Vol 49 Number 3

AstroNotes

New Jersey Astronomical Association

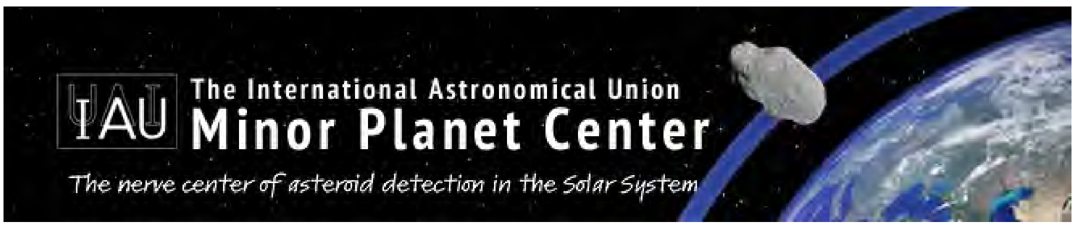
www.njaa.org

March, 2015

Celebrating our 50th Year!

International Astronomical Union - Minor Planet Center Recognizes Paul Robinson Observatory !

"A Surprise Anniversary Present for NJAA"



The Minor Planet Center (MPC) at the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA has awarded the Paul Robinson Observatory with an Observatory Code.

That simple sentence is actually quite an honor.

The MPC is under the auspices of the International Astronomical Union and is responsible for collecting and checking measurements of the positions of asteroids, comets, and other objects in the solar system. They use that information to compute orbits and make predictions of future positions. (The MPC is also responsible for naming asteroids and comets, in conjunction with the Central Bureau for Astronomical Telegrams.)

The Minor Planet Center depends upon a network of observatories, primarily professional, to send them these measurements. The accuracy of calculated orbits depends upon the accuracy of the measurements the MPC receives. When you're predicting a near miss of a large asteroid you really want to get it right! The MPC only accepts measurements from observatories it has certified are capable of producing highly accurate results.

Last summer Stephen Blazier and Mike Smilios imaged asteroids with the 26" to assess its astrometry capability. They assessed the images as high quality and the astrometry excellent. However, they wanted to confirm their judgment by getting the opinion of experts in the field of astrometry at the MPC. The MPC responded with an Observatory Code for the Paul Robinson Observatory, indicating our measurements are of research quality and inviting us to submit to them measurements of other objects.

There are fewer than 2000 observatories around the world that have been assigned Codes by the MPC with the vast majority of those being professional observatories. The Paul Robinson Observatory, with its 26 inch (0.66 meter) telescope, is now one of them.

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Minor Planet Center Award continued...

Over the last several years a small group of members have been working to improve the capabilities of the 26 inch telescope and the Paul Robinson Observatory. You've heard about the addition of a declination motor, adaptive optics (*AstroNotes*, August, 2014), and dome remote control (*AstroNotes*, September, 2014). There are many other additions you have probably not heard about. All of these combine to deliver more precise and accurate scientific imaging. As an illustration of the accuracy of the submission to the MPC, a half a mile variance could have been detected of an asteroid's predicted trajectory at a distance of a million miles.

The attainment of an MPC Observatory Code is a fitting tribute to the New Jersey Astronomical Association as we celebrate its 50th anniversary. Stephen and Mike want to express their appreciation to the leadership and members of NJAA who have supported the 26" with their time and talents, to both maintain the Paul Robinson Observatory and enhance its capabilities. It is also a tribute to the skill and craftsmanship of the founding members that the telescope they championed 50 years ago had the foundation to become the telescope today that brought an MPC Observatory Code to the Paul Robinson Observatory.

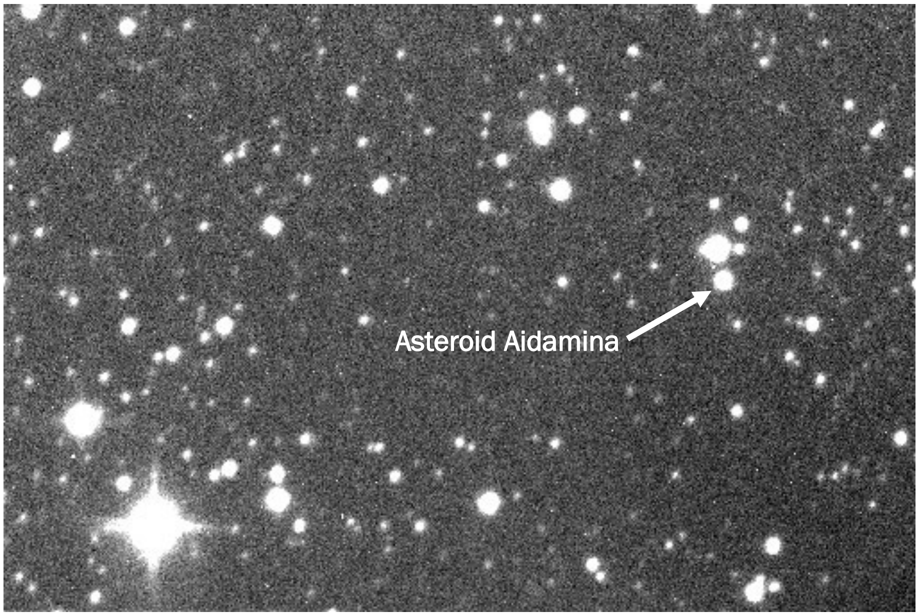
MPC Observatory Codes: http://www.minorplanetcenter.net/iau/lists/ObsCodesF.html

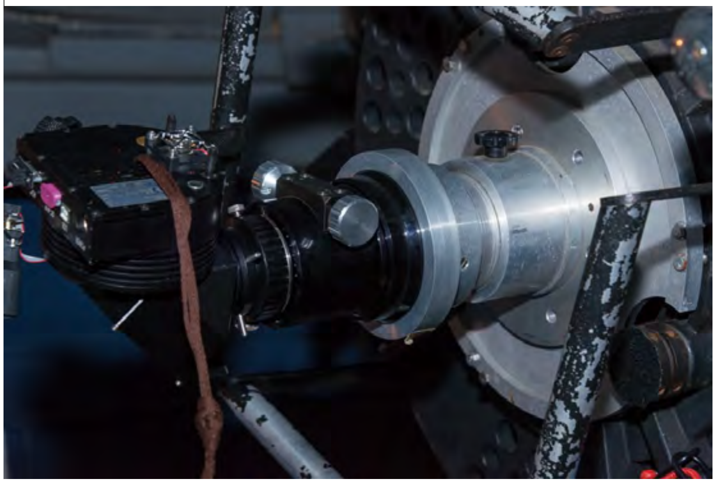
Paul Robinson Observatory Code W67

At Right: one of the images used to measure an asteroid. Stars range from magnitude 9 to 19.

Below: SBIG ST-8 Imaging Camera mounted on the 26" Telescope.

Below Right: NJAA Astrometry Imaging Team making measurements.





President's Corner—Jim Roselli

Our "CCD Team" recently achieved a breakthrough by successfully using adaptive optics to guide our 26 inch scope. Guiding with today's GoTo robotic telescope mounts can be very challenging due to the incredible number of details associated with the process. So when I heard that they achieved this with the 26 inch scope, I new that our membership had to be made aware of their success. I urged the team to write and article and I'm pleased to see this published for the benefit of our membership.

Congratulations to the CCD Team on their accomplishment. Guiding to this degree of accuracy at a focal length of 8,000mm, will open the doors to many other research projects and hopefully funding opportunities as well.

Thank you for your dedication to the project and NJAA.

Jim Roselli

Adaptive Optics— Above the Air - Stephen D. Blazier

Introduction

We love our atmosphere. To breathe, protect us from falling rocks and cosmic rays, our air is essential. But some nights it is so frustrating as we watch the light through an eyepiece shimmer or shake to the point we see double, or boil so much we don't know where focus really is, we wish that air gone. Ah, for a Hubble Telescope of our own. We can dream can't we? And out of dreams come solutions. Adaptive optics is a technology that removes some of the problems the atmosphere creates. Several telescopes well known to us have used adaptive optics to improve their imaging. Those telescopes include the 200-inch Hale telescope at Palomar Observatory, the 60-inch telescope at Mount Wilson, and recently, the 26-inch telescope at the NJAA Paul Robinson Observatory.

In Theory

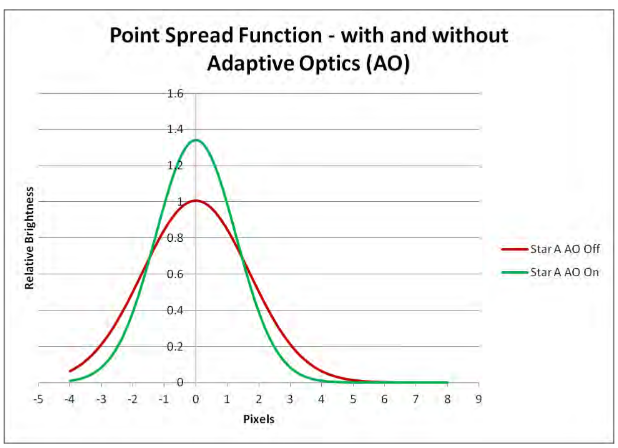
To undo the bad effects of the atmosphere we must be able to measure these distortions, and quickly compensate for them. To do this requires understanding, and understanding begins with seeing (pun intended). When we look at a star with the unaided eye it often appears to twinkle, which is an indication that the wavefront of light from the star has been distorted in its journey through the atmosphere. This distortion is caused by turbulence and atmospheric refraction differences accompanying temperature, pressure, and humidity changes in the atmosphere. The net result is that portions of the light wavefront from the star travel faster than average through the atmosphere and other portions travel slower, resulting in phase differences. So what began as a plane wavefront arrives at the telescope deformed, similar to a sheet of paper that has been crumpled and reopened – it's not exactly flat anymore. In addition, these distortions are rapidly changing. When we magnify this star light with a telescope we magnify the distortions as well. The rapidly changing phase differences result in blurred images through the telescope, and are often referred to as "seeing," with less blurring called better seeing and more blurring called worse seeing.

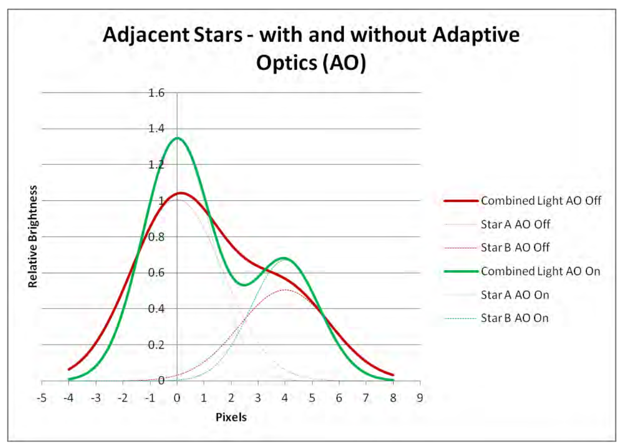
These distortions affect images by spreading out (blurring) the light across more pixels in a camera. This makes stars look bloated instead of tight in the images, and the light from close objects overlaps. In addition, the amount of light an individual pixel captures is reduced, making it harder to detect faint objects, resolve stars, and see fine details.

Adaptive Optics - Stephen D. Blazier *continued…*

The illustrations below show these effects in a theoretical sense. The charts plot the intensity (brightness) of light on the Y axis as it might appear across a CCD detector at the prime focus of a telescope. The X axis is labeled pixels, with 0 being an arbitrary pixel location on the detector. Positive values indicate pixels to the right of that arbitrary location and negative values pixels to the left. The chart presents a one dimensional view, such as a single row of pixels on the CCD detector. The charts show a smooth line, but of course pixels will sum the light for a whole pixel at a time. Although stars can be considered point sources of light, by the time the light reaches a camera the light is always spread out for various reasons. The manner in which the light spreads is called the Point Spread Function, or PSF. For simplicity, the PSF is drawn as a normal (or Gaussian) distribution.

The first chart shows the PSF for a single star (labeled Star A) under two different conditions. The red line shows the star as it appears without adaptive optics, with the light spread out over a larger area. For simplicity, the chart shows the peak at an X value of 0 and Y value of 1. The green line shows the same star as it appears with adaptive optics. For this example we show a 25% reduction in Full Width Half Maximum, the typical metric for star width. The tighter curve with adaptive optics results in a peak at a higher value, since the same amount of light is spread over a smaller area. That higher peak leads to detecting fainter objects.





The next chart shows the combined light from two close stars of different brightness. In this situation it can be difficult to determine that there are two separate stars instead of one, or in other words, to resolve the stars in the image. The brighter star is the same Star A used in the example above. The fainter star (labeled Star B) has half the brightness of Star A and is 4 arcseconds to the right, using a pixel scale of 1 arcsecond per pixel. The pixels in a CCD camera would report the combined light from the two stars, and the solid lines in the chart represent the combined light from the two stars. Light from the individual stars is shown by thin dotted lines. As before, the red lines show the light as it appears without adaptive optics, while the green lines represent the light with adaptive optics.

The lines representing the light with adaptive optics peak significantly higher than the lines representing light without adaptive optics. In addition, the adaptive optics line shows two peaks while the non-adaptive optics line shows only one peak with a broad curve that is extended to the right. In this example, without adaptive optics it would appear there is a single large star, but with adaptive optics the image would be resolved to reveal the two stars. In summary, these observations illustrate that adaptive optics makes stars look brighter, and resolves closer stars.

Adaptive Optics - Stephen D. Blazier *continued…*

The distortions in the light can be thought of in two components: a shift of the overall image to slightly different positions in the field of view, and a distortion in the shape of the wavefront of that shifting image. Returning to the sheet of paper analogy, draw a grid of parallel finely spaced horizontal and vertical lines on a flat sheet of paper. Make a photocopy of the paper with the grid and tape the copy on a table as a reference image. Crumple the original paper and reopen it. Now lay the paper down on top of the copy taped to the table, but slightly offset so that the grid lines are not exactly on top of each other. Peering through the previously crumpled paper and observing both grids combined, it may appear as a single grid with thicker lines, or as two grids with lines very close to each other, depending on the amount of offset when laying the paper on top of the copy. In other words, the grid will have shifted slightly from its initial position. In addition, the crumpling of the paper will have left slight folds so that the lines in the copy are not perfectly straight. When laid on top of the copy it will be obvious the lines do not have their original shape.

To undo these distortions we need to shift the image back to the original position and change the shape of the wavefront in precisely the opposite manner from what the atmosphere did to the wavefront. But to figure out how to undo the distortions, we need to measure what the atmosphere did. The easiest way to make those measurements is to examine what happens to a point source of light – a star. The overall shift in the image can be measured by calculating the center of the light from the star (the centroid). The distortion to the wavefront can be measured by a wavefront sensor (for this discussion we'll leave it at that). Once the amount of shift and deformation is measured, mirrors can be tilted and reshaped to compensate for the

deformations.

In Practice

Putting these theories into practice has a number of challenges. For example, since the deformations change rapidly, exposures must be very short and measurements done quickly. How short depends upon a number of factors, including how much of the deformation is to be corrected. There is no simple answer, but measuring shifts of the image might require 10 exposures every second, while undoing significantly more of the deformations might take 500 exposures every second. To get a decent image in that short an exposure requires a high flux of photons. That means a large guide scope, bright guide star, or both.

In addition, the wavefront deformations vary in different parts of the sky. The angle over which the turbulent pattern is statistically the same (referred to as isoplanantic patch) is very small. The angle for similar shifting motion (referred to as isokinetic patch) is somewhat larger, but still small. While some improvement can be derived over somewhat larger angles, the net result is that the guide star must be in or very close to the field of view of the target.

Bright guide stars can be hard to come by, so some observatories generate their own using a LASER to excite atoms high in the atmosphere (see photograph below). The photons emitted by these excited atoms travel back to the telescope, simulating a star. Other approaches are to limit observing to objects near bright stars, or to forego some of the possible improvement by using longer exposures of the guide star.

Adaptive Optics - Stephen D. Blazier *continued…*

Once measurements of the deformations are available, devices are then needed to undo the damage. One approach is to use separate devices for the shifting of the image and the wavefront distortions. A tip/tilt mirror can be used to shift the overall image to a common position. A deformable mirror and a grid of actuators are often used to correct the shape of the wavefront.

The improvement expected through adaptive optics depends upon a number of factors, including the size of the telescope (bigger is better, as if you didn't know), the distance of the guide star from the target, the coherence of the atmospheric turbulence, the wavelength of the observation, and the amount of distortion that is attempted to be corrected (e.g., shifting motion versus wavefront shape). For the most aggressive, professional, large observatory (read "big money") the goal is frequently stated in terms of diffraction limited (thus the bigger is better phrase), and some results have been reported better than twice the diffraction limit for some of those observatories. For less well funded projects, where only the higher order distortions are addressed, reductions in star width, as measured by the Full Width Half Maximum (FWHM), of around 25% have been reported.

At NJAA

Across the years the CCD team, including William Linke, Donald LeFevre, Mike Smilios, and myself, has been working to improve deep sky imaging with the 26-inch telescope at NJAA. In partnership with several others, a number of improvements in equipment and technique have been possible. In the beginning years of CCD imaging with the 26-inch, exposures were limited to less than 15 seconds, and stars appeared bloated and elongated. Significant improvements since then include a new clock drive (Bill Buntemeyer and Steve Smith) and a Declination motor (Steve Smith). Another major change since then is the conversion to a Cassegrain, which more than tripled the focal length, from 2586 mm to 8280 mm.

In December of 2007 the CCD group performed an analysis of the 26-inch telescope and concluded that it fundamentally had the capacity to take advantage of adaptive optics, and that with available adaptive optics technology it could reach 18 minute exposures. We also identified that a number of techniques would need to be developed for that to be possible. Fortuitously, in 2012, shortly after we felt we had developed those techniques, we discovered an SBIG adaptive optics unit, the AO-7, in a bequest to NJAA from the estate of George E. Mahlberg.

The AO-7, shown to the right, is designed to address the shifting image component of the distortions. It uses a tip/tilt mirror that can be adjusted up to 50 times a second. We attach the AO-7 to the NJAA ST-8XE CCD camera. The AO-7 attaches to the 26-inch telescope focus tube. The wiring harness is connected to the CCD camera so that they can communicate in controlling the clock drive and Declination motor.

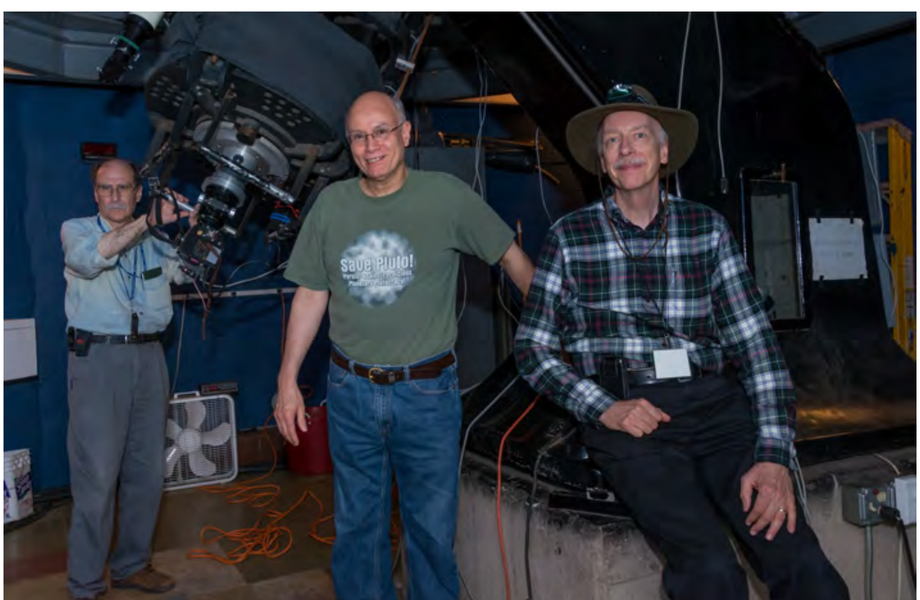
The correction range of the AO-7 is limited by the tilt range of the mirror. Within that range the AO-7 adjusts rapidly. To ensure a correction is not required beyond the range of the mirror's limit, parameters can be set to trigger Right Ascension and Declination motor movement when the mirror tilt exceeds a specified amount. As the motors move the telescope, the AO-7 continues to rapidly adjust the mirror based upon guide star exposures, so tracking remains excellent through those motor adjustments.

Adaptive Optics - Stephen D. Blazier *continued…*

This leads to an important additional benefit of adaptive optics on the 26-inch telescope, and most amateur telescopes. Gears are not perfect, and amateur mounts are machined with worse tolerance than professional equipment. As the 26-inch clock drive turns the gears to track the stars, the small imperfections in the gears are greatly magnified by the over 8 meter focal length of the 26-inch telescope. Without guiding, the stars appear to jump forward, back, up, and down. Autoguiding, without adaptive optics, brings the slow variances of the drive under control, but 2500 pounds of telescope does not react quickly; certainly not as fast as the AO-7 mirror can adjust.

Our current procedures using the SBIG AO-7 with the NJAA 26-inch telescope routinely capture 15 minute exposures with stars tighter than what we started out with on 15 second exposures. The longer exposures capture stars 60 times fainter than those in our early images. Adaptive optics enables us to take these long 15 minute exposures without losing the guide star, and in addition tightens the stars to bring out more detail and even fainter objects.

An example of these improvements for the NJAA 26-inch telescope is shown below, in the comparison of three images. The first image is a short exposure, without adaptive optics, which is well tracked (tracking is easier in short exposures). The second image is a combination (stack) of longer exposures, without adaptive optics, that did not track well (as is common with longer exposures). The third image is a combination of even longer exposures, this time with adaptive optics, which tracked well (a benefit of the adaptive optics). Eris, formerly known as the tenth planet (leading to Pluto's demise as a planet), was the target for all three images. The first two images are from October 1, 2005, less than 10 months after Eris was discovered. At the time, the 26-inch was in a Newtonian configuration, and we were imaging with an SBIG ST-7E CCD camera. The last image is from November 17, 2012. Seven years had elapsed and a number of things changed during that time. The 26-inch was changed to a Cassegrain configuration (with a focal length more than three times longer than the Newtonian), and we moved up to imaging with the SBIG ST-8XE CCD camera and the SBIG AO-7. As slow as Eris moves, in seven years it was in a completely different star field, and this time a much fainter one.



The CCD team.

Left to right Mike Smilios, Stephen Blazier and William Linke.

Adaptive Optics - Stephen D. Blazier *continued…*

Image 1 below is a 10 second exposure. The stars are reasonably round because the telescope tracked the stars well during the 10 seconds the earth rotated for the exposure. The two brighter stars in the image are magnitudes 11 and 12. The fainter stars are magnitude 15-17. Eris, at magnitude 18.7, is not visible. Even the large light gathering power of the NJAA 26-inch telescope is not enough to reveal objects as faint as Eris at this short exposure.

Image 2 is a composite of 17 three minute exposures. While the additional exposure time is sufficient to reveal faint Eris (just to the left of the label in the image), during the three minute exposures the earth's rotation was not well compensated, and stars, as well as Eris, are elongated to short streaks.

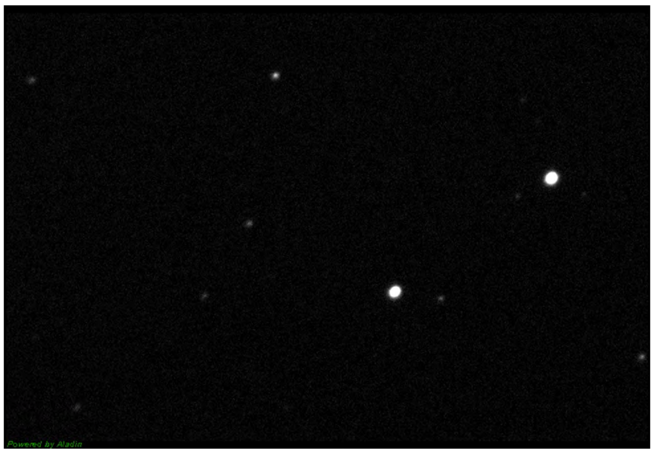


Image 1

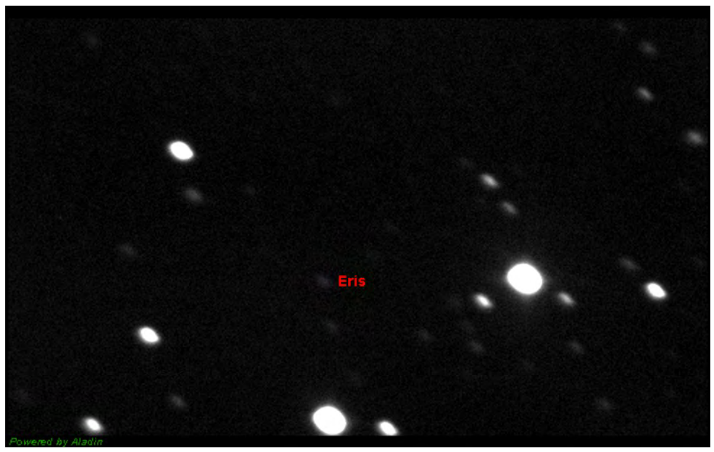


Image 2

Image 3 in our comparison is a composite of four 15 minute exposures. These exposures used adaptive optics. Eris is in a very different star field in this image. The brighter stars in this field of view are magnitude 15, and the fainter stars are magnitude 20. The image also contains a few galaxies magnitude 18-20. As can be seen in the image, the stars are well shaped. The adaptive optics compensated for mount tracking errors, eliminating the streaks seen in the composite three minute image. The better tracking put more photons on fewer pixels, increasing the contrast of the stars, as well as Eris, against the background. In addition, the consistency of the adaptive optics tracking allowed much longer exposures. So during about the same amount of total imaging time (51 versus 60 minutes) there were fewer readouts from the CCD chip (4 versus 17), resulting in less read noise, and therefore a higher signal to noise ratio in the image taking advantage of adaptive optics. For these reasons Eris stands out from the background much better in the adaptive optics image than in the composite image without adaptive optics, even though the total exposure time is about the same in the two images.

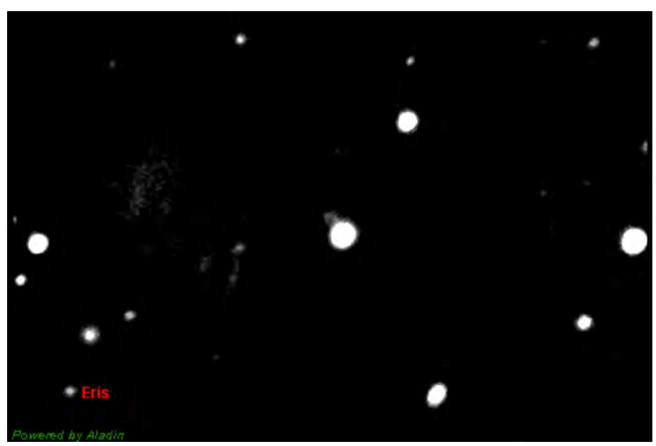


Image 3

Adaptive Optics - Stephen D. Blazier *continued…*

Adaptive optics can compensate for mount tracking problems, including periodic error and random error. Of course adaptive optics is best known for its benefits in atmospheric seeing, independent of mount tracking problems. Seeing at NJAA is frequently forecasted as Poor (FWHM approximately 3-4 arcseconds). Professional observatories are built at sites with far better seeing (typically less than 1 arcsecond). In our first test of adaptive optics we measured the same three stars in two 15 minute exposures. The Clear Sky Clock forecasted the seeing as Poor. The first image was autoguided with the ST-8XE CCD camera, and tracking was good, but adaptive optics was not used. The second was taken with the adaptive optics active. In the image without adaptive optics the stars had an average FWHM of 4.07 arcseconds. In the image with adaptive optics the stars had an average FWHM of 3.02 arcseconds, showing an improvement of 25%. This is consistent with the improvement achieved by experienced users of tip-tilt adaptive optics.

We continue to work with the AO-7 and 26-inch telescope to improve imaging capabilities. Recent results indicate we can surpass the 18 minute exposure goal established in 2007. And as is frequently the case in engineering, when one challenge starts to come under control, another makes an appearance. And we turn our Focus to that one….

Stephen D. Blazier

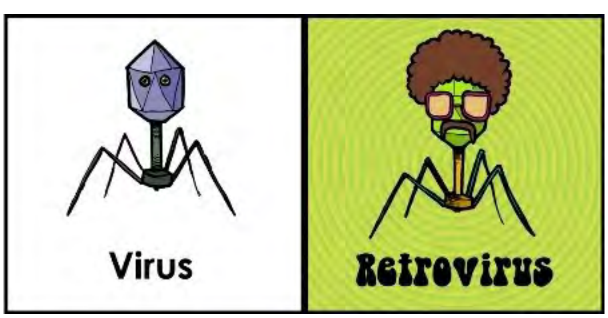
Additional pictures of the CCD Team at work can be found at http://www.njaa.org/njaaccd

This entire article can be download at http://www.njaa.org/publib/NJAA AO.pdf

Image 1
Single 10 second exposure taken by Donald LeFevre, William Linke, Mike Smilios, and Stephen Blazier on October 1, 2005, using the New Jersey Astronomical Association 26-inch Newtonian reflector and SBIG ST-7E CCD camera. Eris position determined through Project Pluto's Guide. Image acquired with CCDOPS and converted for publication by Mirametrics Mira Pro and the ALADIN interactive sky atlas.

Image 2
Composite of 17 separate 3 minute exposures (total of 51 minutes) taken by Donald LeFevre, William Linke, Mike Smilios, and Stephen Blazier on October 1, 2005, using the New Jersey Astronomical Association 26-inch Newtonian reflector and SBIG ST-7E CCD camera. Image acquired with CCDOPS. Image calibration and composition using Mirametrics Mira Pro. Converted for publication by the ALADIN interactive sky atlas.

Image 3
Composite of four separate 15 minute exposures (total of 60 minutes) taken by Mike Smilios and Stephen Blazier on November 17, 2012, using the New Jersey Astronomical Association 26-inch Cassegrain and SBIG ST-8XE CCD camera in combination with the SBIG AO-7. Image acquired with Diffraction Limited MaxIm DL Pro. Image calibration and composition using Mirametrics Mira Pro. Galaxy identification through the NASA/IPAC Extragalactic Database (NED). Star magnitudes from the USNO-B1.0 Catalog. Image to object matching through the ALADIN interactive sky atlas.



AstroNotes

New Jersey Astronomical Association

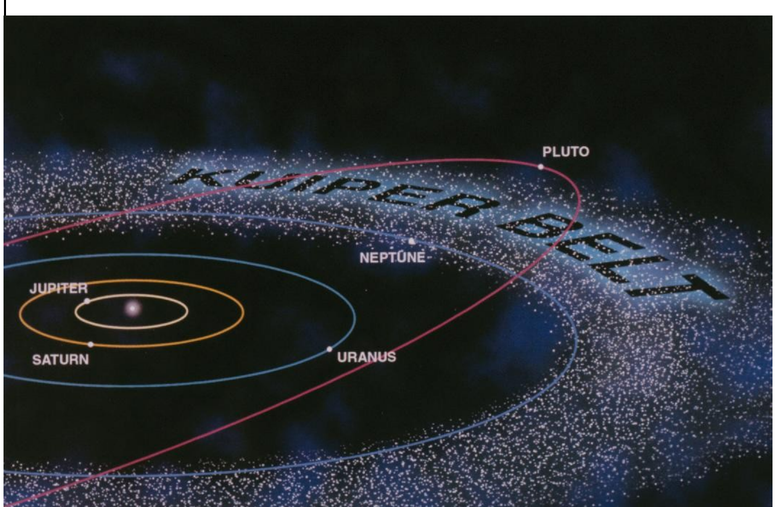
www.njaa.org December, 2016

Helping the Public Reach for the Stars!

NJAA Collaborates with Lowell Observatory

Helps refine KBO orbits in the far reaches of the solar system.

The 4.3-meter *Discovery Channel Telescope* - Lowell's flagship instrument.



KBO's - Kuiper Belt Objects lie beyond the orbit of Neptune.

Trio of NJAA member's findings listed among top observatories of the world.

By Stephen Blazier

The Paul Robinson Observatory is one of only five observatories that have been accepted into collaboration with Lowell Observatory on a project to improve the orbits of distant small bodies in the solar system. How did this come about you might ask? Read on to find out the details!

It takes a lot of work to make an observatory function, and a long history of successes build on each other for greater achievement. Lowell Observatory has been operational since 1896. Their focus started with Mars. Their successes led to the discovery of Pluto in 1930, which became known as the ninth planet. Little did they know at the time that Pluto was not just another planet, but a whole new class of solar system objects that would eventually be called Kuiper Belt Objects, or KBOs. In 1951 Gerard Kuiper speculated on a disc region beyond Neptune that formed in the early solar system and contained many small bodies. However, only Pluto had been found in his time and he thought the small bodies had been scattered away by the larger planets. So it is ironic they are named after him: Kuiper Belt Objects.

continued...

"*I've loved the stars too fondly to be fearful of the night.*" - Galileo

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NJAA Collaborates with Lowell Observatory Continued…

Their existence was debated for some time, since the feeble light from our sun at that distance made them too faint to be detected. But technology advances, and in 1992 another object was found about as far from the sun as Pluto. Astronomers took KBOs more seriously, and searches turned up some more distant objects. Lowell Observatory, having found the first KBO (Pluto), took a leadership role in KBO study. One professional astronomer at Lowell, Dr. Lawrence Wasserman, was instrumental in a special program to outfit large telescopes in the northern and southern hemispheres with a sensitive detector that had a wide field of view, designed specifically to find KBOs. It was another success, discovering about 380 of these objects. They are now often referred to using the more general classification of Trans-Neptunian Objects, or TNOs.

KBO Hunters Stephen Blazier, Michael Smilios and William Linke at NJAA's 26" telescope.

The study of TNOs is important in understanding the formation and history of our solar system, and likely other solar systems. For example, the orbits of these distant objects are less sensitive to the massive gas giants, like Jupiter and Saturn. Jupiter's huge gravity reshapes the orbits of asteroids in the Main Belt. After many orbits around our sun and the strong pull of Jupiter on the main belt asteroids, their orbits often reflect resonances with the giant planet and the pulls of other close and large planets. This leaves little information about their original orbits or their interactions with smaller objects. On the other hand, the TNOs are far enough away from Jupiter and Saturn that their orbits are not as influenced by the two. Information from the TNO orbits can be used to study patterns much further back in time. They can also be used as detectors of bodies further away from our sun, similar to how the orbit of Uranus led to the discovery of Neptune. For example, you probably saw on the news the announcement of evidence for a Super Earth or Neptune sized body far beyond Pluto. (S&T Podcast: In Search of Planet 9). This object has not been found with a telescope. Rather it was deduced by analyzing the orbits of TNOs like the ones we have measured. This is somewhat reminiscent of the analysis that led for the search for Pluto.

Palomar Observatory also contributed findings.

However, there is a problem (isn't there always). Funding for the discovery program Dr. Wasserman was part of lasted about five years. An accurate model of an orbit requires measurement of the object's position along a significant part of the orbital arc. At the distance of these objects from the sun it often takes more than 250 years to make an orbit. Only a small part of the orbital arcs were measured and the orbits are imprecise. As time goes on, these objects drift farther and farther from their predicted positions. When they drift too far, they are beyond what an image of their predicted position can show. Some of these objects are already lost!

One might think that the Hubble Space Telescope and other large telescopes could be used to image the predicted fields before more are lost. While that is technically possible, there are many demands on these

continued...

NJAA Collaborates with Lowell Observatory Continued…

great telescopes, and re-measuring TNOs is not at the top of the list. As the trend has moved to building larger professional telescopes, funding organizations have pooled their resources to cover the huge expense of a few telescopes, instead of building a larger number of smaller telescopes. Competition for telescope time has become intense, with long wait times or outright denial of some observing programs. Dr. Wasserman was unable to get enough telescope time from the professional observatories, so he turned

Observatories at Mauna Kea also contributed findings.

to amateurs through Lowell Observatory. Lowell made it clear that they would provide no equipment for this collaboration. The amateur observatory needs to already have a large telescope with equipment capable of imaging these objects, which are much fainter than Pluto. In fact, in most cases the light coming from one of these objects is less than the light from a single candle at a distance of 10,000 miles. And that's where your observatory comes in. For many years a number of people have been working on the 26" telescope of the Paul Robinson Observatory to improve its imaging capabilities. A number of those initiatives are discussed in "Adaptive Optics", *AstroNotes*, August 2014.

Lowell also would provide no training, so the collaborators need to already know how to measure these distant objects. The Minor Planet Center assignment of Observatory Code W67 to the Paul Robinson Observatory ("International Astronomical Union - Minor Planet Center Recognizes Paul Robinson Observatory", *AstroNotes*, March 2015) was enough to convince Dr. Wasserman that our observatory has the skill and capabilities. When Dr. Wasserman heard we are in that elite group, he immediately welcomed us to his project. Recently we started collaborating with Lowell on the measurement of TNOs before they become lost. Dr. Wasserman sends us a list of interesting targets, and we select one of those to image and to measure. We submit our data to Dr. Wasserman and the Minor Planet Center. The Minor Planet Center checks our measurements for reasonableness, re-computes the orbit of the TNO, and publishes the result for all astronomers to use. Our collaboration has already had an impact; objects we have measured now have improved orbits with reduced uncertainty, and have been removed from the list of objects needing measurement now.

continued...

NJAA Collaborates with Lowell Observatory Continued…

Of course it is not just the improvements that have been made to the Paul Robinson Observatory that makes this collaboration possible. It is also the support network of the NJAA members. The observatory exists to promote and encourage interest in the science of astronomy. The observatory would not be here without the efforts of those who support the grounds, facilities, and the numerous programs of NJAA. And it wouldn't exist without the dues of all of the members. So yes, it is <u>your</u> observatory, and you have a part in the collaboration with Lowell.

So please take a moment to feel good about what you are doing to support Dr. Wasserman of Lowell Observatory and other professional astronomers. And while you're at it, you can take a look at some of the data, and see your observatory's name listed along with the likes of the European Southern Observatory, Kitt Peak, Mauna Kea, and Palomar:

1) http://www.minorplanetcenter.net/db_search/show_object?utf8=%E2%9C%93&object_id=2010+VW11
2) http://www.minorplanetcenter.net/db_search/show_object?utf8=%E2%9C%93&object_id=2007+XV50

<u>Excerpted and Edited from the IAU Minor Planet Center</u>

470443= 2007 XV50 Discovered at Palomar on 2007-12-13 by Palomar.

Orbit type: Distant object

Observations 65 total observations over interval: 2007 12 13.24133 – 2016 02 07.13498

Date (UT)	J2000 RA	J2000 Dec	Magn	Location
2007 12 13.24133	04 06 21.12	+25 47 05.7	21.2 R	675 – Palomar Mountain
2007 12 13.28509	04 06 20.93	+25 47 05.5	21.3 R	675 – Palomar Mountain
2008 10 27.49032	04 14 26.03	+26 30 20.8		695 – Kitt Peak
2009 10 18.61277	04 19 25.05	+27 07 21.8		568 – Mauna Kea
2009 10 18.63126	04 19 24.97	+27 07 21.8		568 – Mauna Kea
2011 10 25.41927	04 27 54.001	+28 19 34.13	21.2 w	F51 – Pan-STARRS 1, Haleakala
2011 10 25.43380	04 27 53.942	+28 19 34.18	21.3 w	F51 – Pan-STARRS 1, Haleakala
2011 12 01.204795	04 24 58.41	+28 17 44.1	21.7 V	H21 – Astronomical Research Observatory, Westfield
2013 12 25.28852	04 31 57.748	+29 25 17.37	21.2 w	F51 – Pan-STARRS 1, Haleakala
2013 12 25.30167	04 31 57.685	+29 25 17.37	21.3 w	F51 – Pan-STARRS 1, Haleakala
2016 02 06.05830	04 38 39.07	+30 26 54.4	20.6 R	**W67 – Paul Robinson Observatory, Voorhees State Park**
2016 02 06.12611	04 38 38.95	+30 26 53.9	20.6 R	**W67 – Paul Robinson Observatory, Voorhees State Park**