LSST:UK Newsletter 35 (July 2023)

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Introduction

The undoubted highlight of July for LSST:UK was our three-part session at NAM2023 (summarised below). We were fortunate to secure three authoritative speakers from the US - Bob Blum (Director of Rubin Observatory Operations), Christina Williams (from the Rubin Community Science Team) and Ashley Villar (co-chair of the Informatics and Statistics Science Collaboration) - for our introductory/background session, and it was particularly good to see so many Early Career Researchers presenting preparatory science talks, to complement presentations outlining a number of the UK's in-kind contributions.

The programme for the 2023 Project and Community Workshop has now been released. In-person registration has now closed (although it is possible to join a waiting list), but registration for remote participation is still possible.

As mentioned last month, (self-)nominations are being sought for membership of the Rubin Science Advisory Council (SAC), with a deadline of July 31st to complete the nomination form. While SAC members serve in a personal capacity, rather than representing any scientific or national/institutional constituency, it is *expected* that at least one member of the SAC will be from the UK, so LSST:UK members (at any career stage and with any scientific interest) are strongly encouraged to consider nominating themselves: @Stephen Smartt can provide further details of what the role entails, as he and @Meg Schwamb are amongst those now leaving the SAC at the end of their terms.

The second piece written by EPCC staff working in the LSST:UK Science Centre has appeared, with @James Perry 's account of introducing GPU acceleration into the GalSim code to help speed up DESC simulations.

Those with ideas for future newsletter items should contact the LSST:UK Project Managers (@George Beckett and @Terry Sloan lusc_pm@mlist.is.ed.ac.uk), while everyone is encouraged to subscribe to the Rubin Observatory Digest for more general news from the US observatory team.

@Bob Mann

Galaxy clustering with the Rubin LSST

As part of the Phase C of the LSST:UK Science Centre (LUSC) programme, a new contribution will focus on providing infrastructure for the accurate estimation of the clustering of galaxies, which is of central importance to the cosmological science to be carried out by the Dark Energy Science Collaboration, as well as galaxy evolution studies targeted by the Galaxies Science Collaboration. The work will be carried out between the University of Oxford and Imperial College (PIs: Alonso & Leistedt) and will aim to model the non-cosmological modulation of galaxy density caused by Galactic and observational sky contaminants (e.g., dust extinction, stars, PSF fluctuations). This will involve a combination of well-established techniques (e.g. foreground templates fitting and deprojection) as well as new ones based on Source Injections (SI), where mock objects are added to images which are reprocessed in order to characterise system responses and sensitivity to foregrounds. SI are promising but require the development of new algorithms and new infrastructure to be embedded in the DESC and GSC software ecosystems. This contribution will tackle this challenge and validate the associated software on early Rubin data to model the survey's transfer function in detail.

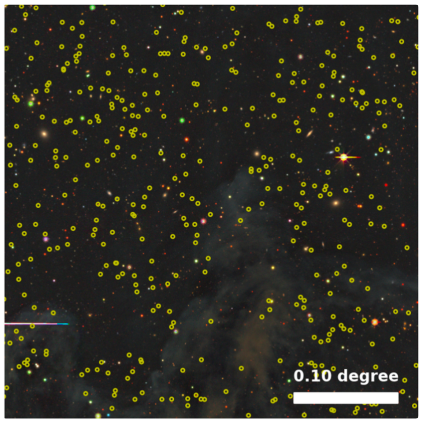


Figure 7 of https://iopscience.iop.org/article/10.3847/1538-3881/acb213, illustrating how a foreground (here, dust) can extremely affect the detection of a particular type of galaxy (here, ELGs).

@David Alonso and @Boris Leistedt

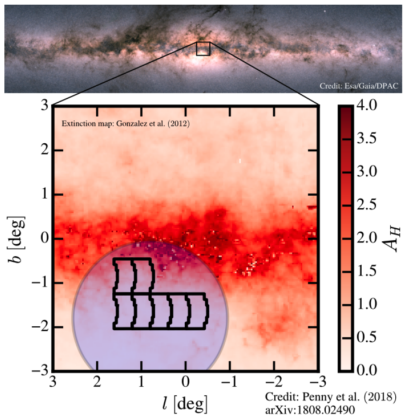
Maximising the Science Return of Major Survey Facilities

The Vera C. Rubin Observatory will be one of several flagship survey facilities beginning operations over the next decade alongside projects such as the *Nancy Grace Roman Space Telescope*. As part of the community call for input into the *Roman* Mission Core Community Surveys, a team of international researchers (across several LSST science collaborations and including members of

LSST:UK) submitted a white paper demonstrating ways to maximise the science return of upcoming major facilities, with a particular focus on LSST's and *Roman's* Galactic Bulge Surveys.

The deep near-IR imaging that *Roman* will deliver will be highly complementary to the capabilities of other survey telescopes (such as Rubin) that will operate contemporaneously, particularly those facilities that can provide data at different wavelengths and messengers or different time intervals. Combining data from multiple facilities can provide critical astrophysical insights, provided the data acquisition is carefully scheduled and careful plans are made for appropriate joint data analyses.

In the white paper, we discuss how *Roman*'s characterisation of lensing events caused by exoplanets, stellar systems and stellar remnants can be enhanced by data from Rubin. The same combination of data will also be highly advantageous for the determination of stellar properties and for distinguishing exoplanetary transits. It will enable more accurate period-colour-luminosity relationships to be measured for variable stars throughout the Milky Way Bulge and Bar, probing Galactic structure and dynamics in the 'heart' of the Milky Way. The combination of *Roman*'s near-IR and Rubin's optical data will also be highly beneficial for High Latitude Surveys, for example, in the measurement of photometric redshifts of galaxies, characterising supernovae lightcurves and probing the edges of the Milky Way halo.



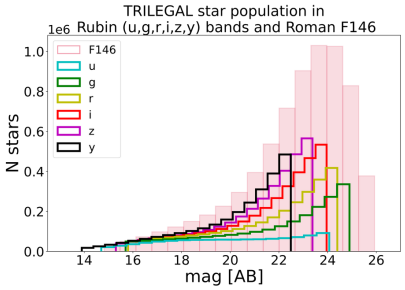
The left panel of Figure 5 from Maximizing science return by coordinating the survey strategies of... presenting a comparison of the *Roman* Galactic Bulge Time Domain Survey field (black mosaic outline) and a proposed LSST Galactic Bulge deep drilling field (blue circle).

Coordinating the timing of Bulge observations between the two observatories can maximise the science outputs of both surveys. In particular, if Rubin undertakes rolling cadence seasons of the Bulge, these would be most beneficial if they occurred during the gaps in *Roman* Bulge seasons. We also highlight the value of acquiring contemporaneous

observations in constraining the masses of free-floating planet microlensing events. Therefore, close coordination between the groups responsible for the *Roman* Mission and Rubin Observatory survey strategies is essential to maximise the scientific return of the combined data products.

Within the white paper, the team could only present a sample of the full potential of coordinated efforts between these observatories. Hence, we advocate for a thorough study to be conducted as a joint effort between these major projects. We also recommend close coordination of the survey observing strategies, data handling and metrics of the next generation of Great Observatories and existing survey catalogues.

Furthermore, metrics designed to evaluate how changes in the strategy of one survey impact the scientific return of another should be implemented by observatories in developing their surveys, considering a wide range of complementary facilities and catalogues. It would also be valuable to have a common framework for writing and running survey strategy simulations and metrics rather than developing separate code bases for each facility. The Metric Analysis Framework (MAF, LSST) is an example of a project-supported code base that has successfully integrated metric code contributed from the wider community.



The right panel of Figure 5 from Maximizing science return by coordinating the survey strategies of... presenting histograms of stellar apparent magnitudes for the proposed Bulge survey fields based on the TRILEGAL galactic model, showing that *Roman* and Rubin will observe complementary stellar samples.

The white paper can be found in full on arXiv:

Maximizing science return by coordinating the survey strategies of...

[Abridged] The Nancy Grace Roman Space Telescope will be one of several flagship survey facilities operating over the next decade starting $\sim$2025. The deep near-IR imaging that Roman will...

arXiv.org

@Steven Gough-Kelly

LSST:UK sessions at NAM2023

We had three LSST-related sessions at the 2023 National Astronomy Meeting in Cardiff, with talks divided into three categories.

The first session started with a brief scene-setting introduction from @Bob Mann , followed by a wide-ranging update on Rubin construction and operations plans from **Bob Blum**, the Rubin Director for Operations, who noted that 2023 is a key year: testing of the Telescope Mount Assembly continues, while LSSTCam is undergoing final testing at SLAC, prior to being shipped to Chile in the autumn. He also summarised the current understanding of the likely impact of satellite constellations on the LSST - i.e., a *nuisance* (<1% of pixels affected), rather than a *catastrophe* (>10% affected), but with a realisation that no combination of mitigations will remove the impact entirely - and also outlined the Observatory's sustainability plans, which have the goal of making operations on Cerro Pachon carbon-neutral. In the next talk, **Christina Williams** from the Rubin Community Science Team introduced the Rubin Science Platform (RSP) - the integrated set of web applications that Rubin is developing to support analysis of LSST data - and described how the Data Preview programme is helping users learn to use the RSP tools through manipulation of simulated and, soon, commissioning data. The final introductory talk came from **Ashley Villar**, co-chair of the Informatics and Statistics Science Collaboration, who introduced the eight LSST Science Collaborations, which now comprise more than 2000 people from 33 countries. Villar summarised the scope of each Science Collaboration and their role in advising the Observatory, as well as coordinating the future scientific exploitation of LSST data. She emphasised that they aspire to providing an inclusive and supportive environment within which LSST science can take place and that, in particular, they provide Early Career Researchers with an excellent way to secure a place in the LSST community.

In the final presentation of the first session, @George Beckett delivered the first of a set of talks describing the UK's in-kind contributions to Rubin operations, covering the development of the UK's Independent Data Access Centre (IDAC). Beckett emphasised that, while there are a dozen IDACs planned, it is likely that the one in the UK will be only "full IDAC", holding all the LSST Data Release products and running an instance of the RSP (in the IRIS cloud environment), as well as hosting the UK's *Lasair* broker and datasets from a number of UK in-kind contributions. The second session started with @James Mullaney describing another the UK's major in-kind contributions, namely its 25% share of the workload for Data Release Processing (DRP). Mullaney explained the various steps in the DRP, the variety of data products that it will produce and the international (French-UK-US) team that will undertake it. The same pipeline software being used for the DRP will also be used in another UK in-kind contribution, to produce an LSST-VISTA optical/near-infrared dataset, and @Manda Banerji summarised how this has been tested, by performing the fusion of HyperSuprimeCam and VISTA data. This work has been complicated by the continuing development of modules in the pipeline, but the Southampton team have recently passed a major milestone in producing catalogues from the full areal overlap of the HSC and VISTA surveys. In the next talk @Tom J Wilson described an in-kind contribution that will perform catalogue-level data fusion, with particular attention to the modelling of the Astrometric Uncertainty Function, which will be crucial for the estimation of accurate cross-match probabilities, given how crowded the sky seen by LSST will be. Next up was @Christopher Frohmaier , who described TiDES, the Time-Domain Extragalatic Survey, which will perform spectroscopic follow-up of LSST transients with 4MOST. TiDES has three scientific objectives: (i) to map the diversity of the transient universe (which it will do by obtaining spectra for >40,000 LSST transients); (ii) to constrain dark energy models

through the Hubble diagram for >50,000 Type Ia supernovae; and (iii) perform reverberation mapping of >1000 AGN to z~2.5. A more technical in-kind contribution was described by @aaron.watkins , who has been studying how to optimise the DRP pipeline for low-surface-brightness science. After investigating a number of alternative sky-subtraction algorithms, it appears that the best approach - as well as the simplest - will be to omit one of the steps in the sky correction procedure currently being applied to HSC data.

The remaining nine talks, spanning the remainder of the second session and all of the third, comprised a series of talks on scientific preparations for LSST data. In the first of these, @Naomi Robertson discussed the range of modelling choices that face DESC as it prepares for the cosmic shear analysis of the LSST Year 1 dataset. These range from methodological (e.g., which statistics to measure) to technical (e.g., which sampler to use) to scientific choices (e.g., how best to correct for the intrinsic alignments of galaxies) and careful studies of their interplay are needed before DESC decides the best way to analyse the Year 1 data. Studies of stellar streams in the Milky Way have provided information about the gravitational potential of the Galaxy, and **Madison Walder** discussed how these methods can be extended to external galaxies with the advent of data from Euclid, LSST and, later, the Nancy Grace Roman Space Telescope, which, together, are expected to detect thousands of extragalactic streams, albeit with much less known about each than is the case for Galactic stream. Nonetheless, Walder showed that the radial profile of a galaxy can be determined with only the track of the stream on the sky, provided it is long enough, while the addition of at least one radial velocity measurement is needed to yield an estimate of the galactic halo mass. **Mike Walmsley** started the final session with a description of how the Zooniverse platform has been used for a range of galaxy morphology studies and how the methodology used to date may be scaled up for LSST and Euclid. A second Zooniverse project was then outlined by **Adam McMaster**, who has been using citizen scientists to identify potential black hole microlensing events; to date that has used SuperWASP data, but the intention is to apply the same approach to data from TESS, ZTF and, eventually, LSST. **Francesco Petri** showed how the depth of LSST data will allow the selection of many millions of Lyman-break galaxies in the interval $3 < z < 5$, whose clustering, cross-correlated with CMB lensing, will probe the universe before it became dominated by dark energy. @Sugata Kaviraj explained how existing surveys have presented a biased view of the dwarf galaxy population and showed that initial HSC results imply that LSST data will reveal large numbers of red (i.e., quenched) dwarf galaxies out to cosmologically-significant redshifts for the first time, thereby allowing the determination of the evolution of this numerically-predominant component of the galaxy population. The next two talks described novel cosmological analyses that will be possible with LSST data: **Isabelle Yi** explained that the Doppler magnification dipole should be detectable by LSST, while **Sebastian von Hausegger** described three DESC projects to probe the isotropy and homogeneity of the Universe. A poor wifi connection prevented **Suhail Dhawan** from delivering the final talk, which would have covered the use of strongly-lensed supernovae as cosmological probes, with the goal of an independent estimate of the Hubble constant to ~1% from LSST.

Taken together, the talks in these three sessions presented a welcome update on the status of Rubin construction and operations planning, as well as a good impression of the UK contributions to Rubin operations that will earn data rights for UK researchers and the wide range of ways that they intend to exploit those data rights for science. Particularly impressive and encouraging was the fact that so many of the sciece preparation talks were given by Early Career Researchers, which bodes well for the long-term scientific return on STFC's investment in UK involvement in LSST. @James Mullaney concluded the session by offering tutorials on accessing data through the Rubin Data Previews, which

give users an early look at the Rubin Science Platform and tools to interrogate and interpret the data. James' has built up substantial experience and is happy to offer advice and help to the UK community.

@Bob Mann and @Stephen Smartt

Recent LSST:UK Science Centre outputs

The LSST:UK Science Centre has recently produced the following technical reports.

Title	Author(s)	Description
D3.3.4 LSST to 4MOST communication bridge	C. Frohmaier and M. Sullivan (both Southampton)	The 4m multi-object spectroscopic telescope (4MOST) will commence operations in 2024. The Time-Domain Extragalactic Survey (TiDES) on 4MOST will follow-up LSST discovered transients to obtain spectroscopic measurements for tens-of-thousands of supernovae, galaxies, active-galactic nuclei (AGN), and strongly-lensed systems. For the transients and their hosts, this data will allow us to map the astrophysical diversity of cosmic explosions and measure the equation of state parameter for dark energy to unprecedented precision. TiDES forms the basis of the LSST:UK Phase B WP3.3: Spectroscopic classification of transients. In D3.3.3 we produced a software product that interacted with the Lasair broker and ran a selection function on the retrieved light curves. At the time of submission of D3.3.3, the Zwicky Transient Facility (ZTF) had been undergoing maintenance for a number of weeks leaving us unable to test the operation of the code on a real-time data stream. Instead, we used an archieve of transients and simulated a dataflow. In this deliverable, D3.3.4, we implement the real-time Kafka stream capabilities from Lasair and present our communication bridge to submit LSST discovered transients into the 4MOST system. Our communication bridge is the link between any transient broker and 4MOST - although for our purposes, we have developed it around the UK's Lasair broker. Our software periodically checks our TiDES Kafka stream on Lasair for new transients. The software ingests the transient light curve and applies the D3.3.3 software products. The objects that

		meet this selection criteria are stored in a PostgreSQL database that stages the transients before they are submitted to 4MOST. We then use the 4MOST API (currently in proprietary development stages within 4MOST) to submit transients to the 4MOST observing queue. The 4MOST API returns the status of the submitted transient and we update our system to keep in sync with the 4MOST database. The software pipeline is orchestrated using Prefect1 and deployed on the Somerville system. Given that LSST is still a number of years away, the development and testing has used the ZTF data but with minimal tweaks we can adapt our software to work with LSST alerts.

@Terry Sloan

Forthcoming meetings of interest

The online registration for the Rubin Project and Community Workshop 2023 remains open.

Other meetings of potential interest for the coming months include:

Dates	Meeting Title/ Event	Meeting Website/ Contact	Venue
16/Oct/23—20/Oct/23	DESC Sprint Week	DESC Confluence (login required)	Carnegie Mellon University (CMU), Pittsburgh
25/Sep/23—29/Sep/23	LSST@Europe 5	LSST@Europe5 | Poreč, Croatia | September 25-29 2023	Croatia, Poreč
13/Sep/23-14/Sep/23	Lasair LSST review and users meeting Oxford	LSST:UK website here	Oxford, Department of Physics
07/Aug/23—11/Aug/23	Rubin Project and Community Workshop	Rubin Observatory Project & Community Workshop | Project & Community Workshop 2023	Tucson, AZ

Members of the Consortium (not in receipt of travel funding through one of the Science Centre grants) may apply for travel support for meetings of this kind via the the LSST:UK Pool Travel Fund. Details are available at Forthcoming LSST-related Meetings .

Note that the current list of forthcoming meeting is always available on the Relevant Meetings page. You may also wish to check information held on the LSST organisation website LSST-organised events and the LSST Corporation website.

@George Beckett

Announcements

If you have significant announcements that are directly relevant to LSST:UK and would like to share the announcement in a future newsletter, please contact the LSST:UK project managers.