Arkansas Sky Observatories' Installation and Use of the PlaneWave CDK-17

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By Dr. Clay Sherrod

At Arkansas Sky Observatories (ASO), founded in 1971, we have an array of telescopes ranging in size from good, portable Apochromatic refractors to a little-used 32-inch Cassegrain. The system's four major observatory locations are in use pretty much 60 percent of all nights throughout the year, this being the average percentage of clear night skies.

Efforts at these observatories concentrate on several key studies: (1) First and foremost are comets and comet morphology, with up to 30 comets studied and logged nightly; (2) astrometry of Near Earth Objects (NEOs) and typically concentration devoted to recently discovered earth-crossing objects for which the orbits are still very uncertain; (3) cataclysmic variable stars and novae/extragalactic supernovae; and, (4) planetary atmospheres, particularly those of Mars and Jupiter.

As conditions in Arkansas and other once-rural areas continue to deteriorate in terms of nighttime sky steadiness, transparency and seeing, the idea of using larger telescopes reaches a breakpoint where the conditions can no longer

Dr. Clay Sherrod and the Arkansas Sky Observatories' Mathis Instruments MI500 mounted PlaneWave CDK17.

support larger aperture instruments. Up to a point I have always preached that "larger is better" in terms of telescopes of equal optical and mechanical quality. But worldwide, as the atmosphere surrounding us now supports more and more heavy molecular components, which hold and move heat and refractive waves, this trend is changing.

Fortunately, recent technological advances allow us to conduct ever more refined research with telescopes of what was once thought to be modest proportions. Indeed, one of the telescopes that we use today – a PlaneWave CDK-17 (Corrected Dall-Kirkham) – combined with modern CCD and digital processing enhancements via a bank of computers and specialty programs, is far more capable of reaching fainter magnitudes and making enhanced studies beyond what even the Palomar 200-inch telescope could accomplish only 40 years ago.

So the philosophy at ASO changed about 10 years ago to begin developing systems that relied on the very best resolution available from high-quality optics combined with custom digital enhancements through computer means. We then assessed what our goals were, designed computer output needs for our programs and had those developed out of house, and began to pull in hardware resources that could match our goals – knowing full well that we were going to be limited by increasingly lighted and polluted Arkansas skies. Knowing that ASO was not moving to the arid southwest, the challenge was to adapt to provide the very best equipment to be used where we were destined to be.

The PlaneWave CDK

The remarkable PlaneWave CDK is, in my opinion, a work of art, both mechanically and optically. Constructed of virtually zero expansion carbon fiber and the finest machined aluminum fittings, the telescope provides hours of "focus free" operation throughout the rapidly changing nighttime temperatures of Petit Jean Mountain, where both summer and winter air temperatures can drop as much as 50 degrees from sunset to dawn.

The telescope is operated robotically via a computer system in the observatory's office and once the Mathis Instruments MI-500 mount is initialized (we park the telescope in a predetermined position at the end of each night's session) the operator need not enter the telescope room again until it is time to cap up the telescope and disconnect power and computer cables at the end of the night.

The inability for moderate to large telescopes to maintain the plane of focus as the temperature changes is a very frustrating experience and even temperature-compensating focusers cannot accomplish what a telescope constructed of carbon fiber can do in this realm. For the CDK, there are minor focus adjustments that need to be made from the heat of summer to the chill of winter – these amounting to less than one millimeter. But once the primary mirror has equalized to the temperature of the nighttime air, the focus for any given night will remain stable and not need any further adjustment with the CDK.

The design of the Planewave CDK is so exacting that even the custom dovetail saddle plate is made with a combination of low expansion materials so that flexure during temperature changes do not affect the overall spacing of the telescope components.

PlaneWave Instruments' CDKs are outfitted with the fine Hedrick focuser, a design that prevents any possible axial slipping from the weight of heavy equipment; this focuser is provided with a remote focusing computer program that allows the user to make any small needed adjustments very easily from the PC screen; the total travel distance of this focuser is a very limited 1.5 inch, so it is important that the user position the focuser exactly midway at the initial setup to allow for the small extremes necessitated from summer to winter. I have found that adjustments of only 0.05mm are adequate throughout the extreme temperatures of Arkansas nights. Such fine adjustments are a snap with the PlaneWave interface which displays the focuser position to within 1/100th millimeter with very repeatable accuracy. There appears to be virtually zero backlash in either direction with even the smallest correction to focus.

To assist in rapid equalization of the primary mirror, three large and very silent/vibration-free fans can be operated all at once, or any one at a time, either manually or via a preset temperature thermostat that sets the fans in motion and shuts them off when equilibrium is reached.

Optically, the PlaneWave CDK is the finest in the field. It is ideal for astrophotography because of its large, wide and very flat field of view, providing full-chip coverage of even the largest CCD cameras. The flat field and fast f/6.8 focal ratio were among the reasons that this telescope was selected for the ASO Astrometric Observatory building (Minor Planet Center H45). A true flat field is desirable for both astrometric and precise photometric measurements of asteroids and their motions across the sky; a custom astrometric measuring program at ASO allows for field stars to be selected and rejected based on residual placement in the field from any one of seven large star catalogs that fill one computer that is devoted entirely to providing star position data at the observatories.

In designing the CDK, PlaneWave Instruments coupled modified Dall-Kirkham Cassegrain optical primary and secondary mirrors with a revolutionary doublet lens that is located in the optical path inside the primary baffle tube; the light cone, focusing from the secondary, passes through this doublet and provides the field flattening and f/stop reduction necessary to the remarkable performance of the telescope. It is an incredibly accurate (and surprisingly effective) solution to the conventional long-focus Cassegrainian design. I have measured light loss through this doublet and it is truly minimal, about that expected with a conventional "focal reducer," but of far better quality and much larger aperture.

However, even that fast f/6.8 configuration was still inadequate for the needs of the ASO Astrometric Program. PlaneWave is therefore developing a soon-to-be available 0/.66 reducer that will fit firmly into the Hendrick focuser to allow precise mechanical and optical alignment as they do with their series of camera and visual adapters – everything bolts to the back and nothing can "skew" from precise alignment.

In lieu of the awaited Planewave reducer, I experimented and found that the Astro-Physics 0/.67 focal reducer placed at the proper spacing in a 2-inch barrel for our ST200 XM Class I monochrome CCD worked perfectly. It presents no vignetting, no image fall-off and no distortion nor coma whatsoever when used with the PlaneWave and the ST2000 XM. This combination results in a focal ratio of f/4.7 overall and provides a perfect field of view for our astrometric requirements. The ST2000 XM has a pixel size of 6.4 microns however, which does not match well with this combination, but binning 2 x 2 provides an incredibly good match for optimal pixel size to maximize the system's potential resolution.

The Mathis Instruments MI-500 GEM

Without so much as a grumble, the large Mathis Instruments MI-500 German equatorial mount can handle the 125-pound CDK-17 and accessories with plenty of potential still in its back pocket. The specific MI-500 that we are using features a large bronze 13.1-inch worm gear and stainless steel worm driver. The optional solid bronze worm gear was selected due to its far greater resistance to wear over aluminum and in recognition of our relatively constant use of the telescope and mount. We selected, and still believe it's the best choice, Mathis Instruments' option of the Astro-Physics GTO servo drive system with very large Maxxon high-torque motors and Swiss encoders in both axes of this large GEM.

Four (4) 25-pound weights on the threaded DEC shaft are required to adequately balance the CDK in functioning mode. Balance is very easy – by loosening both clutches you can literally spin the large mount and telescope with mere toothpick pressure.

We learned quickly however that the tracking on this mount is not as good if perfectly balanced, with a bit of "stictional shake" in the RA axis. To overcome this we simply have a quick-release bracket that carries a small 5-pound weight that can hang from either the counterweight shaft or the back of the large PlaneWave telescope dovetail saddle, whichever of the two positions is on the EAST side of the mount at any given time.

One full week was spent drift aligning the system which sits on a massive seven-foot tall rectangular metal pier that alone weights 2,300 pounds. To attest to the accuracy of both the mount and the need for using drift alignment, this telescope will track unguided for as much as six minutes on a CCD image at f/4.7, this being more than enough exposure to capture faint asteroids and comets to 22 magnitude.

A Few Issues

As for downside issues, we learned quite early that the Mathis and AP servo combination simply cannot remember where the pier is – it performs a meridian flip quite well, provided that the target is far (i.e. about one hour of RA) on either side of the meridian. However, there can be frustrating moments attempting to acquire a target that is nearly overhead, within one hour east or one hour west of the meridian, and the operator must be careful to monitor at such times.

We have even installed a small CCTV in the observing room so that we can watch the telescope near the meridian to better prevent pier collisions.

Another major downside, particularly for southern USA observers, with the open-tube design of the CDK is that of dust and blowing pollen in the air which is prone to accumulate on the primary mirror surface as well as to falling onto the very hard-to-reach front surface of the lens doublet down in the baffle tube.

PlaneWave offers an accessory "Spandex Shroud" that can be pulled tightly over the open truss of the CDK, but once on it can be difficult to remove or move to one side – something that is absolutely necessary to reaching the primary mirror's protective cover as well as the Baggie-style covers over the secondary and baffle tubes. With the shroud fully installed, the operator simply cannot access any of these covers.

As for the Mathis mount and A-P servo system, a word of caution: all wiring going into the servo unit, as well as the cables from that computer into both the A-P hand box and the two drive motors, must be unplugged completely when not in use, as should the power cord. The system – I have learned the hard way – is quite prone to electronic damage from surges and spikes, whether from a thunderstorms miles away or the failure of a transformer on a nearby highway after being felled by an errant automobile.

I don't mean to harp on what many would consider the relatively minor issues we have had with this equipment. Overall, our PlaneWave CDK/Mathis Instruments GEM combination deserves and gets an A++.

As with any system there are going to be small things that might irritate or confuse, but I have never had the opportunity to operate such a complex, yet trouble free telescope system, from the largest observatory telescopes to those commercially made. And whether, as have many other current producers of premium telescopes, Rick Hedrick and Joe Haberman of PlaneWave decline to publish such easily misinterpreted "statistical test data" as Strehl ratio, surface figure, wavefront error or the like, I can attest to one simple fact: They don't have to – the performance and results speak for themselves. AT