

Frank Elmore Ross and His Variable Star Discoveries

Wayne Osborn

*Yerkes Observatory, 373 W. Geneva Street, Williams Bay, WI 53191;
Wayne.Osborn@cmich.edu*

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Abstract Frank Ross (1874–1960) was a talented astronomer who excelled in such diverse fields as computational astronomy, optical instrument design, and astrophotography. His career and astronomical contributions are briefly summarized. One contribution was finding 379 probable new variable stars. Most of these variables are poorly studied, and for a number the identifications are still uncertain and the variability not yet confirmed more than eighty years after publication. Ross’s original observing cards and plates are being used to re-examine the stars and resolve the problem cases. Follow-up work on a few stars has yielded interesting results. This work is illustrated with one example.

1. Introduction

Part of the celebration of 100 years of the American Association of Variable Star Observers in 2011 was a special joint meeting with the Historical Astronomy Division of the American Astronomical Society. This paper summarizes a talk at that session, the subject being chosen because of its connection to both astronomical history and variable star astronomy. The paper starts with the history—a discussion of the career of the astronomer Frank Ross. Then it is shown how some of the historical material from Ross’s career has relevance to today’s variable star research.

2. Career of Frank Ross

Frank Elmore Ross (Figure 1) was a talented astronomer and optical system designer whose career can be roughly divided into three phases. His early professional years were spent as a computational astronomer. This was followed by about a decade working as an industrial physicist. His later years were spent as an observational astronomer at the Yerkes Observatory. In all three of these rather different fields he made significant scientific contributions.

Ross was born in San Francisco, California, on April 2, 1874. After attending local schools, he enrolled at the University of California (Berkeley) from which he received his B.S. in 1896 and his Ph.D. in 1901, both degrees being in mathematics. His Ph.D. was one of the first two awarded by California in mathematics (Morgan 1967), and his strong mathematical abilities can be

seen throughout his career. Ross's graduate mathematics studies included work in astronomy. He both did some observing at Lick Observatory, leading to his first published paper (Ross 1899), and learned the techniques of astronomical orbit computation that he would successfully employ in his early career. His early computational strength can be inferred from the references to his work on calculating perturbations of the Watson asteroids (Newkirk 1904a, 1904b, Leuschner 1910).

In 1902 Ross moved from the west to the east coast after accepting a position as an assistant in the Nautical Almanac Office in Washington D.C. He served one year there followed by two years in a similar position at the Carnegie Institute. These appointments involved carrying out computations under the supervision of Simon Newcomb, and he continued providing service to the Nautical Almanac Office until shortly before he left the east for Yerkes Observatory in 1924 (van Biesbroeck 1961). Projects included determinations of orbits for comet 1844 II Mauvais (Ross 1905a), Saturn's distant satellite Phoebe (Ross 1905b), and the then recently-discovered Jovian satellites VI Himalia (Ross 1905c, 1905e, 1907a) and VII Elara (Ross 1905d, 1906, 1907b), as well as working on improving the theories for the observed motions of the Moon (Newcomb and Ross 1907; Ross 1910, 1911a, 1911c, 1914b, 1915, 1918a), the Sun (Ross 1916a), Venus (Ross 1913d), and Mars (Ross 1916b, 1918b; Ross and Newcomb 1917).

In 1905 Ross became the director of the International Latitude Observatory (ILO) at Gaithersburg, Maryland. There he expanded his theoretical investigations to the problem of latitude determination (Ross 1912a, 1912b, 1913a, 1913c, 1913e, 1914c). But one also finds evidence of his instrumental and experimental interest that is first seen in a 1905 paper on improving the mounting of the Lick Crossley reflector (Perrine and Ross 1905). At the ILO he investigated the zenith tube used for observations (Ross 1911b) and then developed an improved version that used photography (Ross 1914a). His PZT (photographic zenith tube) doubled the accuracy of the observations and it became the standard for latitude observations for over fifty years. Its use of photography stimulated Ross's investigations of photographic emulsions and their characteristics (Ross 1913b).

Budget considerations caused a temporary closure of the ILO in 1915 (Bowers and Sengstack 1984; Butowsky 1989) and Ross accepted a position as a physicist with Eastman Kodak in Rochester, New York. During his nine-year period in industry he carried out several of his seminal studies of the photographic process and image effects that eventually resulted in over twenty papers and culminated with his classic book *Physics of the Developed Photographic Image* (Ross 1924). Also during this period Ross began designing camera systems. This work was initially driven by the need for aerial reconnaissance cameras in World War I, but eventually resulted in a design for an efficient wide-field doublet for astronomical use (Ross 1921, Ross 1922). "Ross cameras," which

can produce good star images over fields of 20° or more across, were soon installed at several observatories.

In 1924, at the age of fifty, Ross was appointed a professor of astronomy at the University of Chicago assigned to the university's Yerkes Observatory. As described by Osterbrock (1997), the appointment was recommended by Yerkes Director Edwin Frost who was seeking someone with photography experience to replace the recently deceased eminent astrophotographer E. E. Barnard. Frost expected Ross to carry on Barnard's photographic program, and he did so very productively. Ross realized that re-observation of the fields that Barnard had photographed would permit moving and variable objects to be detected, and this project was very successful. He also used a camera based on his design to produce a new atlas of the Milky Way (Ross, Calvert, and Newman 1934) that complemented the posthumously-published one of Barnard (Barnard, Frost, and Calvert 1927). But Ross also developed projects independent of those pioneered by Barnard. He continued his optics work, designing field-correcting systems and new cameras (Ross 1932, 1933, 1934, 1935), and his photographic experiments (Ross 1931b). He explored how to do accurate photometry (Ross 1936) and how to best image the planets, including photographing them in the ultraviolet and infrared as well as in visible pass bands. His UV observations led to his discovery of cloud features on Venus (Ross 1927c, 1928c).

Ross retired in 1939. He had always been a Californian at heart, and even during his Yerkes years had spent considerable time most years observing at Mt. Wilson and Lick Observatories. It was natural therefore that on retirement he relocated to southern California. He became associated with the Mt. Wilson Observatory as a consultant on optics, working on optical components for the 48-inch Schmidt and 200-inch reflector planned for Mt. Palomar. He also designed lenses for the motion picture industry (Nicholson 1961). Ross passed away on September 21, 1960, at the age of 86.

3. The Ross variable Stars

How Frank Ross is connected to modern variable star research lies in some of the work he carried out at Yerkes Observatory. Yerkes is known for its 40-inch refractor. Once the largest astronomical telescope in the world, by the time Ross joined the Yerkes staff it had been surpassed by several much larger and more versatile reflectors and was relegated to specialized observing programs. One of the areas for which the great refractors were well suited was astrometry—the determination of accurate positions—and Yerkes had a well-established program for the determination of stellar parallaxes.

The pioneer astrophotographer E. E. Barnard had taken a large number of deep plates with the Yerkes wide-field Bruce telescope in the period 1904–1922. Ross realized that by re-photographing the fields with the same camera he would be able to compare the plates through blinking and detect stars of large

proper motion. Such stars would be excellent candidates for the Yerkes parallax program as large proper motion typically reflects a rather small distance. Ross eventually published eleven papers listing 1,069 high proper motion stars, three of which are even today among the fifteen closest stars known.

Ross's blinking of plate pairs also led to discoveries of 379 suspected variable stars. These were announced in ten papers published between 1925 and 1931 (Ross 1925, 1926a, 1926b, 1927a, 1927b, 1928a, 1928b, 1929, 1930, 1931a). Today, most of the Ross variable candidates have been confirmed as variables, but only a few have been studied. About 40 of his suspected variables have not been confirmed; some were shown to result from minor planets visible on one plate of a blinked pair (Bedient 2003, Marsden 2007), while for others the published positions were in error or too imprecise to unambiguously identify the star.

4. Recent work on the Ross variables

In 2010 a project was begun at Yerkes to review the Ross plates and identify the "lost" variable candidates (Figure 2). It was quickly found that Ross had marked the fields of his variables on the plates (Figure 3). More importantly, Ross's note cards for his variable work were located (Figure 4), and the combination of the cards and the plates made identification of the objects certain.

We have elected to systematically examine all of the Ross variables, not just the ones with identification problems. This has allowed us to not only determine better positions when needed but also to derive better epochs (Ross only published the local dates for the plates he used) and magnitudes more closely related to B of the UBV system (Ross's values are systematically about 2 magnitudes too bright); such data may be useful in that these observations are often the earliest known for the variable. This approach has also allowed us to look more closely at some of the more interesting objects. So far we have worked through about half of the stars (Osborn and Mills 2011).

An interesting example of how this work ties in to variable star research is provided by the star Ross Variable 4, also known as NSV 1436. Ross's note card is shown in Figure 5, and the field on the two discovery plates is shown in Figure 6. Ross 4 is the fairly bright star visible on the 1905 plate taken by Barnard but not seen on the 1925 plate by Ross. The star's position is very close to an X-ray source, so we elected to investigate its light curve using other plates of this field in the Yerkes collection. The object was found to be always at $B = 16$ or fainter except for two outbursts—the one in 1905 and another in 1948, when it brightened to at least $B=13$ (see Figure 7). These results suggested Ross 4 is a cataclysmic variable, and possibly of the rare recurrent novae type (Brown *et al.* 2010). A third outburst was observed in March 2011, and the recent observations indicate a classification as a dwarf nova is more likely. (Osborne *et al.* 2011).

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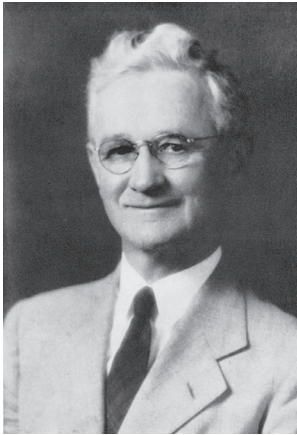


Figure 1. Frank E. Ross (1874–1960).
From Nicholson (1961).

Figure 2. Yerkes volunteer
O. Frank Mills prepares to
examine a Ross plate.
Figures 2–6 are from the
author.



Figure 3. Ross's plate number 22
(R-22) with his markings of several
proper motion and variable stars.



Figure 4. The box containing Ross's
note cards for his variable star
discoveries.



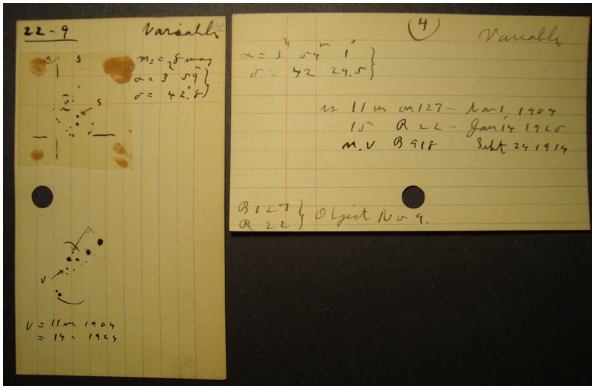


Figure 5. Ross’s note cards for Ross 4 (NSV 1436). The card on the left has the finding chart (compare the lower sketch on the card to the field shown in Figure 6). The card on the right gives the determined 1875 coordinates and estimated magnitudes on three plates.

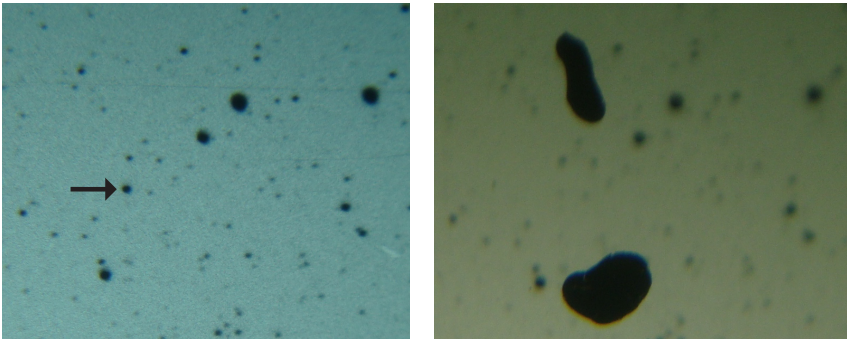


Figure 6. The field of Ross 4 (NSV 1436) on the discovery plates. The image from Barnard’s 1905 plate B-127 is on the left, and that from Ross’s 1925 plate R-22 is on the right. The variable is marked with an arrow on the left image, and Ross’s ink marks are seen on the right image that show its approximate location.

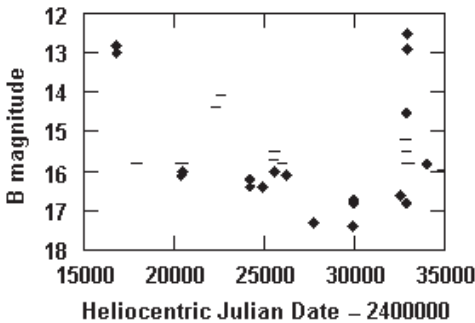


Figure 7. The light curve of Ross 4 (NSV 1436) from 1904 to 1952 From Brown *et al.* 2010.