell and his colleagues at the Lick Observatory.

Visual estimates of apparent brightness or magnitude had been made at the transit circle for stars brighter than the 9th magnitude and were recorded in the *Bonner Durchmusterung* published in 1862. At the Harvard Observatory, through a colossal effort by several observers for many years, more accurate visual magnitudes of these stars had been measured with meridian photometers, but no photographic magnitudes were available for these stars, and for fainter objects no observations had been made.

Knowledge of stellar distances, needed to convert the magnitudes to intrinsic luminosities, was almost entirely lacking because of the tedious and inaccurate observational procedures used in their determination.

The advent of larger telescopes with greater focal lengths together with improved methods of observation and reduction provided much more accurate distances. By the use of direct photographs with the great Yerkes 40-inch refractor and, later, other large telescopes, in a comparatively short time a considerable number of reliable stellar distances were determined. They furnished a solid foundation upon which studies of the Galaxy as a whole might be based. Data were still lacking for the more

distant and the fainter stars. Within a few years distance measures were vastly extended by the spectroscopic method developed by W. S. Adams, and Seares undertook to extend the magnitude scale to the limit of the 60-inch telescope.

It was evident that new photometric methods and basic standards would be needed for the stars fainter than those of the Harvard North Polar Sequence. This sequence was preferred because its position in the sky permitted observations throughout the night and the year.

To obtain accurate standards for the extended range of 100 million to 1 in brightness, much preliminary investigation was necessary. With his characteristic devotion to precision Seares began by thoroughly checking the magnitudes of the Polar Sequence as observed at Harvard and several other observatories. Corrections for the bright and the faint stars were found necessary, but for the stars of intermediate magnitudes the Harvard values were acceptable and furnished the zero point for new dterminations of additional and fainter stars. The Harvard Polar Sequence was largely visual, but by the use of color filters and dyed photographic plates Seares was able to duplicate the visual values by photography. He called these results "photovisual" magnitudes.

He observed stars of known brightness to check the zero point. For the scale, he placed above the telescope tube wire-gauge screens and diaphragms whose reductions of light could be determined once for all. Temperature variations produced changes in the figure of the mirror which, in turn, altered the shape of the stellar images on the plates and the corrections to be applied on account of the distance of each star image from the axis, but with scrupulous attention to the details of observing techniques satisfactory results with uncertainties less than 0.1 magnitude could be obtained. After meeting the numerous difficulties that arose he was able to extend the scale to the 20th photographic magnitude.

Because of the limitations of the Harvard Sequence, Seares came to the conclusion that a much larger number of standard stars was needed, and in 1932 he planned a definitive catalogue to include a wider range of magnitudes and colors, using stars from $+80°$ declination to the pole.

Seven existing catalogues were intercompared and elaborate analyses made to reduce the magnitudes to his system, which was adopted by the International Astronomical Union in 1922. The final catalogue included, as well, results deduced by Seares from large-scale photographs taken by F. E. Ross with four different cameras.

The resulting photographic and photovisual values with color indices for 2271 stars brighter than about photographic magnitude 11.5 were published in 1941. The estimated average error is 0.02 magnitude.

On account of the vast number of stars in our galactic system, Kapteyn in 1906 proposed a sampling method for cutting down the time required to obtain valuable data with regard to the characteristics of the stars themselves and the structure of the Milky Way system. By world-wide cooperation, observations of positions, motion, magnitude, color, spectrum, and distance of stars in limited sample regions might be obtained in time to permit useful conclusions concerning the structure and evolution of the Galaxy to be drawn within a few decades. Some 206 areas at regular intervals over the whole sky and, in addition, 46 others of special interest were chosen. The scheme, which he called "The Plan of Selected Areas," received enthusiastic support from astronomers, and in the next fifty years much observational effort was directed toward its completion.

Naturally, the photometry of the faintest stars fell to Seares and he gave concentrated attention to the immense undertaking, using photographic plates taken with the 60-inch reflector. The standards in each of the 139 Kapteyn Areas north of $-15°$

declination were established with reference to the zero point of the North Polar Sequence. These standards were then used to determine the brightness of all stars within a distance of 23 minutes of arc from the central star of the Area brighter than magnitude 16 and many others to magnitude 20, making a total of 68,000 stars for which accurate photographic magnitudes in the Selected Areas were available. In 1930 these magnitudes were published as the *Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1-139* by Seares, Kapteyn, and van Rhijn. A large part of the measures were made at Groningen on plates taken at Mount Wilson by H. D. Babcock, E. A. Fath, H. Shapley, and F. H. Seares.

By use of the method of exposure ratios which he devised, Seares found that color indices and photovisual magnitudes based on the photographic magnitudes of the Catalogue could be accurately determined. These observations and reductions were carried on for several years for the different Areas.

The value of these important projects was widely recognized. At the 1922 Rome meeting of the International Astronomical Union, Seares was elected President of the Commission on Stellar Photometry and served for sixteen years in that office. His values for the North Polar Sequence were adopted as International Standards. He also was a member of the Commissions on Stellar Statistics and Selected Areas.

Seares used the data derived from these photometric observations and others obtained elsewhere for statistical studies on many subjects pertaining to the individual stars and to the structural aspects of the Milky Way as a whole. Of his publications after 1912, seventeen dealt with the observational problems of the North Polar Sequence and the northern Selected Areas. Data based on the results for individual stars, such as colors, temperatures, masses, densities, and luminosities, and those relating to the structure of the Galaxy, such as star

counts, distances, distribution, and the effects of space absorption, were analyzed and thoroughly discussed in more than fifty publications, many of which represented pioneering explorations in a variety of fields of astronomical research.

The carefully coordinated results served as a solid foundation upon which subsequent investigations and conclusions could be safely based. Either from a direct comparison of the photographic with the visual magnitudes of stars of the same spectral type, or by the ratio of exposure times required to produce equal stellar images, Seares obtained color indices of stars which led to numerous significant results that were related to the physical conditions within the stars and to the contents and structure of the stellar system.

Two of the most important of these were: (1) late-type giant stars of high luminosity were proved to have appreciably larger color indices and are redder than dwarfs of the same spectral type; (2) the distant stars are redder than the nearby stars.

The first effect results from absorption by the extended atmosphere of the star and in this way reveals some data about its size, composition, intrinsic luminosity, and indirectly its distance.

The second effect, which is the result of scattering and absorption of the star's blue and violet light by the interstellar dust and gas lying in the long path from the star to the earth, depends directly upon the distance traveled under such conditions. Seares, therefore, gave much study to the distribution of the dark areas as well as to the stars in order to obtain a true picture of the structure of the Milky Way system as it would appear when viewed from an external point, and compared it with the spiral galaxies which could be observed at different inclinations. It was found that the absorption material was much denser near the plane of the galactic equator,

but that it was not uniformly distributed. Even with the naked eye the great dark rifts along the Milky Way can be easily seen on moonless nights.

Since the early visual counts of stars by Sir William Herschel, the concentration of stars to the plane of the Milky Way had been recognized, but, with photographic plates and a large telescope, Seares extended the counts to include fainter stars of different colors and greater distances. He estimated the total number of stars in the Milky Way system to be some 30 billions.

The location of the absorbing clouds and their effect upon the light received from various classes of stars were determined. Extensive study of the distribution of stars with different physical properties was continued for many years. The size and structure of the Galaxy were deduced and the location of the sun with reference to the plane and center of the system was determined.

Stellar temperatures and spectral types are also directly related to the colors of the stars. Several of Seares's papers were devoted to these considerations. Investigations during many years were required to separate and establish these various relations, but they have been fundamental in all later studies of the composition and structure of galactic systems.

In 1921 Seares made an elaborate study of the masses, densities, and related properties of stars. Since there is no direct method of weighing the material content of objects at stellar distances, the masses must be determined from the gravitational effects observed in the few double stars of known parallax, and the spectroscopic binary stars for which the orbital inclination can be found. Seares recognized the narrow basis upon which knowledge of this important property of the stars rested and made a critical study of the problem, examining the relationship of the masses to other physical parameters,

such as motion, spectrum, luminosity, density, dimensions, and surface brightness.

He assumed that single stars have in the mean the same masses as the components of double stars. Curves showing the relations between the mass, density, absolute magnitude, and spectral type were drawn on the plan of a Russell diagram. From these curves corresponding unobserved properties could be read. The evolutionary implications were also discussed.

In his research Seares did not often stray far from the field of stellar photometry. An outstanding digression was his exhaustive theoretical analysis in 1913 of the Zeeman effect due to a general magnetic field of the sun.

As might be expected from his close attention to his chosen field of research, his publications, numbering 180, were largely limited to reports upon his studies relating to stellar photometry. They were often highly detailed and no effort was spared to make them as clear and effective as possible. He was most generous in acknowledging the part played by his colleagues and joint authors.

He wrote biographical sketches of his fellow-workers J. C. Kapteyn, George E. Hale, W. S. Adams, and A. van Maanen in which he showed deep appreciation of their contributions to astronomy.

In addition to his research activities to which he gave unremitting devotion for nearly forty years, as Assistant Director, Seares made many important contributions to the progress of the Mount Wilson Observatory by supervising the Computing Division, and by aiding with wise counsel and ready understanding the program of the Observatory. As editor of the publications of the Observatory he set a high standard for the presentation of scientific results, which is evident in the twenty-five volumes of the *Contributions of the Mount Wilson Observatory* and other Observatory publications.

In his masterly Elihu Root Lecture on the "Concept of Uniformity" delivered in Washington on April 19, 1938, Seares showed a genuine interest in pure philosophy. This lecture traced the growth of the scientific method in unfolding the laws of nature and its reaction upon mankind. The lecture concluded with these words, which are no less cogent today: "If the problems arising out of human relations are to be solved at all, it will be through the same scientific approach to facts, made in the same dispassionate spirit of inquiry, that has given man command over his physical environment."

In all of his contacts Dr. Seares never failed to maintain a courtly attitude and he expected of others the same serious outlook that he had. These qualities gained him the respect and admiration of his colleagues. He was always happy to give advice and help when called upon, and he was fair and considerate. He set up for himself standards of thoroughness that led to many years of patient study of the results of his own investigations and those of others. With a strong physical constitution he was able to carry out with unceasing vigor programs of exhausting observations and tedious investigations for long periods well past the time usually expected for active careers.

Miss Mary Cross Joyner of the Computing Staff of the Observatory collaborated with Seares in many papers as joint author over a period of twenty-seven years, and after the death of his first wife they were married in 1942. They continued working together at the Observatory office until her retirement in 1946 after thirty-one years of service. They frequently dined with old friends and distinguished visitors at the Valley Hunt Club or the Athenaeum of the California Institute of Technology. After a few years they took up residence, first at Santa Barbara and later at Honolulu, where Mrs. Seares is still living.

Although not a "joiner" in the popular use of the term,

Dr. Seares was honored by membership and election to office in a number of scientific societies. He was especially active in the Astronomical Society of the Pacific, in which he became a member in 1893, and at various times held all of the elective offices. He was awarded the Catherine Bruce Medal of the Society in 1940 and an Honorary Diploma in 1963 in recognition of seventy years of membership.

He became a member of the Société Astronomique de France in 1901; of the American Astronomical Society in 1902 (Councilor, 1929-1932); of the American Association for the Advancement of Science in 1907 (Vice-President, Section D, 1936). He was elected an Associate of the Royal Astronomical Society in 1918, and to membership in the American Philosophical Society in 1917, in the National Academy of Sciences in 1919, and in the Washington Academy of Sciences in 1920. He took an active part in the work of the International Astronomical Union from its beginning in 1919 until 1958, serving on the commissions on Stellar Photometry (President, 1922-1938), on Stellar Statistics, and on Selected Areas.

CHRONOLOGY

1873	Born near Cassopolis, Michigan, May 17
1878	Family moved to Iowa
1887	Family moved to California
1887-1890	Pasadena High School
1891-1895	University of California, Berkeley, B.S. degree
1893	Member, Astronomical Society of the Pacific
1895-1899	Fellow, instructor, University of California
1896	Married Mabel Urmy
1897-1898	Vice-President, Director, Librarian, Astronomical Society of the Pacific
1899-1901	Studies in Berlin and Paris
1901-1909	Professor, University of Missouri, and Director of the Laws Observatory
1901	Member, Société Astronomique de France
1902	Member, American Astronomical Society
1907	Member, American Association for the Advancement of Science
1909-1940	Staff member, Mount Wilson Observatory of the Carnegie Institution of Washington
1912	Investigated photographic methods in Europe and checked the casting of the 100-inch mirror
1917, 1924	Summer lecturer, University of California
1917	Member, American Philosophical Society
1918	Associate, Royal Astronomical Society
1919	Member, National Academy of Sciences
1920	Member, Washington Academy of Sciences
1922-1938	President, International Astronomical Union Commission on Stellar Photometry
1925-1940	Assistant Director, Mount Wilson Observatory
1927-1934	Collaborating Editor, *Astrophysical Journal*
1929	President, Astronomical Society of the Pacific
1929-1932	Councilor, American Astronomical Society
1930	LL.D. degree, University of California
1934	LL.D. degree, University of Missouri
1934-1945	Associate Editor, *Astrophysical Journal*
1936	Vice-President, American Association for the Advancement of Science, Section D

1940-1945	Research Associate, Carnegie Institution of Washington
1940	Bruce Gold Medal, Astronomical Society of the Pacific
1940	Mabel Urmy Seares died
1940-1946	Director, Astronomical Society of the Pacific
1942	Married Mary Cross Joyner
1963	Honorary Diploma, Astronomical Society of the Pacific
1964	Died in Honolulu, July 20

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KEY TO ABBREVIATIONS

Astron. J. = Astronomical Journal
Astron. Nachr. = Astronomische Nachrichten
Astrophys. J. = Astrophysical Journal
Carnegie Inst. Wash. Publ. = Carnegie Institution of Washington Publication
Laws Obs. Bull. = Laws Observatory Bulletin, University of Missouri
Monthly Notices Roy. Astron. Soc. = Monthly Notices of the Royal Astronomical Society
Mt. Wilson Contrib. = Contributions from the Mount Wilson Observatory
Pop. Astron. = Popular Astronomy
Proc. Nat. Acad. Sci. = Proceedings of the National Academy of Sciences
Publ. Am. Astron. Soc. = Publications of the American Astronomical Society
Publ. Astron. Soc. Pacific = Publications of the Astronomical Society of the Pacific
Trans. Intern. Astron. Union = Transactions of the International Astronomical Union

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