WIYN OBSERVATORY
WISCONSIN INDIANA YALE & NOAO
Newsletter
February 2013

Director's News

Pat Knezek

In my last column, I noted that one of my favorite CDs is Israel Kamakawiwo'ole's "Facing Future." Little did I know that six months later I would myself be facing a very different future. This column is very bittersweet for me, as it will be my last as WIYN Director, and I will be going on to a new challenge as the Deputy Division Director of the Astronomy Division of the National Science Foundation. (Talk about a mouthful!) I have spent nearly 12 wonderful years at WIYN and NOAO, and the decision to leave was not easy, especially given the many colleagues I enjoy working with here, and the challenges that WIYN faces. My goal with my new position is to take my experience from WIYN and NOAO and work on the challenges that face astronomy at the national level. But before I go, I want to take this opportunity to thank the many individuals both within the WIYN partnership (including the local WIYN and KPNO support staff) and the broader community for making my time at WIYN and NOAO such an extraordinary experience. I have a connection with Kitt Peak that very few of you know – I was actually born in Tucson, and my parents took me to Kitt Peak before I was a year old. My mom swears that was the start of everything, and it has been a joy to be able to support astronomy there. So thanks to you all!

Meanwhile important things continue to happen at WIYN! So here's an update about what has been going on. One major accomplishment is that, as expected, pODI will begin shared-risk operations in March. See this issue for more details about how the commissioning effort for the instrument has been going, along with another on an early science result. Hand-in-hand with this commissioning effort has been development and testing of many of the components of the pODI-PPA pipeline, portal and archive system. Interest in the pODI system is clearly high, as 28% of 2013A nights (and nearly 50% of dark nights) are scheduled to use it!

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pODI is Ready for Science

Daniel Harbeck

Just half a year ago, observing with pODI was new and adventurous. For instance, when slewing the telescope we had to run up the stairs to keep the cable wrap disentangled. No more, observing with pODI has become a routine affair for now, and the days are numbered for the first engineering-level command line interface (the "classic" mode). Thanks to the effort of the ODI team and the great support by the Commissioning Working Group (CWG), pODI is maturing and ready for science operations in the 2013A semester. I am very pleased that 39 nights have been scheduled for ODI shared risk use in this semester, and that the first science-only observing nights finished uneventfully without phone calls in the middle of the night.

A great amount of data has been taken during commissioning, and while most of them remain to be analyzed, we have gained a good understanding of pODI's fundamental performance: We have established that pODI delivers better than 0.4" seeing over the full field of view. The detectors' linearity for photometry meets specification, and members of the CWG have started to demonstrate the photometric and astrometric performance of pODI (see article by Steve Howell and the article by Terry Girard & Dana Casetti). Travis Rector artistically translated ODI's imaging capability into a color image of the Bubble Nebulae (see Fig. 1). All the commissioning data will soon become publicly available in the ODI pipeline, portal, and archive.

As I write this article we are in the very early stage of deploying and testing the advanced image acquisition modes. Remember that ODI's detectors are capable of compensating image motion directly in the detectors: As the image charge in the CCD detectors builds up during an integration, it can be moved to follow the optical image motion that could, e.g., be caused by guide errors or telescope vibrations. We sense the image motion in real time by rapidly measuring the position of bright reference stars during an exposure, and then apply the appropriate motion correction using the orthogonal transfer capability of the pODI detectors. Using the average

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WIYN 0.9m Telescope Report

Flynn Haase

Big changes have been underway at the WIYN 0.9m observatory. Not only does WIYN have a new Site Manager for the facility (me), but we are weeks away from the commissioning of HDI. I find myself coming into the Site Manager position at a very interesting time.

Let me start here by talking a little about myself. I've actually been working on Kitt Peak for almost 15 years now. I started working over at the Visitors Center on Kitt Peak in November of 1997 as a part time employee while working on an engineering degree at the University of Arizona. After graduating, I continued working with the Visitors Center, and eventually found myself as supervisor for all routinely scheduled night-time public programs, with about 12-15 people working under my direction. Encased in these job responsibilities was the continued maintenance and improvement of the three Visitors Center observatories. Along the way I diversified my skill set on into imaging with CCDs; where a significant portion was self-taught. I've been working with observatories, their functioning and maintenance, and CCD imaging for some 10 years now. I've grown to really enjoy CCD imaging and working with the hardware – telescopes, CCD cameras, and observatories. Towards the end of my time working with the Visitors Center, I became one of the key personnel working with the public programs hosted by the 0.9m – both before and after the Visitors Center joined the WIYN 0.9m consortium. Now I find myself working in Hillary Mathis' former position. Compared to what I'd been used to, working with the 0.9m is an exciting opportunity for me. I still have much to learn, but am very eager about this new position - working with the observatory, and the observers.

Below: Flynn Haase

Besides the maintenance and operation of the facility, I feel a very strong dedication and support to the observers that use the 0.9m. Part of my job is to make sure that you, the observer, have the most successful observing run possible. For those of you that use the 0.9m, don't hesitate to ask any question, or to let me know of some way that I may be able to help you out. I may not be able to help 100% of the time, but I'll certainly do what I can. As the cliché goes, my door is always open. You may reach me at fhaase@noao.edu
Just a few weeks from the time of this writing, we will be starting the commissioning and testing of the Half Degree Imager (HDI). Peter Onaka and his group from University of Hawai'i are currently scheduled to bring HDI out in late February, and after their final installation and testing of HDI, the capabilities of the 0.9m will be significantly enhanced. HDI will have a noticeably larger field of view than the aging S2KB, and a significantly shorter download time for images. Further details comparing the two imaging systems can be found in the table below.

Comparison of S2KB and HDI:

	S2KB	**HDI**
Pixel size:	21 x 21 um 0.6 x 0.6 arcsec	15 x 15 um 0.43 x 0.43 arcsec
# pixels:	2048 x 2048	4096 x 4112
Area on sky:	20.5 x 20.5 arcmin	29.2 x 29.2 arcmin
Readnoise: (various modes)	9, 14, 20	4, 5, 7, 10
Readout time:	180 sec	111 sec / N amplifiers (1x1 bin) (N = 1, 2, 4)
Well depth (e-):	240,000	300,000
Coolant:	LN2	Closed system
Quantum efficiency:		
300 nm	10 %	35 %
350	35	50
400	70	75
450	75	80
500	77	80
650	90	75
750	80	70
850	50	55
950	25	25

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WIYN 0.9m Telescope Report
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Those of you who may want to study very transient photometry targets will benefit from this greatly. One area of study that would definitely benefit here is the study of transiting Exo-planets. The current set-up with S2KB just cannot effectively give adequate data points for detailed light-curves. We are also working to fill out a dedicated 0.9m filter library. As many know, we've already got the Harris set, as well as the set of H-alpha related filters. We are currently expanding this to include a Stromgren series, and a set of SDSS filters. For those of you interested in use of these filters, bandpass information for them will be included on the 0.9m website shortly.

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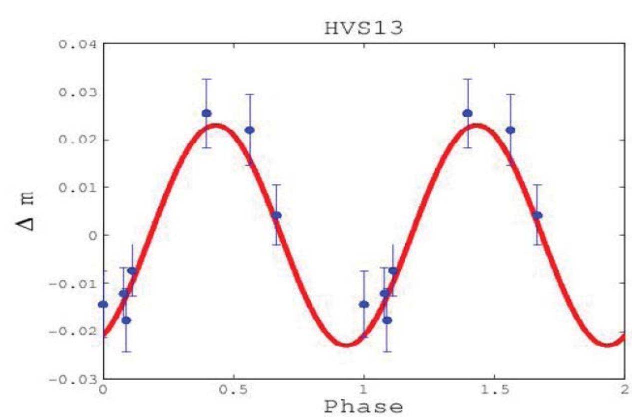

Science Highlights
Jayadev Rajagopal

This issue's Science Highlight is from the MiniMo imager. A going-away gift from a much-used and productive instrument (we did not offer MiniMo for 2013A and pODI will take up the facility optical imager role).

Variability of Hypervelocity Stars

The Galactic Center of the Milky Way houses Sgr A*, the nearest massive black hole (MBH) of ~ 4 x 10^6 solar mass. As a binary star system approaches Sgr A*, the binary may be disrupted whereby one star loses energy and falls into a highly eccentric orbit around the MBH while the companion star gains energy. At times, this gain in energy is sufficient to send the star careening out of the galaxy never to return. Such stars are known as "hypervelocity stars" (hereafter HVSs). HVSs were first observed in 2005, and today over 20 HVSs are confirmed. HVSs offer a direct link to the conditions at the Galactic Center. They may also house planets, and can help probe the shape of the Galactic halo. However, the nature of these HVSs is ambiguous. At an effective temperature T ~ 12,000 K, HVSs may be main-sequence (MS) or evolved blue horizontal branch stars. In a paper recently submitted to ApJ (http://arxiv.org/abs/1302.1899), Idan Ginsburg (Dartmouth College), Warren Brown (SAO), and Gary Wegner (Dartmouth College) describe observations of 11 HVSs taken at the WIYN 3.5 m in order to determine their nature via differential photometry. If these HVSs are on the MS, they have a good probability of being slowly pulsating B (SPB) stars. SPBs have photometric variations of a few millimagnitudes and periods of ~ 1 day. Due to such small variations in magnitude, high signal-to-noise data were necessary, and the WIYN was ideal for this observing program. Observations were made with Mini-Mosaic Imager. Of the 11 targets, five show variation and four are strong candidates for being SPBs. This is an important result in understanding the nature of HVSs, and before this study only one such star had ever been observed using differential photometry. The figure is illustrative of the precision necessary for observing HVSs.

This image (left) shows the the folded light curve of star HVS13 with data taken by the WIYN 3.5 m in the SDSS g-band.

pODI is Ready for Science

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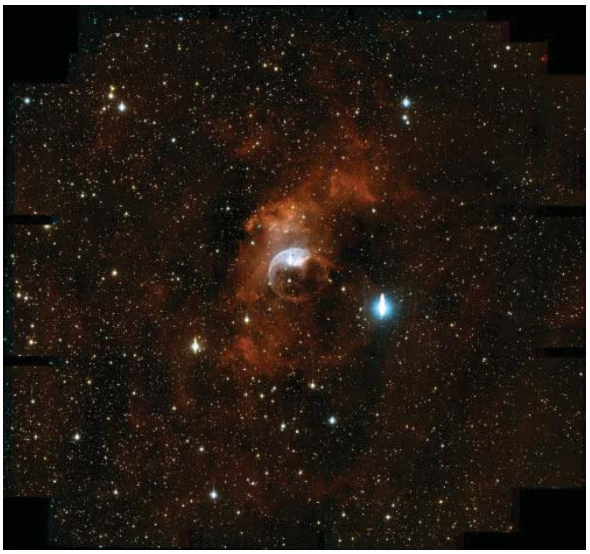
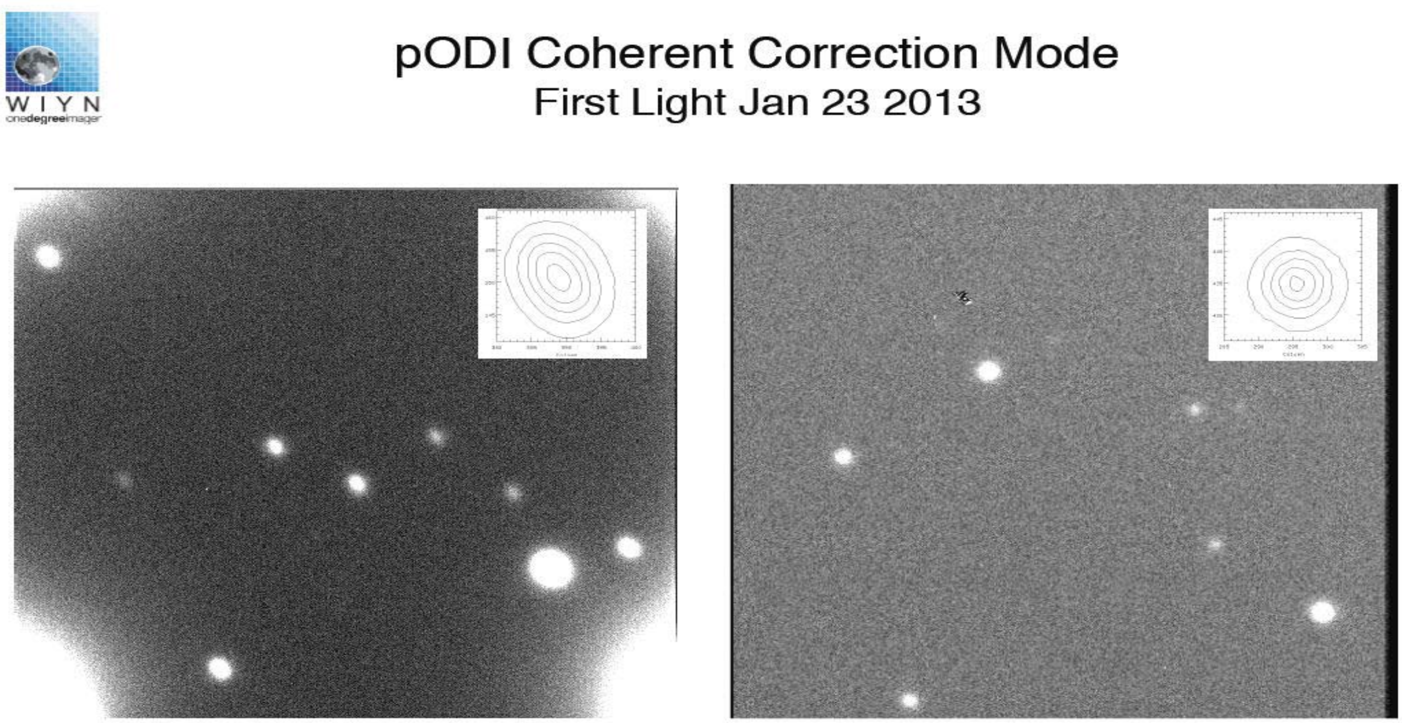
motion of several stars will compensate for common-mode image motion. Using the motion of a single guide star would locally also correct for atmospheric image distortion, however, with pODI we focus on the first application only.

We just successfully demonstrated the common mode image motion correction when the telescope slowly drifted off its target. During that exposure (shown in Fig. 2) we applied on-chip corrections for image motion to a subset of the detectors, while some detectors were passively integrating. The corrected detectors showed round stars, while all stars are elongated on the uncorrected images. This was the first time that on-chip image motion compensations had been achieved with pODI. The ODI team is now focusing on increasing the speed of the correction loop from currently about 3Hz to 10 to 20Hz. At such higher correction rates we expect to further improve the delivered image quality compared to correctly guided exposures.



(Left) Figure 1: Bubble Nebula as seen by pODI; data processing by pODI PPA system, image combination by T. Rector.

(Below) Figure 2: On-chip image motion stabilization compensated for a drifting telescope (left), resulting in round stars (right).



No OT-correction: Elongated stars due to telescope drift.

OT-correction applied: Round stars, telescope drift is compensated.

pODI Image o20130123T224451.0

Astrometric Precision

Dana Casetti & Terry Girard (Yale University)

A series of dithered exposures in selected area SA94 (taken in October 2012) has been analyzed to explore the astrometric potential of pODI. Each of the OTAs was treated as a separate "unit". Centering was by 2-d Gaussian fitting. Intercomparison between the dithers yielded a single-measure astrometric precision of ~6-7 mas in r-band (FWHM=0.70") and ~5-6 mas in z-band (FWHM=0.5"). This is for well-measured objects with S/N > 40.

A test proper-motion reduction was made using the central nine OTAs and existing photographic measures at earlier epochs (2.5-m du Pont and Mayall 4-m plates). The pODI positions were based on just five 300-sec r-band exposures. With the inclusion of the pODI data, we obtain an individual proper-motion precision of 1.2 mas/yr for known QSOs in the field. The improvement over the plate data alone is illustrated in the Figure 3 below.

(Below) Figure 3: Relative proper motions of galaxies and QSOs in a 24'x24' area in the field of SA 94, over the magnitude range r = 17 - 22.5. Left: results from photographic plates alone over a 26-year time baseline. Right: results from photographic plates and pODI data (central 9 OTAs) over a 36-year time baseline. For QSOs, the precision has improved by a factor of two, and for galaxies by 1.6.

Director's News

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At the 0.9m, the Half Degree Imager (HDI) will be arriving at the end of February for its initial fit checks and testing. It will then go back to Hawaii for final optimization and characterization, with an anticipated final trip for commissioning in late spring of 2013. See the 0.9m article in this issue for more details about this new instrument.

As I finish this column, I look forward to one more opportunity to work with some of those who are truly dedicated to determining a path forward for the WIYN facilities. There will be all-day meetings of the Science Steering Committee, a WIYN Planning meeting focused on developing near-term and long-term priorities, and the Board meeting. There are a lot of very smart people working to chart the future, and I am confident that while it won't be easy (and what worth having is?), there is a future to be had. In the meantime, I'll close with another of my favorite songs, a Jimmy Buffett song written about New Orleans after Hurricane Katrina, "Breathe In, Breathe Out, Move On." I know that the WIYN partnership is in the process of doing this, and so am I – but I look forward to crossing paths again a little more than a year from now (when my conflict of interest with all things AURA ends), and hope to help WIYN move on at that point, just in a different role.

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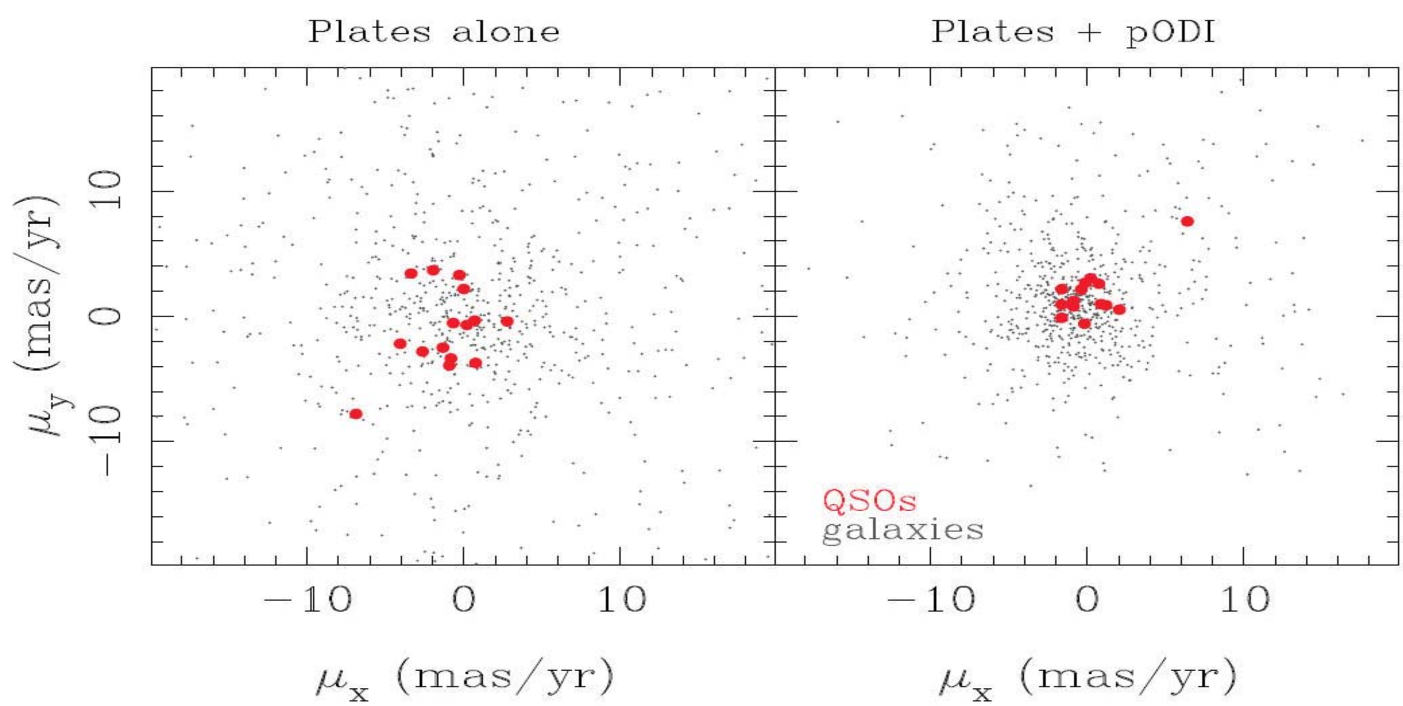

Planet Slaying

Steve Howell

How many exoplanets are there, and how many planet candidates are in fact real? The Kepler mission, for example, has identified up to 2740 exoplanet candidates at the present time. Given the science priority of planet searches, we decided to test out the ability to verify (or not) a Kepler planet candidate with pODI observations.

Kepler monitors stars in a broad bandpass, similar to a combination of the V+R bands, and identifies planets when they transit in front of their host star, obscure a tiny part of it and cause a minuscule dimming of that star. Observing such a planet transit at a different wavelength can provide a validation if the star's dimming is identical, thereby yielding a high level of confidence that the candidate is a real planet. As part of pODI's commissioning we chose to conduct this test but do so in an even more challenging way. First off, we decided to observe a planet transit in U band. This bandpass is not typically used for planet transit observations, but it is one for which pODI is well suited. Next, we decided to observe a relatively small planet, KOI 2950, which orbits its home star at 3.5 Earth radii. KOI 2950's host star has a R-band magnitude of 14.4 (star temperature = 5400K), generally thought to be faint by exoplanet hunter standards. Kepler data suggested a 0.42 day orbital period with a transit length of 54 minutes. The Kepler transit depth was measured as 1.4 mmag (milli-magnitudes).

Observations were obtained in Nov 2012 and lasted for about 1 hour. pODI was used in time series mode obtaining continuous 60 second exposures The seeing was ~0.8 arcsec. The images were reduced using the pODI quicklook pipeline (provided by Ralf Kotulla), and aperture photometry was done on the target star and two nearby stars with similar magnitude. The faintness of the observed star in the U band forced us to bin the resulting photometry by a factor of three, which increases the signal to noise of a data point, but decreases the time resolution. The differential light curve had decent error bars of +/-0.002 mag per binned data point at a time resolution of 4 ½ minutes (see figure below).

Fitting a simple model to the U band transit gave a transit depth of 3.78 mmag. This value is too large if the "planet" was indeed a planet as the Kepler depth is only 1.24 mmag. This difference in transit depth points to the exoplanet candidate as being a likely false positive. In fact, the KOI has now been identified as an eclipsing binary after use of significant additional telescope time by other investigators. This observation, aimed at demonstrating pODI's capability for relative time series photometry, shows how one hour of time led to a simple "planet or not" measurement – in this case, we slayed a planet.