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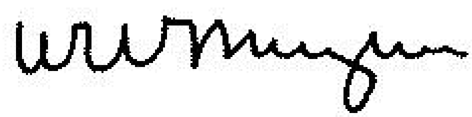

William Wilson Morgan

January 3, 1906 — June 21, 1994

By Donald E. Osterbrock

WILLIAM W. MORGAN WAS born and raised in the South, but went to Yerkes Observatory in Wisconsin as a student and spent the rest of his life there. He was an outstanding observational astronomer who became a master of spectral classification, a field he dominated for many years. He made important contributions to galactic structure, stellar populations, and galaxy research. Fiercely independent, he insisted on describing rigorously "the thing itself," whether it was the spectrum of a star or the form of a galaxy; and he demonstrated that an astronomer who consciously rejected astrophysical theory if it conflicted with his own observational data could often be right in the twentieth century.

EARLY LIFE AND EDUCATION

Morgan was born on January 3, 1906, in Bethesda, Tennessee, a tiny hamlet that no longer exists. His father, William T. Morgan, and his mother, Mary Wilson Morgan, were both home missionaries in the Southern Methodist Church, who went from town to town to spread the Good News. His father, originally a Southern Presbyterian, was a minister who received his training in Chautauqua courses (essentially short-term summer schools) in the South. The family moved frequently, and young William's mother taught him and his sister Mildred, two years younger, at home until he was nine. He first attended school at Perry, Florida, in 1915, then in Colorado Springs, and finished eighth grade at Poplar Bluff, Missouri, in 1919. During World War I his father served as a minister for soldiers in training camps in the South and as the head of a church-sponsored hospitality center. After the war he called himself Major Morgan, presumably his rank in a Salvation Army-like organization. He became an itinerant lecturer, preaching moral uplift and self-improvement, both then including abstinence from alcoholic beverages. William W. Morgan had his first two years of high school at Marvin Junior College, Fredericktown, Missouri, where his mother supervised a girls' dormitory, and his last two at Central High School in Washington, D.C. He was a good student who took four years of Latin, three and a half years of mathematics, three years of science (general, physics, and chemistry) as well as the English and history all his classmates studied.

In 1923 Morgan entered Washington and Lee University in Lexington, Virginia; it dated back to 1749, and Robert E. Lee was its president after the Civil War (when it was still called Washington College). It was an all-male institution, and Morgan's classmates came from all over the South, with a tiny sprinkling of Northerners, mostly the sons of expatriate Southerners. Morgan lived in Lee's Dormitory on campus his first year; after that in a college-approved rooming house, but ate his meals in the Washington and Lee dining hall. He was an especially good student in English and was elected to the freshman English honorary fraternity; after two years the career he visualized for himself was teaching literature. Contrary to Morgan's stories in later life that he had almost no training in science, he was in fact a nearly straight-A student in mathematics, who was awarded a scholarship for excellence in that subject his third year. He also did average work in chemistry (better in class than in the laboratory), good work in physics, and excellent in astronomy. Morgan was dedicated, eager to learn, "gentlemanly . . . in his manners and breeding"; he impressed Benjamin A. Wooten, his professor in physics and astronomy, as a real prospect for the future. Wooten, a Columbia University Ph.D. in physics, obtained a small, professional-quality refracting telescope for the university while Morgan was a student, and he began observing with it. On visits home in Washington Morgan frequented the Naval Observatory. Washington and Lee was no

MIT, but when he left college Morgan was reasonably well prepared for graduate work in the astronomy of his time.

Wooten spent the summer of 1926 at Yerkes Observatory, the astronomical research center of the University of Chicago. Situated in little Williams Bay on beautiful Lake Geneva, a resort area in southern Wisconsin, it was more to Wooten's taste than Ryerson Physical Laboratory on the campus, where he previously had put in an occasional summer. Just before returning to Washington and Lee, Wooten learned that Edwin B. Frost was desperately searching for an assistant to take over the routine program of obtaining daily spectroheliograms, which had been going on for thirty years. Under Frost, Yerkes Observatory was in its doldrums as a research and graduate training center, and there was no new incoming student to continue the work. Wooten recommended Morgan, and Frost snapped him up, particularly when he learned the young paragon was nearly twenty-one and was "very strong and healthy." His father did not want to let him go, with a year still to finish before he would have his undergraduate degree. He could not visualize his son as a scientist; he had expected him to follow his career as a lecturer. But young Morgan was determined to get away; he insisted, and won out. By early September he was at the observatory, learning the ropes. His salary was $900 a year plus tuition, then less than $100 a quarter.

Morgan was quick to learn, keenly interested in astronomical observing, industrious, and highly intelligent. He picked up the necessary photographic techniques quickly and became expert in them. Although he could not be officially admitted as a graduate student without a bachelor's degree, Morgan was allowed to take a full program of graduate courses, all research in astronomy, working with different professors. At the end of his first year Morgan received his bachelor's degree from Chicago on the basis of his transfer credit from Washington and Lee plus the astronomy graduate courses he had taken at Yerkes. He had never set foot on the campus before he went there in May to sign up for his degree.

Morgan continued for two more years as a graduate student at Yerkes, by then observing regularly in the spectroscopic program with the 40-inch refractor. In the middle of that period, in the summer of 1928, he married Helen M. Barrett, daughter of astronomer Storrs B. Barrett, who was the secretary of the observatory. Then Morgan and his young wife spent the 1929-30 academic year on the campus in Chicago, where he took graduate courses in celestial mechanics, physics, and mathematics. Returning to Yerkes in June 1930, he began a Ph.D. thesis on the spectra of A stars under the supervision of Otto Struve, the hard-working, Russian-born staff member. Struve had earned his own Ph.D. at Yerkes in 1923; Morgan was his second thesis student. In this thesis, an excellent one, Morgan concentrated on the "peculiar" A stars, which did not appear to fit into the standard ionization interpretation of stellar atmospheres then being worked out by theoretical astrophysicists. He carefully studied all the spectrograms of A stars in the Yerkes plate files and obtained many more at the telescope. He showed that a few of the A stars previously called peculiar in fact did fit the theory, but more did not. Morgan found that he could recognize many additional peculiar ones and that they were a sizeable minority compared with the "normal" A stars. Most show stronger-than-average spectral lines of various heavier elements, including manganese and some rare earths. Some of these stars have variable spectral lines. He classified the brightest peculiar A stars into several groups, and studied the spectra of a few of them in detail. He emphasized the importance of trying to understand physically how these stars fit into stellar evolution, a remarkably prescient statement in the early 1930s.

Morgan completed his thesis and received his doctoral degree in December 1931 during one of the darkest periods in the Great Depression. Nevertheless, he was kept on the staff, but in the same assistantship he had held as a graduate student. In the summer of 1932 he was promoted to instructor and in 1936 to assistant professor.

SPECTRAL CLASSIFICATION

As a young faculty member Morgan continued working on peculiar A stars and published several more papers on them. The classification system he set up for them was widely adopted and is the basis of the nomenclature for these stars still used today. In a long paper summarizing this work he described painstakingly the spectra of the normal and peculiar A stars in detail, comparing and contrasting them. He concluded that the peculiarities resulted from some physical factor other than the star's surface temperature and gravity, probably variable effective abundance of the elements, but he included no equations or calculations in his paper. Struve, now director, praised Morgan's research, but tried to get him to learn more theoretical astrophysics, particularly the quantitative interpretation of stellar spectra in terms of stellar atmospheric temperatures and densities. It was a new, rapidly growing subject; Struve was attracted by its early successes and saw it as the wave of the future, but Morgan was repelled by its failures (which were many in the 1930s) and avoided it. His interests shifted more and more to spectral classification.

Morgan tested the spectral types of the widely used Henry Draper catalogue, and the improved two-dimensional types of the Mount Wilson system and found he could do still better himself. He learned that, by using only well exposed, widened spectrograms taken with a spectrograph optimized for his program and then carefully developed under controlled conditions, he could obtain homogeneous data that was much better for spectral classification. Morgan pioneered in setting up a completely symbolic, two-dimensional spectral classification system in which he assigned stars types like G2 V, B2 Ia, or A2 IV purely by visual inspection of these high signal-to-noise-ratio spectrograms (in modern terms). Unlike the Mount Wilson observers he completely separated the spectral type and luminosity classification from the absolute-magnitude calibration. Thus, later determinations of the absolute magnitudes of stars would improve the calibration of Morgan's types but would not change them. Likewise, there was no hint in his system that (for instance) a G2 V main-sequence dwarf and a G2 I supergiant had the same effective temperature; that also was a separate calibration and the effective temperatures of either or both of these types, for instance, might change on the basis of later and better physical measurements, without changing the classification system, but making it more useful. Classifying a star's spectrum meant finding the standard star whose spectrum best matched it from the small list determined by Morgan himself. Thus, he consciously rejected any theoretical ideas of "quantitative" data in his classification scheme, but concentrated entirely on what he later came to call "the thing itself," the appearance of the spectrum alone. The rejection bewildered many of his contemporaries, but was an intelligent response to the state of astrophysics at that time. It freed Morgan and his results from the misconceptions based on incorrect theories and faulty data that plagued those same contemporaries' results.

In 1938 he showed that his two-dimensional spectral types and luminosity classes were better correlated with the color indices of nearby stars than the earlier Harvard and Mount Wilson types. His types could therefore be used to determine the stars' intrinsic colors and thus the extinction along the light paths to them. From the calibration of his luminosity classifications he could then determine the best available distances to the stars. In this paper Morgan used only highly accurate photoelectric color indices measured by Kurt F. Bottlinger and Paul Guthnick at Berlin-Babelsberg Observatory. Previous discrepancies disappeared when Morgan's types and these measured colors were used; he always believed in basing his work on the best data only, ignoring the rest. Henry Norris Russell, the outstanding leader of American astrophysics, was greatly impressed by his new results. This recognition helped Morgan in Struve's eyes.

Philip C. Keenan, who had started as a graduate student at Yerkes a few years after Morgan and had also remained on its staff, joined him in the later stages of this work. By 1940 Morgan had the concept for an *Atlas of Stellar Spectra* based entirely on spectrograms taken with his new classification "spectrograph" on the 40-inch refractor. It put to very good use a telescope that most of the other Yerkes faculty members were abandoning for the new 82-inch McDonald Observatory reflector in the clearer skies of Texas. In 1943 Morgan, Keenan, and Edith Kellman (Morgan's assistant, who made the original photographic prints that formed a large part of it) published their spectral atlas, with its "outline of spectral classification" written almost entirely by Morgan. The standard stars listed in it defined what came to be called the MKK system, which very quickly was adopted by astronomers almost everywhere.

SPIRAL ARMS

In 1944, just a year after the publication of the MKK atlas, Walter Baade announced his identification of two stellar populations, which soon turned out to be young stars and old. Within a very few years his surveys of M 31 showed that the young OB stars and H II regions of Population I are concentrated in its spiral arms. They define the spiral arms in it and other similar galaxies. Morgan was inspired by Baade's work and quickly realized that he could use these very same markers to trace the spiral arms in our galaxy. His accurate spectral types of individual OB stars, with their photoelectrically measured color indices, provided the data to determine accurate distances to these stars. Plotting them on a map with the sun at the origin would reveal the spiral arms, or at least the parts of them close enough to find OB stars in them. The distances depended critically on having an accurate absolute-magnitude calibration for the OB stars. Morgan worked very hard to set it up, using data he and others obtained from proper motions, galactic rotation, and clusters and even associations with distances obtained from fainter stars within them. Always he insisted on using only high quality measured photoelectric color indices and spectral types and luminosity classes determined by himself, his graduate students, and his collaborators. Nearly all the color indices came from Joel Stebbins, C. Morse Huffer, and Albert E. Whitford at the University of Wisconsin. Morgan had worked with Jason J. Nassau at the Case Institute of Technology and later with Guillermo Haro, Luis Münch, Graciela and Guillermina Gonzalez, and other Mexican astronomers on the Tonanzintla Observatory staff in finding candidate OB stars for this program, on the objective-prism spectral plates they had taken with their respective Schmidt telescopes. Morgan had taken part in the dedication of Tonanzintla Observatory in 1942 and had presented a paper on spectral classification that greatly influenced the early direction of the research program there.

In the later stages of this program Morgan decided that the OB "aggregates" (the term he used to mean large complexes of nebulae and young stars containing many OB stars), were the best markers to use to map the spiral arms. Measuring independently the distances of many stars in such an association and adopting the mean gave the best measure of the distance to use in plotting the aggregate in the galactic plane. Morgan encouraged two young graduate students at Yerkes Observatory, Stewart Sharpless and me, to find additional candidate associations using filters that isolated the characteristic $H\alpha$, [N II] emission lines of gaseous nebulae with a special very wide-field camera designed by Jesse L. Greenstein and Louis G. Henyey. Morgan had recognized its potential for this program immediately. He generously included both of us as co-authors of the resulting paper, which mapped portions of the Orion spiral arm through the sun and the Perseus arm, the next one beyond it in the galactic plane. Morgan presented the resulting map at the American Astronomical Society meeting in Cleveland in December 1951, where it received unprecedented acclaim in the form of a standing ovation, but sadly he published only an abstract of it. As he revealed years later to David H. DeVorkin in an interview, Morgan suffered a nervous breakdown soon after this meeting, was hospitalized briefly, and then convalesced at home, unable to do scientific work for a time. He soon recovered, but the data he had used in the oral presentation of the paper were rendered obsolete by later, more numerous color indices, spectral classifications, and identifications of additional associations.

Morgan did much of this later spiral arm work in collaboration with Albert Whitford and Arthur D. Code, who measured the color indices, and the three of them published it soon thereafter. Besides the first two arms, their paper also included the next spiral arm inside the sun's distance from the galactic center, the Sagittarius arm. As part of this program Code and Theodore E. Houck, on an expedition to South Africa, obtained better wide-angle photographs showing the southern as well as the northern Milky Way. In all this work Morgan demonstrated his ability to inspire and work very effectively with collaborators to solve important problems.

In applying his technique of spectral classification Morgan early realized that spectrograms taken with his spectrograph, widened and processed with his special low-contrast, fine-grain developer, gave far superior results than the narrow, grainy, and high-contrast plates taken for radial-velocity work. Everyone could grasp that. But he went beyond it to the idea that the number of different spectral types that could be distinguished depended on the instrument, and that certain "natural groups" could be recognized on extremely low-dispersion objective-prism plates. The outstanding examples were the high-luminosity OB stars so important for his galactic-structure studies that he, Bengt Strömgren, and Hugh M. Johnson demonstrated could be segregated with spectra taken at the fantastically low dispersion of 30,000 Å/mm. All that these spectrograms showed was the continuous spectrum of the star, but that was enough to recognize faint distant OB stars that lay in the spiral arms, as Daniel H. Schulte later demonstrated with a small, specially designed Schmidt camera.

Morgan became managing editor of the *Astrophysical Journal* in 1947, under a reorganization of faculty responsibilities that Struve put into effect. The journal belonged to the University of Chicago and ever since George Ellery Hale, the Yerkes director had been its managing editor. After World War II, however, Struve was tired of administrative tasks that kept him from research, and he handed the job over to Morgan. At the same time the university signed a new contract, negotiated by Struve, under which the

American Astronomical Society shared partly in the control of the *Journal* and helped in financing it through its member subscriptions.

Morgan took his editorial responsibilities seriously and worked hard at them. He improved the scientific standards of the *Journal,* particularly in the observational papers. However, pressures connected with rising costs of postwar publication and an extension of this agreement undoubtedly contributed to Morgan's breakdown. There were also various internal tensions among the senior Yerkes faculty members, which led to Struve's resignation and departure for Berkeley in 1950. They must have added to Morgan's mental problems at the time. He resigned as managing editor in 1952, and Subrahmanyan Chandrasekhar succeeded him.

PHOTOELECTRIC PHOTOMETRY AND THE MK SYSTEM

Morgan and Keenan continued improving their system of spectral classification, with Morgan concentrating especially on the early-type stars and Keenan on the later-type. They published the essentials of their revised MK system, defined by its standard stars, in 1951. Morgan's Ph.D. students William P. Bidelman, Arne Slettebak, and Nancy G. Roman worked with him on parts of this program and made important contributions to it. Photoelectric photometry became a rapidly growing field after World War II. Morgan naturally took a keen interest in it, since the color indices it provided were so closely related to spectral types, and with them provided the color excesses that led directly to quantitative measurements of interstellar extinction.

With Harold L. Johnson, who joined the Wisconsin faculty in 1949 and moved on to Yerkes in 1950, Morgan set up the *UBV* system, based on filters chosen to give the best match with the MK types. A crucial element of it was that the *U* (ultraviolet) filter was selected to maximize the effect of the higher Balmer lines and Balmer continuum, while the *B* (blue) filter excluded them as much as possible. As a result the combination of *U* — *B* and *B* — *V* (visual) color indices formed an excellent basis for discriminating between giants and dwarfs and for providing interstellar extinction for "normal" stars. Like the MK system of spectral classification, the *UBV* photometric system was adopted everywhere and quickly became the most widely used system. Their paper on the *UBV* system also contained the complete list of standard stars that defined the MK spectral classification system in full. In a review paper published in 1973 Morgan and Keenan further refined this system, and in 1996 it remains in use as the revised MK system.

STELLAR POPULATIONS

Morgan was tremendously stimulated by Baade's invited lectures on his new concept of stellar populations at the American Astronomical Society meeting at Perkins Observatory, Ohio, in December 1947 and at the subsequent meeting in California in June 1948 for the dedication of the 200-inch telescope. The Yerkes spectroscopist was always eager to apply his methods at the frontiers of the newest fields of astronomy, as he had done in locating the nearby spiral arms in our galaxy. He was the leading authority in the world, from the observational viewpoint, on O and B stars, the hottest, most massive young stars, which are the markers of Population I. Many of his papers dealt with these stars and the groups and clusters in which they occur, their association with interstellar matter (observable as H II regions and as "dust"), how to find them, and how to measure their distances.

In the MKK spectral atlas, even before Baade's identification of the two populations, Morgan and Keenan pointed out a few specific examples of stars with very weak spectral lines and quite high velocities. Baade recognized them as nearby members of his Population II, showing the importance of the MK system of spectral classification in this problem, and Keenan, Morgan, and Guido Münch presented a paper on the spectra of the high-velocity giants at this same 1947 meeting. Morgan reviewed and extended the results in this field in a paper he presented at the conference on stellar populations held in Rome under the auspices of the Pontifical Academy of Sciences in 1957.

Although Morgan did not have access to a large telescope at Yerkes, he hungered to do research on galaxies and globular clusters. This he achieved as a visitor to Lick and Mount Wilson Observatories. Nicholas U. Mayall had obtained a large collection of spectrograms of globular clusters at Lick to measure their radial velocities. Morgan, whom Mayall allowed to use the plates for spectral classification, found that he could estimate fairly accurate integrated spectral types from them and could also assign values of a line-strength parameter. He supplemented these with better, widened spectrograms he obtained of some of the clusters with the 82-inch McDonald Observatory reflector. These plates were optimized for his type of spectral classification. At that time globular clusters were, by Baade's definition, extreme Population II objects and therefore were considered to be old weak-line, metal-poor groups of stars. The available spectra of stars in the relatively nearest globular clusters confirmed their weak-line property. However, Morgan found that, although this correlation held up quite well for distant clusters far from the galactic plane and the galactic center, it did not apply to a small group of clusters close to the galactic center, most of them also at relatively small distances from the galactic plane. Ten years earlier Mayall classified some of them as "later" in spectral type than the other globular clusters. In fact, these clusters near the galactic center showed "normal" strength absorption lines, Morgan insisted, indicating approximately solar-type abundances. Baade, who still held firmly to the idea of two populations and not a multitude of intermediate ones, could possibly accept several, but not the idea that an "old" globular cluster could have a "normal" metal abundance. Jan H. Oort, the leading interpreter of the populations concept, was naturally skeptical, and tended to question endlessly any new idea that did not fit his current theory, which he had worked out to fit the facts as Baade had stated them.

Only Morgan with his years of experience in classifying spectra, his supreme self-confidence in this field, and his aversion to or even downright contempt for theory could have withstood their attacks. But he stuck to his guns, invited questioners to look at the spectrograms themselves (some of them did, but could not see what was obvious to him), and was sure he was right. And he was, as many much more quantitative measurements and long discussions have subsequently confirmed.

Similarly, Morgan, working with George H. Herbig at Lick Observatory, obtained a good spectrogram of the nucleus of M 31, the spiral galaxy that Baade had systematically observed as the analogue of our galaxy. Morgan classified the nucleus as having a K2 III integrated type with strong metal lines, not weak. This conclusion was even harder for Baade to accept, because the central bulge of M 31 was pure Population II according to all his direct photographic tests; and he believed that the nucleus was the densest concentration in it, composed of the same types of stars as the bulge at large. Again, Morgan was right. At the time of his death much of the research on the variety of ages, metal abundances, and kinematic properties of the stars in the central regions of our galaxy can be traced back to his highly individualistic, paradigm-shattering spectroscopic research on stellar populations in the 1950s.

GALAXIES

Naturally, Morgan was keenly interested in the classification of galaxies. His earliest published paper in this field, in collaboration with Mayall, classified their spectra on the basis of the latter's Lick spectrograms. True to his guiding philosophy of "the thing itself," Morgan emphasized that galaxy spectra, like globular-cluster spectra, are the integrated sum of the contributions of multitudes of spectra of individual stars and cannot be assigned unique stellar types, because they do not match the spectra of any standard stars. He therefore used a different notation for galaxy spectra, but was somewhat inhibited by the more conservative Mayall, the provider of the data. In this field Morgan always faced the problem of having to collaborate or use borrowed spectrograms, and he generally tempered his published criticisms of earlier work because he feared, perhaps incorrectly, that such criticism might antagonize his sources. Later Mayall did turn over his spectrograms to Morgan, who used them to discuss further what they revealed about the stellar populations in the galaxies.

Morgan's work on the classification of the forms of galaxies, based largely on close inspection of direct photographs in the Mount Wilson and Palomar Observatories plate files, was one of his most important contributions to galaxy research. He rejected much of the Hubble classification system, arguing convincingly that the objects the great observational cosmologist called S0 were in fact a mixture of galaxies with dissimilar forms and that his Sa, Sb, Sc sequence was based on two criteria that were often in disagreement. Morgan based his classification on only one of them, the strength of the central bulge relative to the disk. Probably he somewhat hindered the acceptance of his galaxy classification by assigning symbols for form types that were quite different from Hubble's, but were related to spectral types, like fS1 or kE5.

Certainly, his symbols DE, D, and (later) cD for some of the types of galaxies that Hubble had included in the S0 class proved extremely useful in finding and analyzing radio galaxies. By the time of his death Morgan's cD notation was used by astronomers everywhere, but most of his other types were never widely accepted, probably because the Hubble system was too well entrenched. Laura P. Bautz, then a Northwestern University faculty member, and several of his graduate students, beginning with Janet Rountree Lesh, collaborated with Morgan in a number of papers on cD galaxies; as a result, many of these objects have published classifications that radio astronomers adopted and used extensively. Morgan also studied and emphasized the importance of the luminosity sequence of active galactic nuclei from Seyfert galaxies to quasistellar objects and coined the name "N galaxies" for intermediate objects.

CAREER

In his early years at Yerkes Morgan felt he received little recognition. Struve assigned him the duties of assistant director without giving him the title, salary, or guidance on policy he deserved. Morgan did not like the post, which he considered a drain on the time and energy he preferred to devote to research. In this position he did little beyond carrying out the basic directives Struve gave or sent him and, after publication of the MKK *Spectral Atlas* brought him his first fame in the astronomical community, he shunned administrative tasks. Yet Morgan loved Yerkes Observatory and believed he owed his career to it. To his dying day he thought it had a special mystique for research. Thus he accepted the directorship of the observatory from 1960 to 1963 and the chairmanship of the department of astronomy from 1960 to 1966 after his colleagues convinced him there was no other suitable faculty member available. He was promoted to full professor in 1947 and was named a distinguished service professor in 1966.

Morgan was an excellent teacher in the small classes that the graduate students at Yerkes Observatory took. He taught only photographic photometry (in his earlier years) and his own subject, spectral classification, which he made every student learn by doing it. To interested, involved students he could be charismatic. When he taught spectral classification one quarter every other year, small groups of University of Wisconsin graduate students would drive from Madison to Williams Bay for his weekly classes. Morgan especially liked to attract Yerkes students who were seen as budding theorists, such as Code, Marshall H. Wrubel, D. Nelson Limber, Jeremiah P. Ostriker, and the writer, into his subject, and we all agreed we learned new ideas as well as new techniques from him. On the other hand, students who resisted involvement in the classwork depressed him, and he was quite capable of abruptly canceling the remaining lectures for the quarter if he felt he was not getting through to the participants. Most of the practitioners of spectral classification in the years after World War II were former students who had learned the subject from Morgan and from Keenan at Ohio State University.

Morgan was elected to the National Academy of Sciences in 1956, and was awarded the Bruce Medal of the Astronomical Society of the Pacific in 1958, the Henry Norris Russell Lectureship of the American Astronomical Society in 1961, and the Henry Draper Medal of the NAS in 1980. He received three honorary doctor's degrees and was named a member or an associate of the academies of several other nations; of the latter the most meaningful to him probably were the Pontifical Academy of Sciences and the Royal Danish Academy of Sciences and Letters.

In 1960 he was the astronomer named by his colleagues to give the main scientific address at the dedication of the Kitt Peak National Observatory, and in 1971 he was again chosen as one of the four invited speakers at the ceremonies marking Mayall's retirement as its director. Later Morgan and Keenan were honored by a workshop on spectral classification, dedicated to them, at the University of Toronto, and by another held under the auspices of the Vatican Observatory in Tucson in 1993, the fiftieth anniversary of the publication of the MKK *Spectral Atlas.*

Among the organizers of both these conferences was Robert F. Garrison, Morgan's Ph.D. thesis student who continued his adviser's approach to spectral classification, concentrating on the data and suppressing theoretical or prior observational prejudices to the extent he could. Another even later Morgan Ph.D. in this mold was Nolan R. Walborn. They both demonstrated in their work that Morgan's principles are just as applicable with the large ground-based and space telescopes of the 1990s as they were with the 40-inch Yerkes refractor in his time.

Morgan and his wife Helen had two children: Emily and William. Helen Morgan died in 1963, and in 1966 he married Jean Doyle Eliot, who, with his children, survived him. She had been a schoolteacher in Williams Bay and later became a faculty member at Roosevelt College in Chicago, commuting back and forth from their home. OTHER INTERESTS

Although Morgan worked very hard in astronomy all his life, he had many other interests as well. A former English major, he loved literature, particularly Shakespeare and Christopher Marlowe. In a retrospective account of his life published in 1988 Morgan wrote that Marlowe's play *Doctor Faustus* was one of the most important influences on his life, from the time he read it as a young high school boy in Missouri. The lesson of *Doctor Faustus*, as he understood it, was the drive to continue learning, to increase one's knowledge of the universe. It made him realize, he told me more than once, that there is no limit to how far a person can go in following his own ideas. In the postwar period he particularly favored T. S. Eliot and Marcel Proust.

Morgan had very wide reading horizons not only in literature but in art, music, and philosophy. He was particularly attracted by the writings of Ludwig Wittgenstein, the apostle of logical positivism. In the 1940s and 1950s Morgan was especially interested in photography and took numerous sensitive pictures, particularly of flowers and groups of flowers in nature. His interest in art was intense, especially the patterns in the work of Mondrian and the cubists, and over the years he accumulated an enormous collection of art books. He organized a local photography club and was its first president. Morgan, a connoisseur of cinema, was also highly involved in showings of historic films at Yerkes Observatory evening social and cultural affairs. All his reading and his other activities he undertook for their own sake, but he believed that they broadened his horizons on astronomy and science. After his breakdown he began writing his thoughts, experiences, ideas, and insights in private notebooks as a form of therapy and had accumulated more than a hundred of these books by the time of his death.

Morgan also had many interests in the more conventional American pastimes, such as detective stories and spectator sports. I well remember watching an early television broadcast of a college football game with a group of graduate students at his house, with the sound turned down so we could simultaneously listen to a radio broadcast of a symphony concert. Morgan, of course, chose both programs. In his mid-forties he continued to play in informal softball games with the graduate students and for years afterward took pleasure in lamenting how, as pitcher, he "had to" strike out his son Billy, then a beginning high school student, in a crucial game.

Morgan was well liked and respected in the little village of Williams Bay. He played a key role in organizing a Boy Scout troop when his son reached that age, and afterward was elected and reelected to the Village Board for four two-year terms. Its other members elected him president for his last two terms, and he was thus unofficially the mayor from 1947 to 1951. Morgan was active in the Williams Bay Congregational Church and, particularly in the years after his official retirement, occasionally gave talks on the universe in lieu of sermons. He was, much more than most observational astronomers, an all-around man.

CONCLUSION

Morgan was an outstanding research astronomer. He was one of the leading experts in the world in the classification of stellar spectra, integrated spectra of clusters and galaxies, and the forms of galaxies. Through his work, much of it done with a relatively small, outmoded telescope and the rest with borrowed observational material, he made many important discoveries on the structure of our galaxy and on the nature of stellar populations. He insisted on describing rigorously what he observed independently of previous observers' possibly incomplete or even incorrect analyses. Morgan tried to free himself of theoretical preconceptions. His unconventional but careful, controlled way of doing research enabled him to make many new discoveries about stars, our galaxy, and other galaxies.

THIS BIOGRAPHICAL MEMOIR IS based largely on the written record of Morgan's research, published in his many scientific papers. It is also based on the hundreds of letters to, from, or about him in the Yerkes Observatory Archives, dated from 1926 to the mid-1950s, and on my own conversations and correspondence with him from 1949 until the year of his death. Many of his former colleagues and students have helped me with their reminiscences of him, particularly Philip C. Keenan and Robert F. Garrison. Above all, I am grateful to Jean Morgan, who answered many of my questions about her late husband. D. Scott Dittman, registrar of Washington and Lee University, and Maxine Hunsinger Sullivan, registrar of the University of Chicago, very kindly made Morgan's student records (which included synopses of his high school work) available for this memoir. Morgan himself published two fairly brief accounts of some aspects of his life and philosophy, but he wrote them years after the early events described in them, and evidently almost entirely from memory, for they contradict in some ways documentary evidence, or much earlier autobiographical data that he left in his papers.[1] Morgan's research for and discovery of the spiral arms in our galaxy were well described by Owen Gingerich in a historical paper, which includes a summary of David H. DeVorkin's interview.[2]

NOTES

[1] The MK system and MK process. In *The MK Process in Stellar Classification*, ed. R. F. Garrison, pp. 18-25. Toronto: University of Toronto Press, 1984. A morphological life. *Annu. Rev. Astron. Astrophys.* 26:1-9, 1988.

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