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A Digital Science Partnership for Southern Skies in the Classroom

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Abstract

A collaboration between the University of Louisville, the University of Southern Queensland, and Northern Kentucky University is developing remotely and robotically operated astronomical facilities for educational outreach, teaching, and research. Telescopes in the southern and northern hemispheres, with a longitude difference that enables students to observe the night sky in daytime classes, are linked by high speed Internet to campuses in Louisville, Kentucky, and Toowoomba, Queensland. Mt. Kent Observatory in Australia also offers the center of the Milky Way, the Magellanic Clouds, and transient events not visible from mid-latitudes in the northern hemisphere. Our Moore Observatory near metropolitan Louisville, Kentucky, isolated from local lighting by a forested nature preserve, offers complementary remote services and the occasional northern comet and supernova to students at USQ. In addition to other instruments at both sites, the robotic operation will use corrected Dall-Kirkham f/6.8 0.5-meter telescopes designed and manufactured for us by Celestron International. The optical system provides a flat well-corrected $27' \times 18'$ field of view with $0.54''$ pixels when coupled with a Kodak KAF-6303E CCD. Open source software supports the weather stations, sky condition monitors, and remote operation of the telescope, cameras, and dome. The southern telescope in Australia will be used through an Internet2 connection from the University of Louisville Belknap Campus with dedicated control facilities in the Physics and Astronomy department for U of L students, and in the Gheens Science Hall and Rauch Planetarium for an outreach educational program to local schools. The northern telescope at our Moore Observatory allows engineering and software development, provides hands-on experience for students, and may be operated remotely by students and collaborators in Australia as well. We expect to install the telescopes in January 2006. This presentation describes our work to develop the hardware and open source software, a preliminary analysis of telescope performance, and the anticipated impact of remote network facilities on astronomy education.

Purpose

The University of Louisville is Kentucky's metropolitan research university, serving a diverse student body, primarily with daytime classes on its urban Belknap Campus. Its Physics and Astronomy program offers courses and laboratories satisfying the General Education requirement for students in all majors, as well as astrophysics courses for undergraduate and graduate students. A +14 hour difference from Louisville to Toowoomba brings a dark sky into their classes. Remote access from several sites similarly benefits USQ's distance education astronomy program. U of L's Rauch Planetarium is offering an opportunity for middle and high school students to participate in group learning experiences with the remotely operated telescopes. A curriculum to meet the goals of the AAAS Project 2061 `http://www.project2061.org/` is being developed.

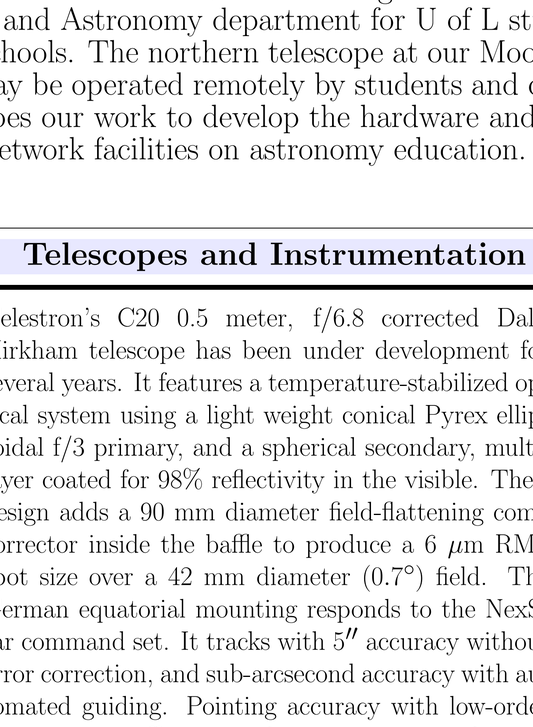
Sites

The Australian telescope is at USQ's Mt. Kent Observatory, near Toowoomba, approximately 130 km from Brisbane. At 682 m altitude on the Great Dividing Range, in a pastoral area of the Darling Downs, and latitude $-27° 47' 52''$, it offers frequent clear skies, good seeing, and an established secure infrastructure.

At Moore Observatory, near metropolitan Louisville, KY, we operate a site for graduate and undergraduate research where the northern robotic telescope is located. At $+38° 20' 40''$ and only 230 m altitude it is a typical light-polluted midwestern site, but it has good stable seeing and is accessible by students on short notice. Moore Observatory also has a 0.6 meter Ritchie-Chrétien research telescope and a wide field spectral imager.

Telescopes and Instrumentation

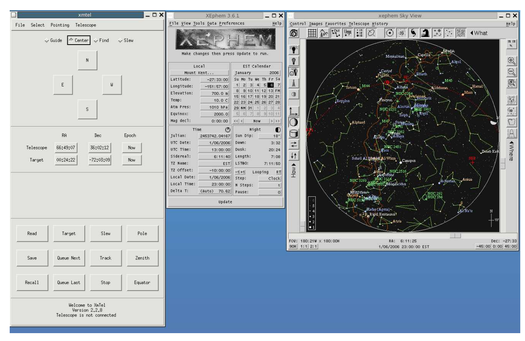
Celestron's C20 0.5 meter, f/6.8 corrected Dall-Kirkham telescope has been under development for several years. It features a temperature-stabilized optical system using a light weight conical Pyrex ellipsoidal f/3 primary, and a spherical secondary, multilayer coated for 98% reflectivity in the visible. Their design adds a 90 mm diameter field-flattening coma corrector inside the baffle to produce a 6 μm RMS spot size over a 42 mm diameter (0.7°) field. The German equatorial mounting responds to the NexStar command set. It tracks with $5''$ accuracy without error correction, and sub-arcsecond accuracy with automated guiding. Pointing accuracy with low-order correction is sufficient to place a target near the center of a CCD field of view.



We use two SBIG CCD cameras and filter sets: an STL-6303 has a Kodak KAF-6303E, 3072 × 2048 9μm, pixel device for RGB color imaging with a 5-filter wheel over a $27' \times 18'$ field. It is well matched to the field of the C20 with $0.5''$ pixels. Somewhat better oversampling of the images is achieved with the ST-10 camera's 2184 × 1472 6.9μm pixels at the expense of a narrower field of view. The ST-10 has the advantage of a 10-filter wheel so that it may be switched remotely from RGBL imaging to UBVRI photometry without a manual change of filter sets. The cameras are designed with internal tracking CCD's and can make use of SBIG's tip-tilt corrector and drift-scan imaging modes. Both telescopes will have long-slit spectroscopic capability, although this requires a manual change. Auxiliary cameras provide a wide f/1.8 color image of the acquisition field, and a real-time video image of the entire sky. A cloud sensor based on the Omega industrial infrared pyrometer records the 10 μm signal from the sky, and a weather station monitors local environmental conditions.

Network, Servers and Software

Mt. Kent is connected to the Toowoomba campus by a 4.8 Mbit/s radio network link (soon upgrading to 34 Mbit/s), then to Brisbane on optical fiber at that quality of service guaranteed during their nighttime. The connection from Brisbane to Louisville is over Internet2. The pipeline is adequate not only for remote operation and data transfer, but also for real-time video and audio with an acceptable latency when the dome video is transmitted using an Axis 241 video server, and video conferencing is through a Polycom VSX 7000. Dual redundant 0.5 TB IBM x346 servers running Suse Linux operate at Mt. Kent and at Louisville to buffer and archive the data flow. Multiple users in Louisville, for example, connect to the local server. Automated sensors provide web-based information on current conditions that bear on telescope operation such as wind, temperature, dew point, cloud cover, and instrument status. Moore Observatory is connected by a T1 (1.5 Mbit/s) link to the main campus network, a slower speed that is still adequate for real-time compressed image transfer and video conferencing while running remote control and data acquisition software. The telescopes and instrumentation are controlled through dedicated PC's running Suse Linux. The open source XmTel user interface is built on top of XEphem. The network is responsive enough to permit running the software on the remote computer and displaying on the user's console, but the system works best when a remote daemon controls the telescope while the display and communication software is at the user end. XmTel is being developed to utilize the excellent graphical interface and databases of XEphem while allowing us to add the specialized drivers for telescope and dome control without the overhead of intermediate "standards" or Windows-based commercial software.



Cameras are controlled by XmCCD, built to operate SBIG hardware remotely. Images are processed and displayed locally using a pipe to SAOimage DS9. In addition to the usual astronomical analysis software packages, we use CinePaint for 32-bit color image processing. Details on software will be on our website at `www.astro.louisville.edu/moore/software`

Example Images

This image of M51 was recorded by R. Hedrick, D. Rowe, J. Fournier, and J. Haberman using the prototype C20 at their Pinto Valley Observatory on May 8, 2005. It is a composite of 4 exposures, 10 minutes each for RGB, and 60 minutes for L, taken with an ST10 camera.

On July 5, 2005, J. Haberman, R. Hedrick, J. Kielkopf, and R. Moore recorded this test image of the 14th magnitude type-II supernova SN2005cs. It is a sum of 6 15-minute exposures with an ST10 camera.

Impact

The opportunities for hands-on discovery and exploration this project offers should, in the words of Project 2061, "bring back the sky – not the same sky, but one that is richer and more varied than people's eyes alone had ever led them to imagine."

Acknowledgments

This project is a collaboration of the University of Louisville and the University of Southern Queensland as part of a Digital Science Partnership with Northern Kentucky University. It is supported in part by a grant from NASA. We are grateful to many who are helping to bring this from a concept to a useful operation, including Rhodes Hart who handles the operations at USQ's Mt. Kent, and Drew Foster who directs U of L's Rauch Planetarium. Dr. Ronald Moore, Vice President for Information Technology at U of L, has given the project his enthusiasm and hands-on support, and has provided the servers and IT infrastructure. Rick Hedrick, Senior Vice President of Celestron International, and Joe Haberman, Optical Engineer, helped with optical and software design issues, and provided access to the prototype telescope at Pinto Valley Observatory. Helen Kielkopf, Andy Newton and Karen Collins in Louisville are contributing creative ideas and assistance at Moore Observatory.