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DISCOVERY

BIG SCIENCE SOLUTIONS SUMMER 2017

New DKIST software contract With acceptance testing completed on the mirror control system of the DKIST completed, Observatory Sciences has won a further contract, this time to develop software for the DKIST's CryoNIRSP instrument. **Page 2**

Three papers for ICALEPCS Observatory Sciences is co-authoring three papers at the 16th International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS) conference, in Spain from 8-13 October. **Page 3**

OBSERVATORY SCIENCES WINS ESO SOFTWARE CONTRACT

In one of its biggest contracts to date, Observatory Sciences is to work with ESO, providing software maintenance services for the VLT and VLTI. The contract is a significant endorsement of Observatory Sciences' credentials.

Bird's eye view of the Very Large Telescope (VLT) at Paranal in Chile. Picture courtesy JL Dauvergne & G Hüdepohl/ESO

Observatory Sciences has won a contract with the European Southern Observatory (ESO) through a multi-national open tender, making it responsible for software that controls the world's most powerful and productive optical observatories, located at one of the best sites in the world for astronomy.

The new contract will provide software maintenance services for ESO's Very Large Telescope (VLT) and the VLT Interferometer (VLTI). The software work will include bug fixes, enhancements and new software modules. The Paranal Observatory in Northern Chile, operated by ESO provides some of the world's largest and most advanced observational facilities, including the four giant unit 8.2m aperture telescopes that make up the VLT.

The VLT instrumentation programme is the most ambitious ever conceived for a single observatory. It includes large-field imagers, adaptive optics corrected cameras and spectrographs, as well as high-resolution and multi-object spectrographs and covers a broad spectral region, from deep ultraviolet (300nm) to mid-infrared (24μm) wavelengths.

The telescopes can work together, to form a giant optical interferometer, the ESO Very Large

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EPICS FOR THE FUTURE

Observatory Sciences is providing EPICS software development effort to the new European Spallation Source being built at Lund in Sweden, working in partnership with Osprey DCS, whose founder Bob Dalesio was one of the original developers of EPICS whilst working at Los Alamos National Laboratory in New Mexico.

Observatory Sciences has built up a global reputation for its expertise with EPICS (Experimental Physics and Industrial Control System), which provides an architecture for control system software to be constructed as a scalable, distributed database of control components.

EPICS is well proven and is used at many of the world's most important scientific institutions. Since its beginning as a two-project collaboration in 1989, EPICS has become globally recognised as a capable, robust, and extensible control system infrastructure for a wide range of projects. It is used on hundreds of projects, including accelerators, tokomaks, telescopes and others, in over seventeen

Model of the future European Spallation Source. Picture courtesy of ESS

countries. Many commercial equipment vendors now advertise EPICS drivers for their technical equipment. For this commitment to

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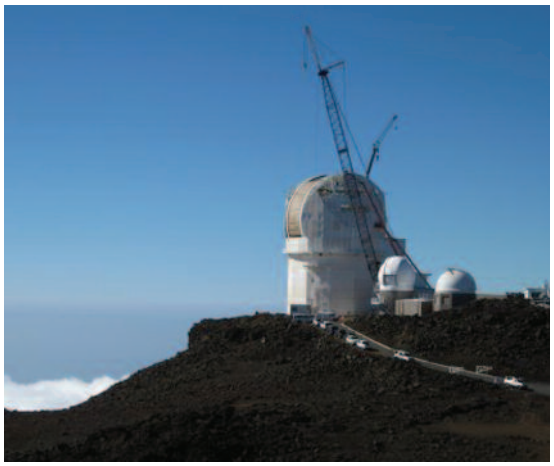
OBSERVATORY SCIENCES WORKING ON DKIST INSTRUMENT SOFTWARE

Consultants from Observatory Sciences have added to their projects on the Daniel K Inouye Solar Telescope (DKIST).



With acceptance testing completed for both the DKIST Feed Optics and Primary Mirror control systems, prior to their installation in Hawaii, Observatory Sciences has won a further contract on the telescope, this time to develop software for the DKIST's Cryogenic Near Infrared Spectro-polarimeter (CryoNIRSP) instrument.

DKIST principal investigator Jeff Kuhn said: "The CryoNIRSP instrument will be one of the largest astronomical instruments the IfA (Institute for Astronomy at the University of Hawaii) has built. It will provide the international community with a detector that brings nighttime sensitivity for observing the relatively faint outer atmosphere of the sun to the world's largest daytime telescope,"

The DKIST was formerly known as the Advanced Technology Solar Telescope (ATST). It was renamed in honour of the late Senator Daniel K Inouye, who, in his nearly 50 years service as an elected representative, did much to support the telescope.

Observatory Sciences' most recent testing work was completed by consultants Alastair Borrowman and Alan Greer for the feed optics control system (FOCS), which monitors the thermally controlled optical components of the telescope. These include primary mirrors M1 and M2; transfer optics (cooled mirrors M3 to M6, their mounts and positioning systems, which collimate the beam and transfer it across both elevation and azimuth axes of the telescope); the Coudé optics (cooled mirrors M7 to M9 and mounts, which provide re-imaging for the adaptive optics).

Alastair explains: "It is basically a number of interconnected subsystems that we are integrating and controlling. We also interface the FOCS with the wavefront correction control system. Wavefront correction, at the heart of the DKIST, will be designed to compensate for most or all of atmospheric seeing effects that can blur observations of fine-scale structures in the solar atmosphere."

Observatory Sciences has been involved in the DKIST project for more than ten years, including development of its telescope control system (TCS) and integrating it with other control subsystems. The TCS has several functions, primarily pointing and tracking, but also compensating for thermal corrections, controlling the adaptive optics and coordinating with other observatory operations. The core of the TCS is a series of closed-loop servo drives in the mount that set the altitude and azimuth of the telescope.

Also recently accepted after tests at the AMOS factory in Liege, Belgium was the control software for the Primary Mirror (M1) – a giant 4.24m diameter, 75mm thick, off-axis paraboloid controlled by over 100 actuators mounted behind the mirror back surface and 24 lateral supports along the outer edge. Both optical control and thermal compensation are provided by the control system. Observatory Sciences also developed the control system for the telescope enclosure, working with AEC Engineering of Minneapolis, Minnesota, who fabricated the steel enclosure. This has now been erected on-site at Haleakala on Maui.

"We have been involved in many aspects of the DKIST project including Observatory Sciences being appointed as their software quality assurance partner," says Alan. "As such we will develop practices and procedures that in-house and collaborating engineers will use. This could see projects developed more quickly and with greater efficiency.

"We have been deeply involved with so many aspects of DKIST and it now feels like a special project to us," he adds. "With over 20 institutions collaborating on the project, it represents one of the most ambitious undertakings of the solar physics community."

ESO CONTRACT FOR OBSERVATORY SCIENCES

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Telescope Interferometer (VLTI), allowing astronomers to see details up to 25 times finer than with the individual telescopes. The light beams are combined in the VLTI using a complex system of mirrors in underground tunnels where the light paths must be kept equal to distances less than 1/1000mm over a distance of a hundred metres. With this kind of precision the VLTI can reconstruct images with an angular resolution of milliarcseconds, equivalent to distinguishing the two headlights of a car at the distance of the Moon.

The Observatory Sciences work will focus on the VLT Common Software Infrastructure – the basic software infrastructure layer with which the VLT and VLTI telescope control software is built. This is a large code base, estimated at 2 million lines of code. This critical software also provides the software infrastructure for all instruments designed for VLT and VLTI, as well as other optical telescopes located at ESO observatories at Paranal and La Silla in Chile.

The initial two year contract is extendible for up to a further three years. Observatory Sciences director Philip Taylor says: "The VLT Common Software Infrastructure is used at the Paranal observatory for operation of all telescopes and all instruments, as well as at sites involved in the development of new instruments and applications for the VLT/VLTI telescopes and other ESO telescopes. It is an important component of one of the most productive observatories in the world.

"This is a significant contract win for Observatory Sciences and is an endorsement of our credentials as a leader in the field of software for telescope control."

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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FIRST LIGHT AT POWERFUL ARRAY OF TELESCOPES

The Magdalena Ridge Observatory marked an important milestone as its first interferometry telescope achieved first light in November.

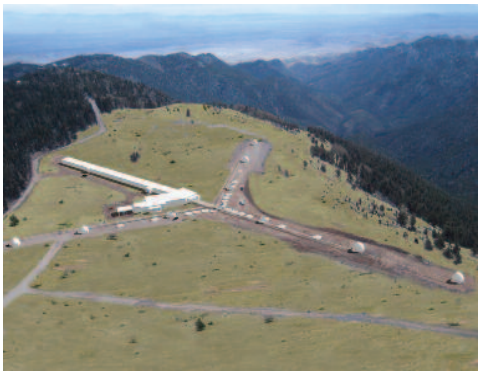
The first of ten telescopes that will make up the Magdalena Ridge Observatory Interferometer (MROI) in New Mexico, USA, experienced first light on November 29th 2016. Construction of the second is underway with a third in the planning stage. Eventually there could be up to ten telescopes operating together to provide astronomers with a completely new insight into the universe. The telescopes are being constructed in Belgium by AMOS (Advanced Mechanical and Optical Systems).

A bespoke telescope control system (TCS) developed by Observatory Sciences for the Magdalena Ridge project has been installed on the first telescope, with similar software expected to be used with all subsequent MROI telescopes.

The MROI is an optical interferometer planned as an array of ten 1.4m diameter telescopes spread out across the mountaintop in a Y configuration, and the light from all ten telescopes can be combined to observe objects in the sky with incredible resolution. The initial phase of the project is the construction of three telescopes, with more to follow at a later date.

The control system was written using the LabVIEW graphical programming language from National Instruments, incorporating positional astronomy and telescope pointing software supplied under licence from Tpoint.

The telescopes are unique, because they were designed specifically for interferometry and the array will eventually become the most powerful optical array on Earth. The resolution is such that



it could be used to identify individual astronauts exploring the moon's surface.

The MROI is being developed by the New Mexico Institute of Technology in collaboration with the UK's University of Cambridge and the US Air Force Research Laboratory.

At present there are only three operating optical interferometers in the world, in Arizona, California and Chile. The MROI will be up to a thousand times more powerful than any of them, and up to 200 times more powerful than the Hubble Space Telescope.

Philip Taylor, a telescope control systems specialist with Observatory Sciences says: "Magdalena Ridge is an ambitious project that promises to move science on a long way. Since telescope construction started in 2007, progress has been delayed due to funding issues. However we are now at an important milestone with First Light having been achieved and the prospect of exciting research work getting underway."

THREE PAPERS FOR ICALEPCS

Observatory Sciences is co-authoring three papers at the 16th International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS) conference. Hosted by the ALBA synchrotron, the conference will take place from 8-13 October 2017 at the Palau de Congressos de Catalunya in Barcelona, Spain. It will cover areas like experiment control, software technology evolution, user interfaces, and control systems upgrades. Observatory Sciences will also have a stand at the exhibition.

ESS SOFTWARE DEVELOPMENT

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constant development Bob Dalesio was presented with a special lifetime achievement award at the ICALEPCS (International Conference on Accelerator and Large Experimental Physics Control Systems) in Kobe, Japan in 2009.

The EPICS V3 release series has evolved over more than 20 years and has seen many small evolutionary steps and internal improvements, while in parallel a new layer for structured data and a new network protocol have been developed, named EPICS V4. This year, EPICS V3 and V4 are being merged to form a new major release called EPICS 7. The work being done at ESS will help achieve this aim.

The European Spallation Source (ESS) is a multi-disciplinary, multi-national research facility and will become the home of the world's most powerful pulsed neutron source. It is based in Sweden, but much of the data analysis capability will be located in Copenhagen, Denmark.

The ground breaking neutron source should be completed by 2019 and in regular use by 2023, providing scientists with new opportunities to increase understanding of atomic structures and mechanisms.

INDIA TO BUILD NEW 2.5m TELESCOPE

Observatory Sciences has recently signed a contract to produce the software for a telescope control system in India – its third telescope project in the country.

India's search for exoplanets is to get a major boost when a new 2.5m infrared telescope comes on-line, complementing the existing 1.2m telescope at the Physical Research Laboratory's (PRL's) Mount Abu Observatory.The new telescope will be constructed in Belgium by AMOS (Advanced Mechanical and Optical Systems) with whom Observatory Sciences has worked on telescope projects several times previously.

At the heart of the new telescope will be an instrument system called PRL Advanced Radial-velocity All-sky Search (PARAS), which will conduct a radial velocity measurement search programme. Observatory Sciences director Philip Taylor explains the basics of the search routine: "Planets rotate about a point that is slightly away from the centre of their star, which is seen from Earth as a slight oscillation. Measuring the amplitude of this wobble gives a good indication of the planet's mass.

"The new telescope equipped with PARAS will be used to confirm and determine the mass of known exoplanets found by earlier NASA space missions."

Whereas previous telescope control systems have been based on a dedicated motion controller, the Mount Abu control system will use a programmable logic controller (PLC), in this case one made by Austrian control engineering company B&R, a division of automation giant ABB. Philip again: "PLCs are almost ubiquitous in the industrial control

The existing 1.2m telescope at the Mount Abu Observatory in Rajasthan, India, will be joined by a new 2.5m telescope

installations that run car plants, oil refineries and other production operations. As such they represent a very well-established technology, that is both reliable and understood by many control engineers. Thus they provide a robust, long-term solution."

However, astronomers and other telescope users at Mount Abu will feel perfectly at home with the new technology, which will run National Instrument LabVIEW software on the Linux operating system.

The observatory is located at an altitude of 1680m and is India's first major facility designed for ground based infrared observations. Other than in the monsoon season (late June to mid-September), there is little rainfall or cloud cover, giving up to 200 nights of observations a year.

There are a number of other telescopes on site, which are used on programmes to track comets, active galactic nuclei, variable planets and the increasing amount of space junk orbiting the Earth.

MEDICAL CYCLOTRON TESTED AND READY TO GO

Acceptance tests on the software for an Indian medical cyclotron have been completed by consultants from Observatory Sciences, including a demonstration of all the beamlines' different capabilities. The tests were carried out in Denmark, near Copenhagen, at the facility of the beamline manufacturer Danfysik during December last year.

Observatory Sciences' contribution was to supply beamline control software for the cyclotron, which will be operated at the Variable Energy Cyclon Centre (VECC) in Kolkata (formerly Calcutta). Run by the Indian government's Department of Atomic Energy, the centre is dedicated to frontier research and development.

In particular, a new 30MeV 500μA proton cyclotron will be used to produce PET (Positron Emission Tomography) and SPECT (Single Photon Emission Computed Tomography) isotopes for medical diagnostics purposes.

At the same time, there will be provision for front-line research experiments in the fields of material sciences, radiochemistry and liquid metal target development.

This is Observatory Sciences' first project for a medical cyclotron facility. The company's expertise with software tools such as EPICS and LabVIEW has previously been used on both synchrotron and astronomical projects, but the same tools are perfectly compatible with medical research facilities.

EXPANSION FOR OBSERVATORY SCIENCES

Marking an extremely busy and successful year, involving a large number of high profile projects, Observatory Sciences is recruiting additional personnel and has expanded into a fourth location. This latest expansion comes after the company outgrew its original headquarters in Cambridge, and relocated to St Ives.

"We had been in our original HQ since our earliest days in 1998," explains director Alan Greer. "It served our purposes well, being located close to Cambridge University and its world renowned Science Park. We have now moved to new premises in St Ives, Cambridgeshire, about 25 kilometres (15 miles) from Cambridge."

At the same time, the company has opened a new office in Fife, Scotland. The office will be headed up by Observatory Sciences consultant Alastair Borrowman, who has made the move north from Cambridge. Alan adds: "The new Scottish facilit complements our offices in St Ives and Brighton and our presence at the Diamond Light Source, the UK's national synchrotron in Oxfordshire."

In terms of personnel, a recruitment drive has seen the company grow by almost 60% over the last year, and Observatory Sciences continues to have opportunities for growth, including prospects with major new projects.