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AMATEUR CONTRIBUTIONS TO ECLIPSING BINARY ASTRONOMY

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Abstract

Both theoretical and observational contributions have been made by amateurs to the astronomy of eclipsing binary stars. The specific contributions of John Goodricke and Edward Pigott, J. Miller Barr, and Alexander Roberts illustrate this point.

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Amateurs have an excellent opportunity to contribute to astronomy in the field of eclipsing binary stars. These stars provide a classic example of the value of amateur effort in an area where professionals find it difficult to commit the necessary time and energy. But not many amateurs seem attracted to this specialized area of observing and analysis. The few AAVSO members who do dedicate their observing and desk time to this service are a part of a long tradition that I would like to highlight in this discussion of amateur contributions to eclipsing binary astronomy.

In 1781 the Pigott family of York began observing in one of the most elaborate private observatories in England. The father, Nathaniel, was a skilled surveyor as well as a practical astronomer. His observing interests concentrated on a program to measure more accurate positions of stars. His son, Edward, on the other hand, seemed more inclined to explore in new areas of this emerging science. One of the Pigott's neighbors in York was John Goodricke. Goodricke was both deaf and mute, but he had received a remarkable education in spite of these handicaps. he was particularly good in mathematics. His tutor had also stimulated his active interest in astronomy. By November of 1781 Goodricke had become an active observer and associate of Edward Pigott. Although Goodricke was eleven years younger, the two formed a very close friendship.

Goodricke set out to observe variable stars, probably at Pigott's suggestion. Searching for new variable stars was a natural evolution of Goodricke's program. Among the stars suspected of variability, and therefore subject to careful observation, was beta Persei, orAlgol. This star was a likely target, as the York observers were aware of a 1672 observation of this star near minimum by Montanari. On the night of October 24, 1782, Goodricke managed to catch beta Persei at minimum. He was then amazed to watch it rise to maximum in the short space of three-and-one-half hours. A second minimum was observed on December 28, 1782, this time by both Pigott and Goodricke. Over the next six months Goodricke observed nine additional minima. From these data he was able to derive a period of 2 days 21 hours. This work formed the basis for a report to the Royal Society in London. Goodricke went on to speculate on the cause of the variation, probably with encouragement from Pigott. He suggested two possible causes of the observed variations: 1) a dark body in orbit around the star with periodic eclipses, or 2) spots on the star which periodically rotate into view. Goodricke favored the first mechanism. A year later in a second report to the Royal Society, Goodricke refined his period to 2 days 20 hours 49 minutes 3 seconds with an uncertainty of plus or minus 15 seconds. This value agrees almost exactly with the accepted modern value. For this work Goodricke was honored by the Royal Society of London with the award of their Copely Medal.

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A few months later, Goodricke discovered a second eclipsing binary, beta Lyrae. He was able to distinguish between the primary and secondary minima, although modern photometry places the depth of these at only 0.86 and 0.47 magnitudes, respectively! This discovery is a monumemt to Goodricke's visual acuity, observing skill, and patience. Goodricke also discovered the variability of delta Cephei. He commented on its characteristic light curve (rapid rise and slower decline) just prior to his untimely death at the age of 21.

Edward Pigott's role as the mentor, and perhaps as the innovator in this team, is only now being recognized. This is undoubtedly due to his extreme generosity in ascribing the total credit for the discovery of the period, and possible causes of variation in Algol, to Goodricke. Michael Hoskins has recently reviewed the original observing logs and available correspondence of both astronomers. It is clear from this new perspective that history must treat Pigott more kindly for his role on beta Persei!

Pigott was a very productive and creative amateur astronomer in his own right. He discovered a total of three comets, a nebula in Corona Borealis, and the variable stars eta Aquilae, R Coronae Borealis, and R Scutum. In addition, he published useful papers on techniques for making meridian transit measurements. He was invited to become a member of the London (later Royal) Astronomical Society by John Herschel, but this belated recognition came only weeks before Pigott's death in 1825 at the age of 72.

In 1844, nearly 50 years after the discoveries of Goodricke and Pigott, Argelander's now famous appeal to the friends of astronomy appeared. Argelander urged that amateur as well as professional astronomers observe variable stars. At that time, the list of known variable stars, including all known novae, numbered only twenty-two stars. Some amateurs responded to this appeal. Between 1856 and 1863, 46 minima of Algol were timed by a Maine farmer and amateur astronomer named Stillman Masterman. In 1877 another amateur, Edwin F. Sawyer of Jamaica Plain, Massachusetts, began observing variable stars, as part of a photometric survey of the sky. In the process of this survey, Sawyer discovered numerous variables, including the Algol variable R Canis Majoris. By the end of the 19th century, the list had grown to include seven hundred variable stars, and the number was growing exponentially, as the photographic search of the skies produced hundreds of discoveries per year.

It was in 1900 that J. Miller Barr made his first significant contribution. Barr was born in 1857 in the small Canadian town of St. Catherines. Little is known of his youth, or how he became interested in astronomy. Barr is noteworthy among amateurs in the extent to which he extracted cogent facts from the available material, analyzed the facts, and drew sound conclusions.

In a paper submitted to the **Astrophysical Journal** in January, 1900, Barr demonstrated that the orbital elements of a spectroscopic binary could be calculated from radial velocities. Barr used data which had only recently been published by W. W. Campbell of Lick Observatory. Campbell's data included only six sets of radial velocities for the spectroscopic binary Capella. From this information, Barr calculated the minimum masses and probable separation of the two stars. He went on to predict, correctly, that at some time in the future Capella would be detected as a visual binary. In 1901, Barr suggested techniques which might be used to detect the spectrum of the secondary component of a binary. During this period Barr began to write about variable stars in a more popular vein. His articles about variable stars appeared in the **Handbook** of the Royal Astronomical Society of Canada (RASC) for several years. In the 1907 edition of the **Handbook**, for instance, his "The Study of Variable Stars" occupied 12

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pages, and is a fairly complete observer's handbook.

J. Miller Barr is one of the few individuals ever to have an astronomical phenomenon named after him. In an article in the **Journal of the RASC** for 1908, Barr pointed out that for the orbits of thirty spectroscopic binaries then available to him, a curious asymmetry existed. The angle between the ascending node and periastron for twenty-six of the thirty stars lay between 0° and 180°. This unexpected result could only be attributed to some unrecognized systematic error in the observations. The Barr Effect is now recognized as real. It is attributed to distortions of spectral lines associated with gas streams moving between and around the stars in the binary system.

At about this same time (early in the 20th century), another amateur astronomer reached the peak of his contributions in South Africa. Alexander William Roberts was born in Scotland. After receiving his education there, he migrated to South Africa to devote a lifetime to the education of the natives. His days at The Native College at Lovedale were fully occupied, but he felt the need for some activity that would divert his mind and provide recreation. Variable star astronomy seemed to offer the necessary intellectual challenge. This view was further strengthened through correspondence with David Gill, Royal Astronomer at the Cape Observatory, B. A. Gould, then Director of the Cordoba Observatory in Argentina, and E. C. Pickering, Director of Harvard College Observatory.

After two years of self-imposed "probation" during which he familiarized himself with the southern skies, in 1891 Roberts began a systematic survey of the sky. His procedure was to observe and sketch sections of the sky. Then he would "re-visit" the sketch a few nights/weeks later and look for changes. Using this technique, Roberts discovered twenty new variable stars, including four Algol-type eclipsing binaries. This remarkable achievement called attention to his work. Additional equipment, particularly a prismatic photometer, was soon made available. Using this new photometer, Roberts developed a long and exquisite series of observations of RR Centauri and V Puppis. He was able to show with these data that both were binary stars, nearly in contact, and that the stars involved were severely distorted into oblate spheroidal shapes by tidal effects. This provided crucial observational proof of theories that had only recently been presented by Poincare and Darwin. With data gleaned from these light curves, Roberts also made calculations of the density of individual stars in four binary systems.

Roberts made exhaustive studies of the light curves of Cepheid variables, and long period and irregular variables were also on his observing list. When he was active as an observer, Roberts taught with as little as three hours' sleep!

Both Barr and Roberts made their most important contributions in the few years preceding the formation of AAVSO in 1911. It is therefore somewhat strange that this important work on a "hot topic" among professional astronomers was not immediately taken up by the earliest AAVSO observers. It was not until 1957 that AAVSO member Jeremey Knowles published a paper in **Sky & Telescope** in which he discussed the variability of the period of Algol, observing techniques, and the tracing-paper method of data plotting and reduction. In a 1960 **Sky & Telescope** article, Alan Batten described the professional astronomer's need for observations of eclipsing binary stars. Leif Robinson at **Sky & Telescope** followed up on this with a series of articles on observing eclipsing binaries. In these articles he described individual eclipsing binaries, and how amateurs could make a significant contribution on this class of stars. Robinson promised to publish the observations of qualified observers who submitted them to

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Sky & Telescope.

A few amateur astronomers answered Robinson's call, including David Williams and Marvin Baldwin. They and others began submitting observations of eclipsing binaries to Robinson, who assembled and published the results. Williams formed a small committee to publish ephemerides and develop charts. By 1962 there were 8 to 10 observers reporting results to Robinson. The effort had become too large for Robinson to coordinate by 1965. Williams agreed to chair a committee formed under the auspices of the AAVSO to continue this work. However, by 1969 Williams' own workload as Editor of **Review of Popular Astronomy** forced him to resign from this position. Baldwin agreed to take over the committee at that point, and has served in that capacity to this date. AAVSO observers have, for several decades now, made excellent contributions in this interesting area of astronomy.

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