KPNO/KITTPEAK
NATIONAL OBSERVATORY

The International Dark-Sky Association: A Critical Resource for Astronomy

David Crawford & Richard Green

The International Dark-Sky Association (IDA) is the leading organization encouraging the preservation of dark skies through the promotion of quality outdoor lighting practices. With more than ten thousand members and a staff of seven, IDA has worked effectively throughout the world with the professional lighting community, community authorities, and elected officials to produce results in dark-sky preservation through outdoor lighting ordinances, public education, technical committee service, and alliance development.

The Value of IDA

IDA's mission is to preserve the nighttime environment for the benefit of everybody, and that includes extensive activities to preserve the prime dark skies so necessary for cutting-edge astronomy. Brighter skies mean a higher background level and a higher noise level. Artificial sky glow (light pollution) reduces the value of large investments by both public and private institutions in state-of-the-art astronomical telescopes. Table 1 demonstrates

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These matched images show the growth of lighting in the Tucson metropolitan area, as seen from Kitt Peak. The measured increase in sky glow is considerably lower than the increase of population, by more than a factor of two.

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the potential (and real) loss of value in telescopes with the growth in sky glow. Such a pattern will hold for all future telescopes as well, including those that are very expensive by present standards. No site is too remote to be affected by sky glow, now or in the future.

As has been apparent for a long time, the sky-brightness background has been increasing almost everywhere, and at an accelerating rate, including in the vicinity of prime large telescope observing sites. The only exceptions to this increasing rate of sky degradation are locations such as southern Arizona, where there has been a sustained push for effective outdoor lighting ordinances and effective ordinance enforcement for over 30 years. These ordinances, along with many revisions over the years, have slowed and even reversed (at some wavelengths) the growth of the adverse sky glow. When IDA was incorporated in 1988, its staff took over much of this continuing activity, and expanded it to other towns and counties throughout the state, and indeed well beyond.

Since many outdoor lighting recommendations and all decisions related to the manufacturing of lighting fixtures are made nationally, not locally, this expansion of efforts to a national and even international basis was critical to the continuing success in preserving dark skies for astronomy in the area. This work continues today, and it requires considerable time, much more than in earlier years, due to the growth of Tucson and other metropolitan areas impacting observatories, and to the much wider range of effective networking required locally and nationally. IDA staff spends a large fraction of its time on these local issues, both because IDA is based in Tucson and because of the critical need for local protection. It can and should be a model for other locales.

IDA has been effective over the years working with governmental staff, lighting engineers, and related officials in all of the key locales relative to major observatories—southern Arizona, Hawaii, Chile, southern California, and others. Codes have been established in most of these places, and regular updates are obtained when necessary. Contact with local astronomical and lighting individuals is continuously maintained, and the number of these networks is growing. It is time-consuming work for the small staff.

IDA has developed effective contacts with most of the organizations that can and do make an impact on the level of night lighting, and hence on the adverse sky glow. These organizations can be effective allies *only* if these relationships are kept up and consistently developed. They make the recommendations, they do the designs, and they make the lighting fixtures. They often work for large and well-funded organizations and companies. It is essential for us to know them well and to make them active allies. Effective networking takes time, and it takes a fiscally healthy IDA to do this work. No observatory can do it. IDA will.

The Needs of IDA

It is getting increasingly difficult to devote adequate time as national and international pressures for help grow. Environmental protection is very time consuming. Halfway efforts do little, and the pressures for more and brighter lighting grow even more rapidly than the population growth (a lot of which is in the same areas that attract observatories). We are making significant progress, but there is much, much more to do, and it takes daily attention.

In 2003, IDA staff spent approximately 25 percent of staff effort on issues directly relating to dark-sky preservation for astronomy, at a cost of approximately $99,000. This level of effort will only grow with time.

While the demands on IDA staff have dramatically increased in recent years, the finances of IDA have suffered, due in part to the recent economic slowdown. IDA has had to reduce staff recently in order to bring expenses in line with income, and thus preserve the organization. But IDA needs to restore and increase staff resources in order to carry out the increasing workload.

In 2003, the entire complement of professional astronomical observatories contributed only $2,000 in support of IDA. Sadly, only a tiny fraction of AAS members are IDA members. IDA needs help, both fiscally and through the active involvement of more supporters. The astronomical community is a major beneficiary of IDA efforts. It is time for us to step up, both as individual professional astronomers and as organizations, to support the preservation of our prime resource: dark skies.

We urge you to go to the IDA Web site, *www.darksky.org,* to become a member and show your support.

(For more on the IDA, see "NOAO Astronomer and Tohono O'odham Schools Official Honored by IDA" in the Director's Office section.)

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Table 1. Sky Glow Effects on Large Telescopes
(Based on IDA Information Sheet No. 20)

RELATIVE SKY GLOW LEVEL*	EQUIVALENT APERTURE IN METERS	PERCENT OF ORIGINAL VALUE	COST	COST LOSS
For a 4-m Aperture Telescope				
1.00	4.00	1		
1.10	3.81	88%		
1.20	3.65	78%		
1.25	3.58	74%		
1.50	3.27	58%		
2.00	2.83	39%		
3.00	2.31	23%		
5.00	1.79	11%		
For the 4-m on Kitt Peak			**10.0**	
1.06	3.89	92%	9.2	0.8
1.12	3.78	86%	8.6	1.4
For the 5-m at Palomar				
2	3.54	39%		
For the 3-m at Lick Observatory				
3	1.73	23%		
For the 2.5-m at Mt. Wilson				
5	1.12	11%		
For an 8-m Telescope			**65.0**	
1.05	7.81	94%	60.8	4.1
1.10	7.63	88%	57.1	7.8
For a 16-m Telescope			**422**	
1.010	15.92	99%	417	5.6
1.025	15.80	97%	408	13.8
1.050	15.61	94%	395	26.9
1.100	15.26	88%	371	51.0

*A value of 1.0 is the natural sky background. A value of 1.2 means a 20 percent increase above that level.

This is the loss of capital value due to increased sky glow!

The New OTAs Are Here!

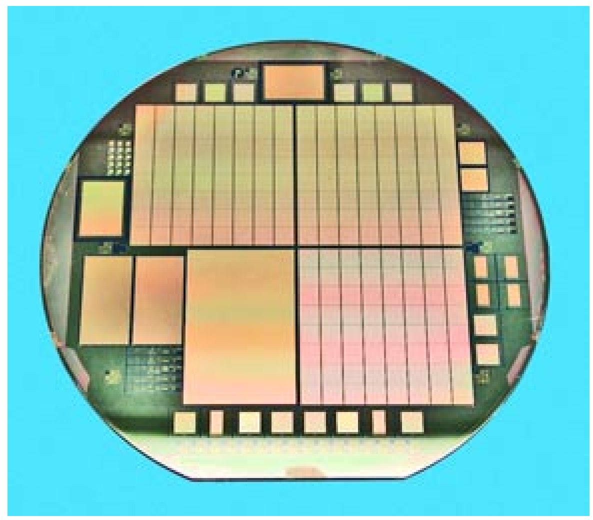
Steve Howell, Richard Green & George Jacoby

The WIYN Consortium has been developing a new-technology type of CCD called an orthogonal transfer array (OTA). The main difference between orthogonal transfer (OT) CCDs and conventional CCDs is the four-layer poly gate structure of OTCCDs, which allows the charge within a pixel to be moved in all four directions during integration. Originally developed to perform fast, real-time, "no moving parts" electronic tip-tilt corrections, OTCCD use has expanded to include high-speed (millisecond and longer) and high-photometric precision (better than 6×10^{-4}) observations. OTCCDs can also be used exactly as normal CCDs with no ill effects. A prototype OTCCD camera, built by John Tonry (University of Hawaii), has been used at WIYN to allow demonstrations of the properties and abilities of OTCCDs. For example, using the "electronic tip-tilt" option with this camera has produced improved image quality in-line with typical gains from mechanical tip-tilt systems such as WTTM. (Scientific calibration and observations with the prototype OTCCD camera are described in Tonry et al., 1997, *PASP,* 109, 1154 and in Howell et al., 2003, *PASP,* 115, 1340.)

The newest breed of OTCCD, the OTA was first described by Kaiser, Tonry, and Luppino (*PASP,* 2000, 112, 768). In close collaboration with the University of Hawaii/MIT Lincoln Laboratory groups, it is being produced for WIYN by Semiconductor Technology Associates/DALSA. Our first foundry run provides 72 OTAs. Since OTAs were first contemplated only four years ago, we have made rapid progress from the conceptual idea to a full-up OTA design, to actual wafer production, and very soon (this year) to completed OTAs with on-sky tests of the initial CCDs. The mechanical silicon wafer shown in the figure has three OTAs on it (the checkerboard looking chips) as well as a 2600×4000 normal CCD, two 800×1200 CCDs, and a number of small test devices around the edges. Each OTA consists of an 8×8 array of approximately 500×500 12-micron pixels.

This design is a clever mix of building on a proven design for CCD and OTCCD pixels, and combining the pixels into an "array of arrays." The 500-square unit cell is very interesting because it confines the impact of very bright stars, which will always be present in large fields of view, and it limits manufacturing failures to small, single-OTCCD regions, thereby increasing the overall usable yield enormously. These unit cells naturally define the idea of guide star regions for rapid readout and image steering, while most of the subarrays will be used for science data with simple dithering to remove the OTA gaps, any dead cells, and guide star or bright star locations.

The design and operation of OTAs is quite complex, as each of the 64 OTCCDs within a single OTA has to be controlled independently. Each 500×500 OTCCD can be assigned as a guide or rapid readout cell, a science cell, or can be turned off if desired (e.g., if defective). The gaps between the OTCCDs or streets, as they are called, can be seen in the figure, and contain all the necessary control lines and other on-chip logic to run each of the 64 independent cells. Present-day CCD controllers are inadequate to run OTAs, so efforts are underway to develop new controllers for such devices at both NOAO (MONSOON) and the University of Hawaii (IOTA).



This mechanical silicon wafer incorporates three OTAs (the checkerboard looking chips), a 2600×4000 CCD, two 800×1200 CCDs, and a number of small test devices (around the edges). The streets (gaps between the OTCCDs) contain all the necessary control lines and other on-chip logic to run each of the 64 independent cells.

Fully completed thick OTA devices are expected to be delivered by May 2004, with thinned devices ready for testing by August. Packaging of the OTAs will be done by Mike Lesser (ITL) and includes custom mounting devices designed by Gerry Luppino (University of Hawaii). Plans at WIYN are to have an OTA in a dewar and on-sky in the fall. We plan to implement OTAs into two new large-format imagers. QUOTA, a 4×4 array of OTAs, will have a 16×16 arcmin field and be available in 2006. It will be a step to the planned one-degree imager (ODI) for WIYN, an array of 8×8 OTAs (32K×32K) to be completed in 2008. Both cameras will have 0.11-arcsec pixels. By-products of the WIYN foundry run are additional 12-micron-pixel CCDs (2600×4000), which will upgrade WIYN spectroscopic applications.

Calypso 1.2-Meter Telescope Seeking Permanent Home

Edgar Smith

The Calypso Observatory is being offered for purchase at modest cost to a qualified institution or consortium. It utilizes a 1.2-meter Ritchey Crétien telescope designed specifically for high-quality imaging. It was completed and became operational on Kitt Peak in 2002. The telescope optics have extremely smooth high-quality surfaces, and the combined rms wavefront error for the primary, secondary, and tertiary mirrors is better than 1/17th wave. To eliminate the effects of dome seeing, the telescope building retracts completely from the telescope, leaving the telescope exposed to the laminar airflow at the edge of Kitt Peak's southwest ridge.

Calypso Telescope (Photo copyright Adeline Caulet.)

The telescope has two imaging cameras: the wide-field camera has a 10-arcmin square field, and the high-resolution camera has an 80-arcsec square field and is equipped with a tip-tilt adaptive guider. The wide-field camera incorporates a thinned, backside-illuminated 4K×4K CCD imager from Fairchild Imaging. The high-resolution camera incorporates a 2K×2K thinned backside-illuminated Loral imager. Each camera can accommodate up to six filters in a cassette-style filter changer.

The median image quality on the wide-field camera is better than 1 arcsec. The high-resolution camera median seeing is better than 0.7 arcsec when using adaptive tip-tilt, and has been as good as 0.3 arcsec on better nights. For further details, see *www.calypso.org*.

In lieu of purchase, proposals for long-term operation and management will also be considered. Astronomers or organizations interested in acquiring or operating the Calypso Observatory are urged to contact *edgar@bway.net*.

Notable Quote

"Dark Energy may be the most profound mystery in all of science. It is not a 'cold fusion' situation, and it is not 'too good to be true.' It's a problem that has caught everyone's fancy, because it might take 100 years to solve, or it might be solved next month with a new observation or experiment. But we need new ideas… ideas that make predictions. Because not every crazy idea is the solution to a profound problem—some are just crazy!"

—A collection of comments from cosmologist Michael Turner, NSF assistant director for mathematical and physical sciences, speaking on 20 March 2004 at the end of the final day of the "Observing Dark Energy" science workshop in Tucson sponsored by NOAO