Preparing the UK AGN community for LSST

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LSST:UK AGN Consortium: Motivation

- Variability studies and characterization
 - Short (transient) and long term
- Extensive multi-wavelength catalogs
 - Identify AGN and their redshifts
 - Combine LSST data with IR, X-ray, and radio

LSST:UK AGN Consortium: Variability

Developing UK Variability Broker software

- For variable stars and AGN
- Manage and combine the 3 LSST data streams of variability information received at UK DAC
- Main deliverables:
 - Near Real-time assessment of variability and classification
 - ▶ Time-domain software tool box

Near Real-time variability broker

- Produce UK DAC-based database of preliminary light curves
 - To be replaced by LSST's annual releases of light curves
- Probabilistic variability flagging
- Preliminary classification

Time domain tool box

- Pre-whitening tool: to remove correlated astrophysical noise prior to period determination and light curve classification analysis
- > Tools for period determination, alias analysis, and false alarm probabilities
- Tools and metrics for analysis of aperiodic events
- Initial light curve classification tool based on fits to well understood templates
- Multi-filter cross correlation metrics for the 6 LSST filters

UK Variability Broker

- Time domain tool box and classification will be available to the community for exploitation of the annual data releases
- ▶ Highly complementary to the UK transient broker LASAIR work package
 - LASAIR will pick-up strongly variable, short time scale events
 - The UK variability broker will pick-up on the lower amplitude/long term or repeat variability sources

Time-Domain Extragalactic Survey (TiDES)

4MOST- 4m Multi-Object Spectroscopic Telescope

- ▶ In operation by 2022
- Optical Range (390-930nm)
- Wide FOV (4.1 sq.deg)
- ▶ ~2400 fibers
- Survey southern sky over 5 years with repeat visits to deep fields
- Well matched to LSST in terms of
 - Sensitivity
 - Location
- The premier wide spectroscopic facility in the southern hemisphere (30 sq deg/night)



LSST 9.6 deg^2 FoV



4MOST 4.1 deg² FoV

TIDES

250,000 fiber hours available

- Aim to target 50,000+ transient spectra
- Science aims
 - Rapid (3-4 day) spectroscopic follow-up and classification of LSST extragalactic transient discoveries
 - Obtain host galaxy redshifts
 - Spectroscopically monitor AGN variability to perform a large AGN broad emission line reverberation mapping (RM) experiment

Broad Emission Line Reverberation Mapping



Middelberg, E. & Bach, U. 2008, Reports on Progress in Physics, Volume 71, Issue 6, id. 066901



Fausnaugh et al. 2017, ApJ, 840, 97

Radius-Luminosity Relation

Time Series Analysis

$$\tau \sim \frac{R}{c}$$
$$R \propto L^{1/2}$$

R-L relationship

$$U = \frac{Q(H)}{4\pi r^2 c n_H}$$
$$r \propto Q^{\frac{1}{2}} \propto L^{\frac{1}{2}}$$



Bentz, et al. 2013, ApJ, 767, 149, 27

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Tides-RM

- Needs repeat spectroscopic observations, so is limited to the 4MOST deep fields and calibration fields
- Will monitor the variability of about 700 preselected AGN
 - Use first round of spectra taken in the 4MOST AGN survey to select objects with broad lines
- Goals
 - Accurately determine BH masses to z~2.5 via broad emission line RM
 - \blacktriangleright Use tight lag-AGN luminosity relation, $\tau \propto {\rm L_{AGN}}^{0.5}$, to standardize for cosmology



TIDES+LSST

- LSST will "tell" us which objects vary the most, which increases our chances at determining a time lag
- The independent continuum light curves from LSST will help extract the continuum from the spectra obtained from TiDES
- LSST will have a higher cadence than 4MOST so will provide better light curves from which to model the driver light curve from
 - Which is why we need continuous monitoring in LSST deep fields

Summary

▶ UK Variability Broker

- Near real-time assessment of variability and classification
- Time-domain software tool box
- TiDES as LSST spectroscopic follow-up survey
 - RM campaign
 - Establish AGN as an independent standardizable candle in cosmology
 - ▶ Determine dynamical masses of supermassive black holes up to to z~2.5