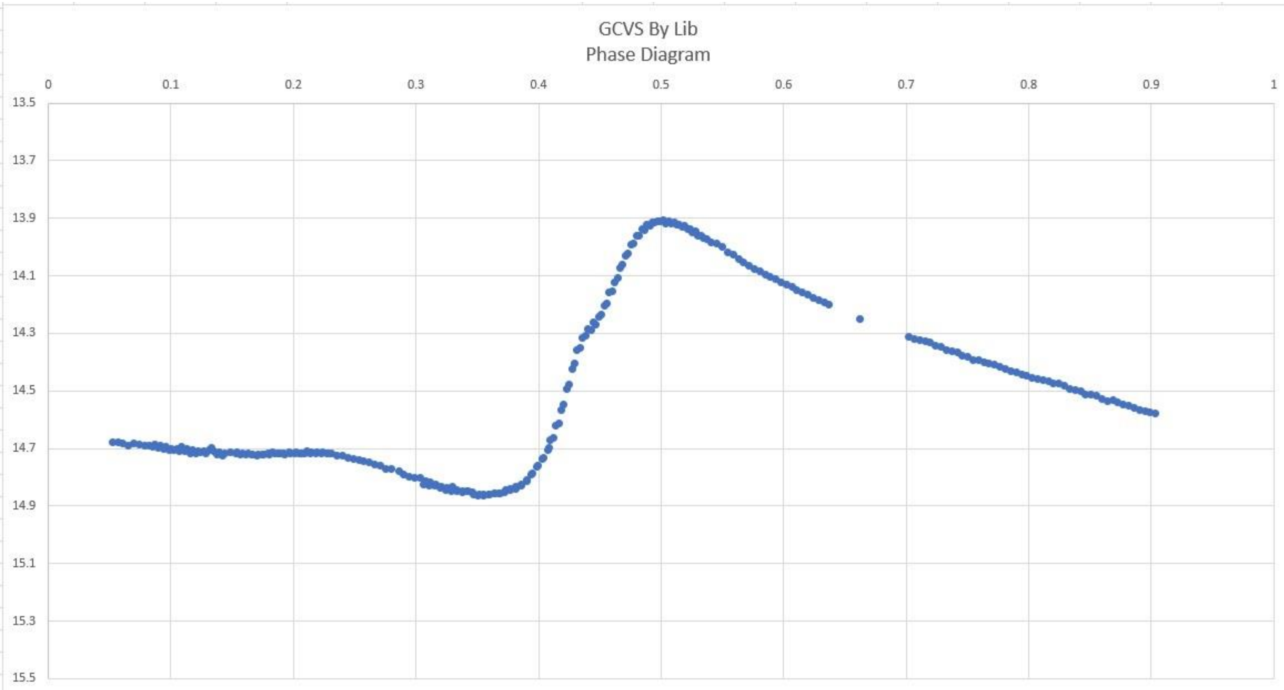
# Photonic Cleaning Technologies presents:
# Crystal Lake Observatory, New Zealand




Phase diagram for the RRab variable By Lib. It shows how the luminosity of the star varies over a period of approximately 12 hours.

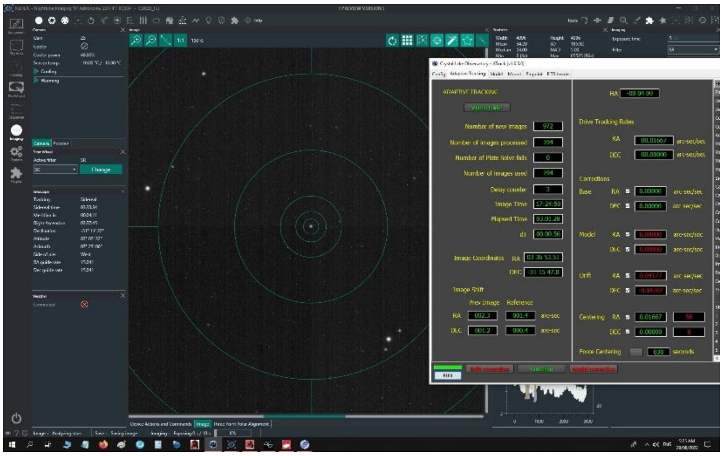
When I was 9 years old my grandmother gave me a 3” reflector telescope purchased at Edmund Scientific and explained that her grandfather in Germany had been an astronomer. I was hooked. The little telescope did not have setting circles so I learned how to find faint objects by pointing the star at the meridian and then using the local sidereal time and right ascension of the object to determine when the object would appear in the eyepiece. This moved me into a more analytical study of the night sky.

At university I majored in physics with access to a 20-inch Cassegrain telescope. This was a big step going from a 3-inch reflector to a 20-inch Cassegrain. After a few months of general use, I requested the physics department to purchase a photoelectric photometer for the telescope so I could learn how to make precise measurements of stellar luminosity. Back then the measurements were analogue and recorded on a strip chart recorder as wavy lines. The next day I had to use a ruler to make a guess at the average voltage level of the signal and then put the measurements on punch cards for processing by the university IBM 1130 computer.

After university I worked for several companies developing mathematical models for applications such as Air Bag deployment, petrochemical industry econometric models, and seat belt retractor manufacturing optimization. Later, I started my own company to design and manufacture small handheld rugged computers for industrial and military applications.

But astronomy was always in the back of my mind and in 1990 I got back into astronomy by writing an educational software program entitled “Telescope Simulator using a 24-inch Telescope” or TS-24 and established Crystal Lake Observatory. TS-24 simulated the use of eyepieces, a photoelectric photometer, and a CCD camera to search for and study asteroids and variable stars.

Up to this point I had only studied the stars in the northern skies so in 1994 I decided to experience the southern hemisphere and moved to New Zealand where everything I had observed was now upside down. The Maori name for New Zealand, Aotearoa, means land of the long white cloud which I can confirm is an accurate depiction.



Adaptive tracking software I wrote to provide precision tracking during an imaging run. ATrack is used to maintain the star in the center, much like an autoguider.

The Eta Carina nebula taken with a Canon EOS 60D DSLR and a 400mm Takahashi lens

PlaneWave CDK20 telescope used for studying RRab stars

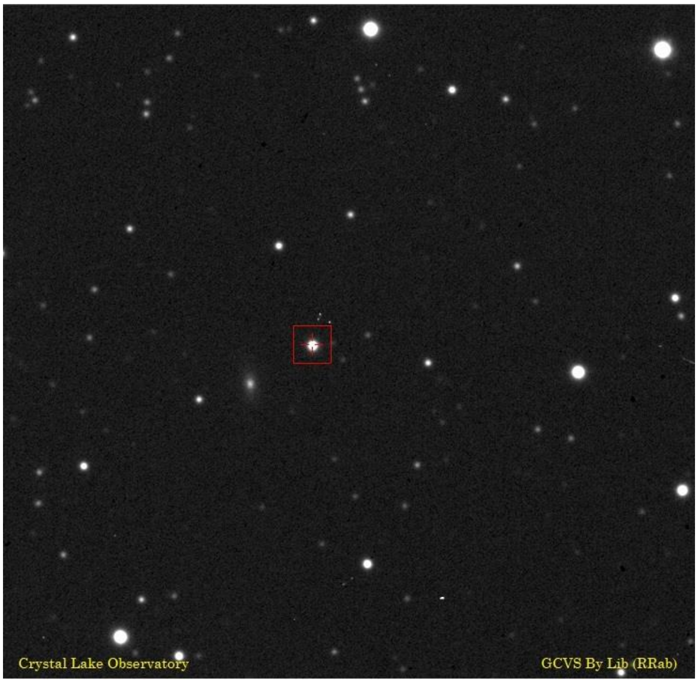
While producing lush green fields and a moderate, pleasant climate the “long white cloud” is problematic for astronomical observation. After a few years to get familiar with New Zealand I finally settled on a piece of land that would be ideal for building a personal observatory.

As observing nights are infrequent and treasured, I returned to my interest in photometry. A lot had changed since those early days, with the photoelectric photometer now replaced with high precision CCD cameras. Instead of measuring a single star I could now measure many stars in a single image. And even more importantly I no longer had to measure the signal manually but could select from many off the shelf software packages to automate the entire process.

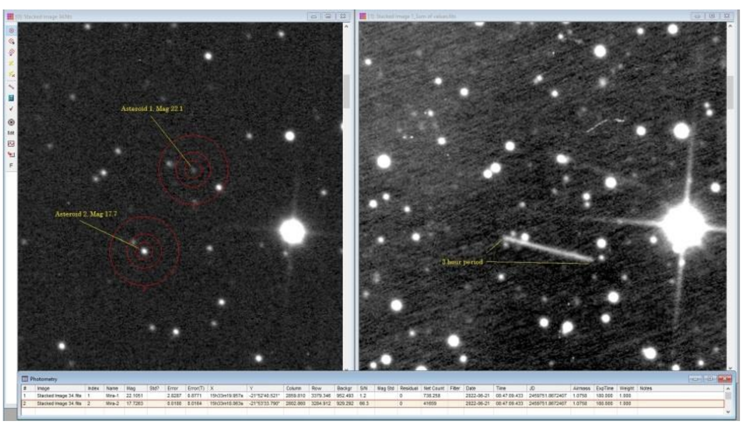
Once I was familiar with the new technology and software and considering the observing conditions here at the observatory, I settled into the photometric study of RRab stars and the Blazhko effect. The Blazhko effect is the variation of the brightness and period of a small class of pulsating variable stars known as RRab stars, a subset of the RR Lyrae variables. The cause of this variation is still unknown, which makes this an excellent long term research project.

I divided the project into “surveys” with each survey running two years. Each survey would include four RRab stars spaced equally in RA over a 6-hour declination arc that spans from an hour angle (HA) of -3 (eastern sky) to +3 (western sky). Images are taken at 10 second intervals and then 18 images stacked to generate a single image every 180 seconds (3 minutes). The methodology minimizes the stellar distortion caused by atmospheric turbulence and random fluctuations in the telescope tracking, resulting in near perfect point spread functions of each star. The photometric precision is less than 1% with error terms usually 0.003 mag.

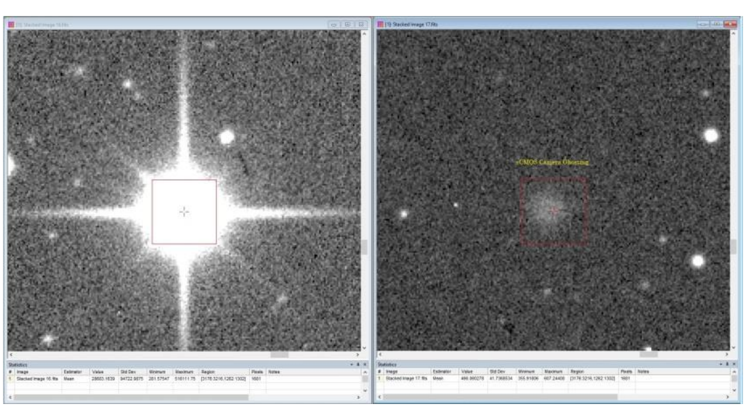
A 6-hour observing run generates more than 1900 images which are then stacked to about 100 measurement images. The length of observing nights ranges from 12 hours in the winter to 6 hours in the summer. Because of this, the number of images collected each night varies. The raw images are saved on a




The star in the center of this image is By Lib, a RRab pulsating variable.



The image on the left shows two faint asteroids passing through the target field. Notice the CDK20 can reach down to 22 magnitude with a 3 minute exposure. The image on the right is a 3 hour composite showing the two asteroid trails.



Ghosting is an artifact of sCMOS cameras where the pixels can retain charge after clearing for a short period of time. The image on the left is a bright star before a pier flip and the image on the right is after the pier flip which moves the star to the opposite side of the image but shows the decaying charge still on the pixels.

network database server for future reference if required.

The principal investigative instrument at Crystal Lake Observatory is a Planewave CDK20 telescope equipped with an FLI Kepler KL4040 sCMOS camera and Astrodon Sloan Photometric filters. Each year the photometric filters are cleaned using the First Contact polymer to remove dirt and dust that accumulates over time. I have found no other method to be more effective as this solution. After removal of the polymer film, I am always amazed at the dust and particle free surface. After several years cleaning I have observed no damage to the filters.

In the winter the long nights can yield 4,000 images each night to be photometrically calibrated. A collection of ensemble stars is used to determine the zero point of each image. The zero point is then applied to the flux measurements of the RRab variable and a check star to yield a photometric measurement of the star’s brightness on that night. Over the course of a year each RRab will be measured several thousand times with all data reported to the AAVSO data base.

The images are additionally examined for new variables or transient events such as asteroids or unexplained changes of brightness in other stars. I have uploaded more than 50,000 measurements to the AVSO at this point and hope to continue to contribute several thousand per year over the next decade and to participate in research programs where my data would be of use. More information and status of Crystal Lake Observatory activities and facility can be found on our website. Crystallakeobservatory.com