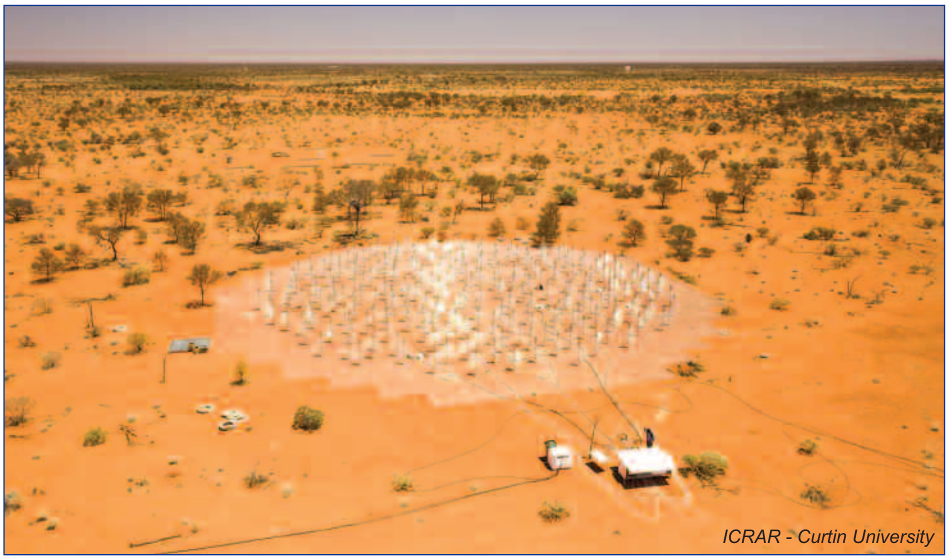
OBSERVATORY SCIENCES News
Summer 2020 ✦ Software for telescopes and accelerators

SQUARE KILOMETRE CONTROL

Observatory Sciences has been awarded a contract to produce control software for the Square Kilometre Array (SKA), an international project that is building the world's largest radio telescope. The SKA is composed of two large telescopes: a low-frequency one in Western Australia (SKA1-Low) and a mid-frequency one in South Africa (SKA1-Mid). Each telescope consists of an array of antennas spread across remote areas of Western Australia and South Africa, with a later expansion into other African countries and Australia. The design is being led by the SKA Organisation based at Jodrell Bank, UK and supported by more than 1,000 engineers and scientists in 20 countries.



ICRAR - Curtin University

The SKA consists of two different antenna systems: dishes for SKA1-Mid and low frequency antenna arrays for SKA1-Low.

The initial work undertaken by Observatory Sciences in the SKA's pre-construction phase will be to enhance the software system known as the Monitor, Control and Calibration Services (MCCS) for the SKA's low frequency array in Australia. When completed, it will consist of 512 Field Stations, each made up of 256 dual-polarisation log-periodic antennas (i.e. 131,072 antennas in total) observing the sky between 50 and 350 MHz. Data flows will be in petabits per second (million billion bits per second, or a hundred thousand times faster than average home broadband), all flowing into a single supercomputing centre through thousands of kilometres of dedicated fibre optic cables. The Field Stations will be distributed over a distance of 65 km in the Western Australia outback.

The MCCS system is responsible for the controlling, monitoring and calibration of all the Field Stations and the receivers and first-beam forming equipment. The antennas in each Field Station are controlled in groups of 16 by Tile Processing Modules (TPMs), each consisting of a FPGA signal processing system that divides the antenna signal into 384 frequency bands and multiplies by a complex gain before combining them to form multiple virtual beams from each Field Station. The main function of the MCCS system is to convert the high-level engineering commands into the gain numbers needed by the TPMs to control the telescope front-end.

The SKA is due to be ratified as a fully-fledged intergovernmental organisation, known as the SKA Observatory, by the end of 2020, after which construction will formally start.

FIRST LIGHT FROM SUN

The world has been treated to new, spectacular pictures of the Sun's surface, taken by the Daniel K Inouye Solar Telescope (DKIST) on Hawaii as it came on stream in January 2020.

DKIST, which is located at an altitude of 3080 metres atop Haleakalā on Maui, Hawaii, has now produced the first step towards a new fuller understanding of the Sun, using telescope control software developed by Observatory Sciences Ltd (OSL).

The photographs show a pattern of turbulent "boiling" plasma convection cells that cover the entire surface of the Sun. Each cell is 500km to 2000km across and details as small as 30km can be clearly seen. More images will continue to be collected, showing even greater details of the Sun.

OSL has been involved with the design and commissioning of DKIST since its earliest days.

In 2010 it was awarded the contract to develop the telescope control system and work on the enclosure control system followed in 2014.

More recently OSL have become involved in DKIST instrument software including the

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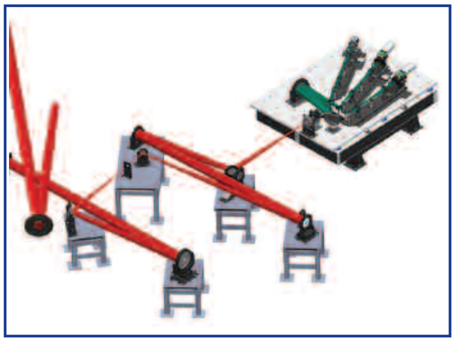
Cryogenic Near-Infrared Spectropolarimeter (CryoNIRSP) system which is used to trace the Sun's coronal magnetism and measure its influence on the Earth. Specialists from OSL are also working on control and acquisition software for the Diffraction Limited Near Infrared Spectropolarimeter (DL-NIRSP) and the Visible Tunable Filter (VTF).



Beampath schematic of the DL-NIRSP

Courtesy of University of Hawaii's Institute for Astronomy

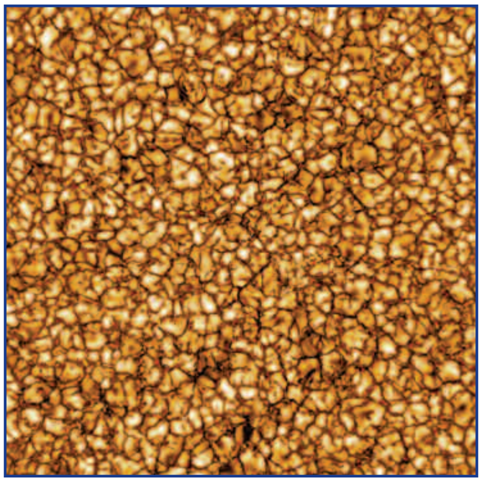
DL-NIRSP, which is being built by the Institute for Astronomy at the University of Hawaii, is a diffraction grating based integral field spectrograph designed to study solar magnetic fields at high spatial and spectral resolutions and polarimetric accuracy. OSL engineer Alan Greer explains: "DL-NIRSP will provide unprecedented simultaneous coverage of the spatial, spectral, polarimetric, and temporal domains."

OSL is also working on the Visible Tunable Filter, which is being built by the Leibniz Institute for Solar Physics in Freiburg, Germany. The filter will spectrally isolate narrow-band images of the Sun at the highest possible spatial and temporal resolution from the DKIST telescope. The VTF will enable clear and rapid imaging spectrometry, Stokes imaging polarimetry, and accurate surface photometry.

As the DKIST programme develops, scientists will become better able to forecast the Sun's colossal emissions of charged particles and their entrained magnetic fields. These cause "space weather" which can damage satellites, harm astronauts, degrade radio communications, and burn out electronic equipment and overhead power cables.

DKIST will complement the recently launched Solar Orbiter space observatory, a joint ESA/NASA mission which will observe from a position close to the Sun at a distance of 42 million kilometres.

During the first half of 2020, the DKIST team of scientists, engineers and technicians will continue testing and commissioning the telescope to make it ready for use by the international solar scientific community.



Close up of the Sun's surface

Courtesy of: NSO/AURA/NSF

TWO-WAY X-RAY BEAMLINE

Observatory Sciences Ltd (OSL) is developing control software for DIAD (Dual Imaging And Diffraction), a new dual beam instrument at the UK's Diamond Light Source synchrotron. DIAD will produce two separate beams to enable the use of two different X-ray measurement techniques; diffraction and imaging. To allow each technique to capture the desired results a novel Beam Selector device is placed in the path of the main beam at the end of the optics hutch. This selector will be controlled from the data acquisition software via the hardware triggering layer to ensure the high speed switching required for the planned experiments.

DIAD will be able to deliver 2D and 3D dynamic imaging of complex structures with monochromatic, Laue or SAXS micro-diffraction information. Its dual beam design represents a step change in the possibilities of, for example, observing changes in shape and stress state of structures during deformation and cracking, or determining morphology and chemistry of phases during chemical reactions.

It will be used to research osteoporosis, tissue scaffolds, asthma, plant roots, fossils, earthquakes, extra-terrestrial materials, carbon sequestration, polymer matrix composites and nuclear waste.

OSL is assisting Diamond with the development process and maintenance of their Generic Data Acquisition (GDA) software system. This is an open-source software framework for creating customised data acquisition software for science facilities such as neutron and x-ray sources. The software is Java/Eclipse-based, free to users and intended to be applicable for any beamline on any synchrotron facility.

OSL has also been providing training for Diamond staff on the use of the Hardware Triggered Scanning software technology, now being adopted on many beamlines.

OSL has a long association with Diamond, having worked on many projects with it and also with its partner organisations and suppliers. OSL has staff currently based full-time at Diamond in Oxfordshire as well as three of four other consultants involved in software development and training projects.

GOING TO SPIE 2020 IN SAN DIEGO, CALIFORNIA

Thomas Ives and Becky Williams of Observatory Sciences are both scheduled to present papers at the 2020 SPIE Astronomical Telescopes + Instrumentation conference in San Diego, California. Being a major international event, there are expected to be about 2500 attendees and over fifty company displays, including Observatory Sciences'.

Observatory Sciences provides full project management and support services for public and private sector clients. This can reduce the learning curve at project implementation and achieve crucial savings in time and manpower.

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Observatory Sciences Ltd

Office 4, 1 New Road, St Ives PE27 5GB

•

PierWerks, 21-22 Old Steine, Brighton BN1 1EL

•

15 Pitreavie Court, Pitreavie Business Park, Dunfermline KY11 8UU

•

Tel: +44(0)1223 655000
contact@observatorysciences.co.uk
www.observatorysciences.co.uk

BLACK HOLES OPEN UP TO NEW HAWAIIAN TELESCOPE

The Maunakea Spectroscopic Explorer (MSE) is a planned wide field 11.25m aperture telescope providing a spectroscopic facility that will lead the world in multi-object spectroscopy. The telescope is planned to be installed in an existing building that currently houses the 4-metre aperture CFHT telescope on the summit of Mauna Kea on the Big Island of Hawaii.

The project is gaining momentum with major partners in Australia, Canada, France, Hawaii, China, India, and various USA institutions. Most recently, a consortium of UK institutes has joined the project as observers. OSL is a long-standing supplier to Hawaiian telescopes.

The telescope will be able to study up to 4,000 astronomical objects at once. As such it will serve astronomers as an essential follow-up resource for multi-wavelength imaging surveys slated to be active throughout the 2020s and also measure the mass of thousands of supermassive black holes in the centre of galaxies.

ELECTRON ANALYSER INTEGRATION

An extremely high energy resolution photoelectron analyser being built in Sweden for the UK's Diamond Light Source synchrotron is to be enhanced with control software developed for it by Observatory Sciences Ltd.

The MBS A-1 Analyser is under construction at MB Scientific in Uppsala and will be used, for example, to produce tunable, focused X-ray beams that probe the depth dependent chemical, electronic, and molecular structure near the surface of materials. Another use will be to observe the distribution of the electrons within the reciprocal space of solids.

OSL engineer Andy Foster, who is working with MB Scientific and Diamond, says: "Our software will enable the existing electron analyser control system, running on National Instruments' LabVIEW software, to be fully integrated into the beamlines at the Diamond facility".

OSL ENHANCING ESO'S CAMERA CONTROL SYSTEMS

The European Southern Observatory (ESO) has installed a new communication interface for the technical detector control system (TDCS) used on the Very Large Telescope (VLT). Developed by Kieran Mulholland of Observatory Sciences Ltd (OSL) it uses Aravis, an open-source library for GenlCam cameras.

Originally the TDCS used a communication interface based on an API from Allied Vision Technologies, but this only supported cameras made by AVT. The new Aravis-based communication interface has been independently developed to provide support for cameras from any vendor. It reads the GenICam interface of a GigE Vision camera to enable control and also has capabilities for USB3Vision cameras.

"We initially tested the interface with cameras from AVT and Basler," says Mulholland, "planning later tests using a CameraLink camera with a GigE Vision adapter. Long term we will add support for more camera manufacturers, and explore possibilities with CameraLink cameras."

The first round of testing took place in October 2019, since when new versions of Aravis have been released and the interface has already been upgraded to these.

This project continues OSL's ongoing work with ESO, including a recently confirmed 12 month contract extension for the software maintenance of the ESO VLT software infrastructure.

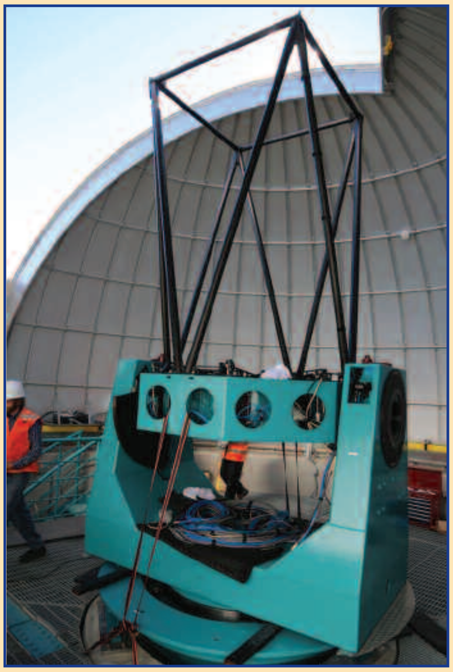
NEW SURVEY TELESCOPE UNDER CONTROL

The Large Synoptic Survey Telescope (LSST), which will conduct a vast astronomical survey for unprecedented discovery of the deep and dynamic universe beginning in 2022, will now be named the Vera C. Rubin Observatory. This new name honours Vera Rubin, a brilliant astronomer and champion for women in science, who did pioneering research into the existence of dark matter. For the first ten years of operation, the Vera C. Rubin Observatory will perform the Rubin Observatory Legacy Survey of Space and Time (LSST).

The Rubin Observatory Auxiliary Telescope has recently been tested in Chile, operating under the control of software written for it by Observatory Sciences Ltd (OSL). Its primary function will be to measure the amount of light being absorbed by the Earth's atmosphere at any given time to provide corrections for the main survey telescope.

Having a dedicated auxiliary telescope supporting the main telescope is unique, and it will increase the quality of the data collected.

The Auxiliary Telescope is actually an older telescope that has been repurposed for its new role in the LSST survey. Originally sited in Arizona, it has been refurbished and relocated to Chile. While the telescope itself is largely original, all the electrical systems including the motors and position encoders have been replaced and have been integrated with the OSL control system at Cerro Pachón in Chile.



The LSST will begin a vast astronomical survey in 2022.

Image: Courtesy LSST Project/NSF/AURA

After the rebuild, extensive testing was undertaken to ensure that all the drives and positioning systems worked and were accurately tuned. Individual tests included driving the telescope toward its upper and lower limits and ensuring the system shut off properly to prevent damage to the telescope, testing for excessive vibration, and testing the speed at which the telescope slews. All this was carried out in Arizona before shipping to Chile, where the remote location makes repairs more difficult.

With this work done the telescope was reassembled on its new site and the dome rebuilt around it. Later the re-coated mirrors were craned into position through the dome.

"Repurposing an existing telescope is obviously cost effective and more sustainable than building from new," says OSL's Philip Taylor. "We are expecting our control software will be tested with the large 8.4-metre aperture Simonyi Survey Telescope during 2020".

SYNCHRONISED TELESCOPE ARRAY EXPANDS

An ambitious plan to create one of the most powerful arrays of telescopes in the world is taking a significant step forward during 2020, incorporating some ground breaking technical solutions.

The Magdalena Ridge Observatory Optical Interferometer (MROI) in New Mexico USA is completing the second of 10 telescopes, with the enclosure delivered early in 2020 and the telescope commissioning on-site later in the year. The system architecture includes an automated alignment system, beam compressors and fringe tracker, all of which interface with similar systems on the first telescope.

The telescope itself is being built by AMOS in Liege, Belgium. While most telescope mount control systems use a dedicated motion controller, this telescope will be using a programmable logic controller (PLC), similar to those found in automated car plants and oil refineries. As such they are proven to be reliable and many control engineers are familiar with them.

The telescope control software was developed by Observatory Sciences Ltd (OSL) using National Instruments' LabVIEW software. A smart, easy to implement, interface has been developed to pass the trajectory demands to the mount control system at microsecond level accuracy.

The MROI is planned to feature up to ten 1.4-metre telescopes, which will collectively be able to simulate a single dish telescope of up to 340m in diameter. The array will create one of the most powerful optical telescopes in the world, with a resolution 100 times greater than the Hubble Space Telescope and the ability to make accurate images of complex astronomical objects many times faster than other existing interferometric arrays currently in operation.