A Lens in Limbo—The Maria Mitchell Memorial Astrograph

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Abstract The Maria Mitchell Astrograph was used for variable star research for a period of over eighty years. This paper gives a technical history and survey of the instrument.

1. Introduction

This is intended as a technical overview of the status of the astrograph at the Nantucket Maria Mitchell Observatory (MMO) rather than a research paper. Recently, Dr. Vladimir Strelnitski, current director of MMO, and his staff, as well as Dr. Bradley Schaefer, have reported on the MMO plate digitization project (Davis *et al.* 2004; Schaefer 2003).

I expect that many AAVSO members are quite familiar with the observatory. However, there are many nuances that make the facility of historic interest and value in the history of scientific instrumentation. This is over and above the existence at the Observatory of Maria Mitchell's original 5-inch Clark Telescope of 1859.

Over the past fifty or more years that I have worked as an optician, optical engineer, and amateur astronomer, I have had the opportunity to come in contact with hundreds of astronomical instruments, some new, old, or very old (Galileo's, for instance). Some were simply viewed *in situ*; some were looked at, looked through, cleaned, or restored. Many pioneering instruments were brought to my attention while I was a high school student working a summer job at Harvard College Observatory (HCO). Never before have I encountered a lens that was once state-of-the-art but despised by its owners as never quite good enough.

2. Discussion

The Maria Mitchell Observatory Astrograph (Figure 1) is a Cooke Triplet, 7.5-inch F/4.5, designed and manufactured by H. Dennis Taylor in England in 1911. Figure 2 shows the classic Cooke triplet design.

In 1984, Dr. James Baker and the author volunteered to undertake a reverse engineering and repair of the astrograph. We were to work with Dr. Emilia P. Belserene, then Director of the Observatory (who had at the time researched much of the historical information given here). We found it to be of excellent quality, considering the glass-types available, and the state of optical design and lens fabrication at the time.

Dr. Baker had visited the lens once before as a post-graduate researcher at Harvard

College Observatory (HCO). He tested it in deep blue light at the observatory's optical shop with then MMO Director, Margaret Harwood.

A Radcliffe graduate, Margaret Harwood was the first user from 1911 until the mid-1950's. Miss Harwood had received a stipend in 1913 from the Nantucket Maria Mitchell Association. She was to continue a research program as a living memorial to Maria Mitchell. Only a few plates were taken during World War I, as Miss Harwood was unhappy with the images and materials were scarce. Four years later, in 1918, H. Dennis Taylor suggested to her that the triplet lens could be used with R1 of the central flint element facing forward for a flat field of uniformly aberrated images or reversed for sharper images in the center of the field, but with larger aberrated blobs at the corners. Miss Harwood tried reversing the lens several times over the next two decades but was never sure which was best for variable star measurements.

She traveled to HCO for assistance in 1941. The lens cell was rebuilt and lenses re-installed by J. W. Fecker. Fecker had done similar work for another observatory (probably gratis). Twice, in Pittsburgh, the lens was re-spaced in the new cell without satisfactory results. As World War II events consumed the activities of Dr. Baker and Fecker, Miss Harwood took the lens back to Nantucket and resumed observations of variables in the Scutum Star Cloud. It seemed no better than before and centering controls for the middle element had been removed.

Dr. Dorrit Hoffleit, MMO Director 1957–1978, ignored the aberration effect and continued variable star research each summer.

So, it was in 1984 that Dr. Belserene asked the Amateur Telescope Makers of Boston to assist Dr. Baker with a reverse engineering and refurbishment task. Ken Launie and George East volunteered to repair the many cell parts while all the lens parameters were determined. Harry Vandermeer, President of Optical Systems and Technology, Inc., gave permission to use the facilities after hours for measurement, cleaning, and re-assembly of the lens elements. Figures 3 and 4 show the cleaned and repainted triplet parts, and the re-installation, respectively.

After the radii, thicknesses, spacings, and dimensions were determined, we needed to know the glass types and dispersions of the elements. Dr. Baker suggested that the elements be weighed so that the specific gravities of the three lenses could be obtained. From that information, Dr. Baker was able to determine that they were of Chance Glass Works manufacture and not a Zeiss or Schott product.

A decade ago, the astrograph had to be taken out of service for lack of Kodak 103Ao glass plates. Unfortunately, there are no CCD's currently available for the 15° field of view and it is unlikely that one could be made that would be suitable. However, there is still interest in establishing which plates were taken for each lens orientation and to determine if the aberrations affected the accuracy of brightness measurements. Also, it would be desirable to correlate measurements with the digitized versions that Dr. Strelnitski and his staff have completed.

Miss Harwood always took meticulous notes in a fine hand and it should be possible to determine the time sequence when she installed the lens forward or reversed.

The passing of Dr. Baker last June before he could find the lens data has delayed the project. When found, the lens can be re-analyzed with the Zemax Ray Trace Program or equivalent. This will re-establish the aberration patterns for each time period.

3. Conclusions

Photometrists have already found that slightly out-of-focus images have little effect on the accuracy of brightness determinations, usually within ± 0.1 magnitude. Having a uniform distribution of blur patterns will only diminish the limiting magnitude of a given photographic plate and exposure time.

As photons build up on a plate, the silver grains are exposed to saturation and spill over to adjacent areas because of turbulence, tracking errors, and optical effects such as halation. The result of saturation is a top hat intensity profile for the brightest sources. The dynamic range of film is far inferior to Quantum Detectors and the human eye. Comparative measurements of stellar brightness on most of the plates obtained with this telescope can be made to an accuracy of ± 0.1 magnitude except at the corners of the field, thanks to the fixed relationship of source brightness to image size.

Determining the time sequences for the MMO Astrograph in the reversed lens condition would make a nice project for a student of stellar photometry or of the history of astronomical instruments. Magnitude estimates of central and near-edge stars could then be compared to determine whether an aberration constant needs to be added as a function of field angle for the reversed lens condition.

References

Davis, A., Barkume, K., Springob, C., Tam, F., Strelnitski, V. 2004, *J. Amer. Assoc. Var. Star Obs.*, **32**, 117.

Schaefer, B. 2003, *Sky & Telescope*, (March), **105**, 42.

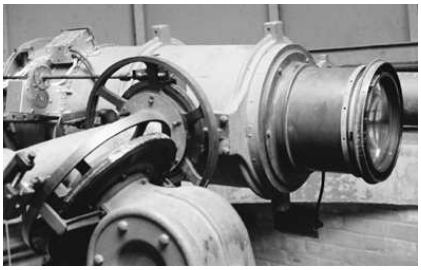

Figure 1. The 1914 Cooke Astrograph Type 1A, 33.75" EFL, F/4.5 at Nantucket before refurbishment.

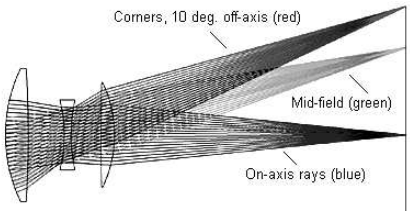

Figure 2. Classic Taylor Triplet Design.

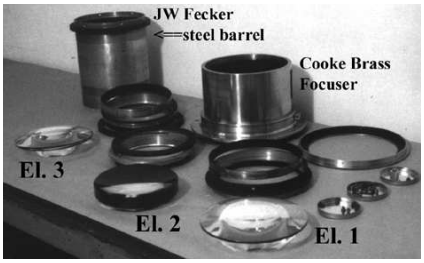

Figure 3. The main lens parts after cleaning and re-painting. All but the steel barrel are original.

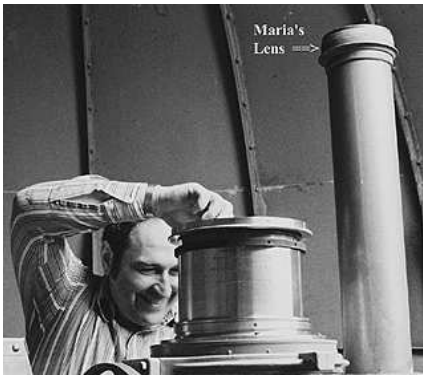

Figure 4. The author re-installing the repaired and improved lens at the Vestal Street Observatory.