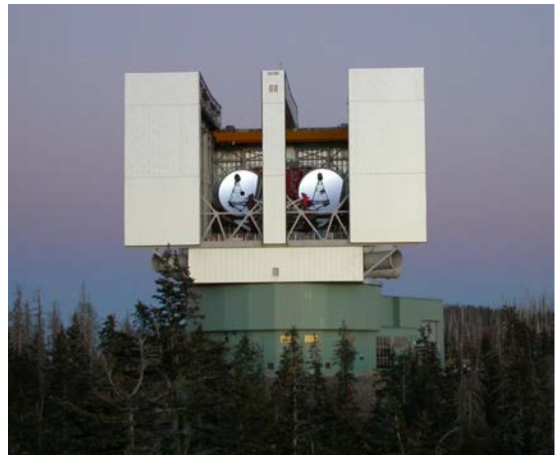
# Science Follow-up for the Rubin Observatory

The Rubin Observatory will be transformative for many areas of astronomy. Realizing its full potential will require follow-up observations with other facilities, particularly spectroscopy with large-aperture telescopes, and measurements that extend the wavelength baseline to the infrared.

## The Role of LBT

The Large Binocular Telescope Observatory is well positioned to contribute such follow-up measurements. The LBTO has access to more than half of the sky area observed in Rubin's primary Wide Fast Deep survey.

With two 8.4m primary mirrors, the LBT has the equivalent aperture of an 11.8m telescope. The telescope has a versatile complement of instruments, with a design permitting rapid change of configurations. These instruments include:

- MODS Multi-Object Double Spectrographs/Imagers providing R~2000 spectra with simultaneous coverage of 320-1100 nm with a 6x6 arcmin field of view.

- LUCI multi-mode infrared instruments, providing an imaging field up to 4 arcmin and spectra with R~2000 to 6500+ in single band z, J, H, K observations. High resolution imaging leveraging the LBT's adaptive optics system is also available.

- PEPSI high-resolution optical spectrograph, providing spectra with R = 53,000, 130,000, and 250,000 covering 383-907 nm in three exposures.

- LBC optical prime-focus cameras with ~24 arcmin field of view, optimized separately for 350-650 nm and 550-1000 nm bandpasses.

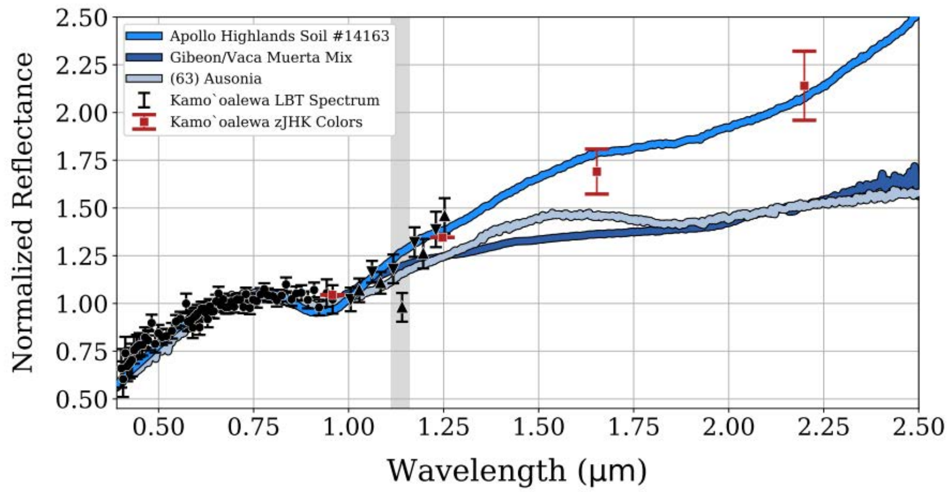
Simultaneous use of different instruments on the two sides of the telescope is possible. For bright sources, additional instruments for mid-IR imaging and integral-field spectroscopy; high-resolution, high-contrast imaging; and interferometry leveraging the 22.8m baseline of the telescope are also available.

Example Science Cases for LBT Follow-up

**LBT measurements will have value across the major science themes identified for Rubin.**

## *I. Survey of the Solar System:*

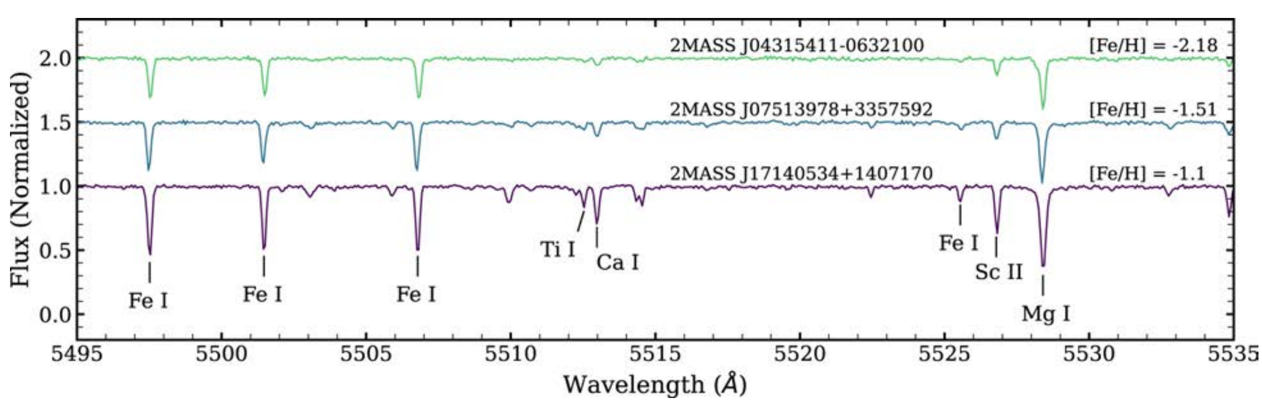
Characterization of asteroids discovered in the survey requires spectroscopic information to identify composition and other properties. Moderate resolution optical spectra are relevant for this purpose, with extension to infrared wavelengths providing additional diagnostic power.




*Combined LBT MODS and LUCI spectral and photometric measurements for Asteroid (469219) Kamo'oalewa with comparison reference SEDs (Sharkey et al. 2022). At the time of observation, the source brightness was V = 22.0 mag.*

## *II. Structure and Stellar Content of the Milky Way:*

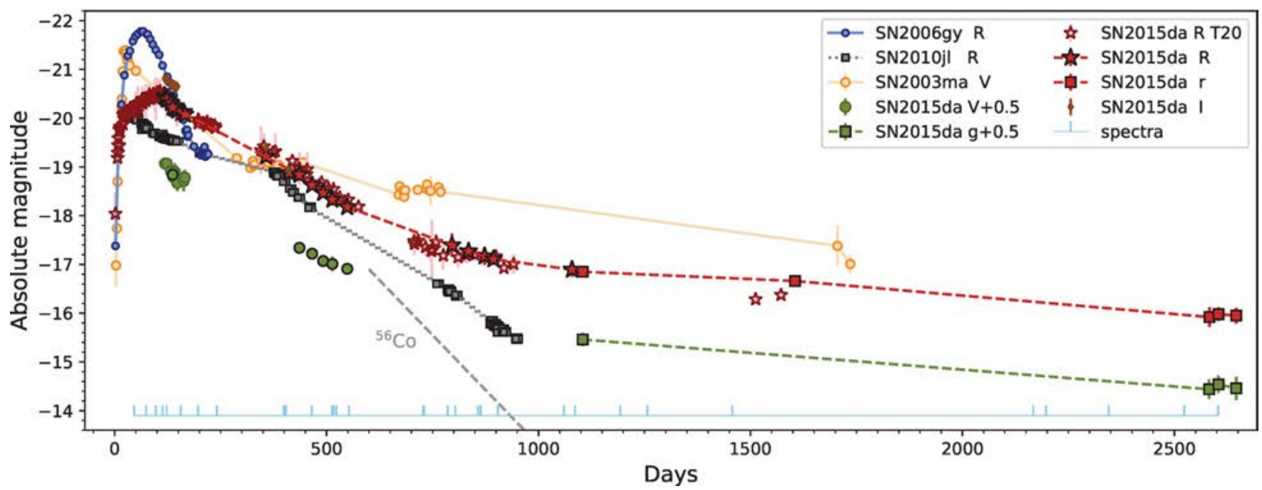
Abundances derived from high-resolution spectra for targeted stellar samples are a powerful tool for investigating the early evolution of the Galaxy, and nucleosynthesis processes in this environment.



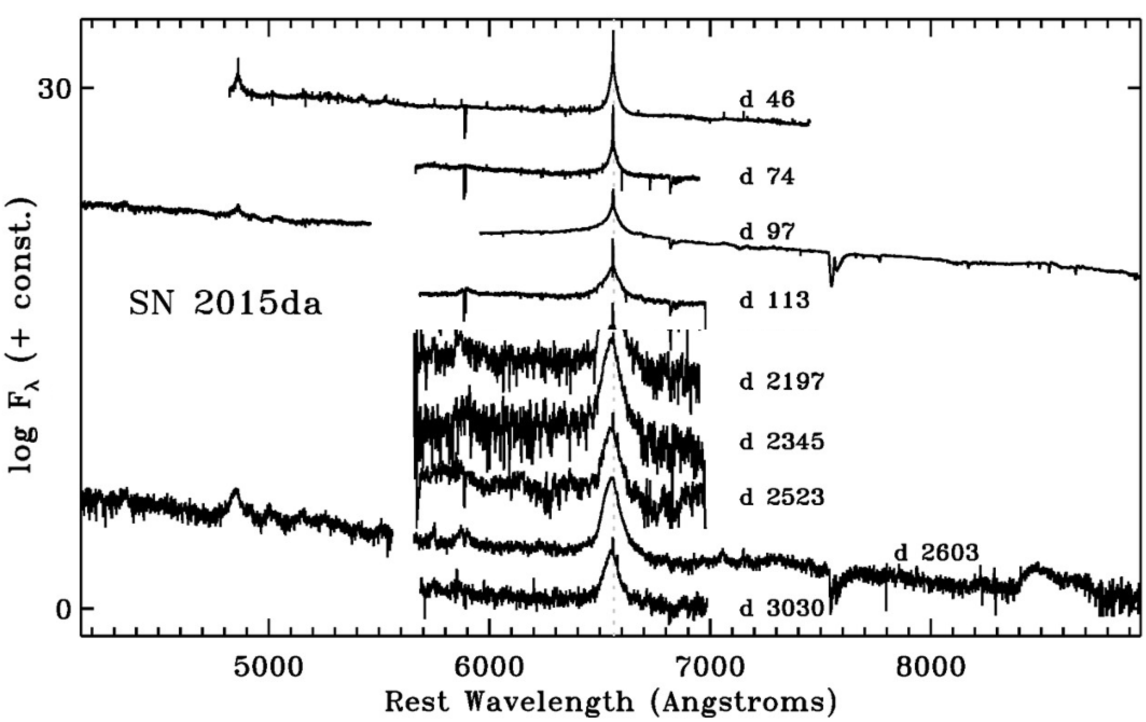

*Section of LBT PEPSI spectra of three solar neighborhood stars from a larger sample used to quantify abundance scatter for 12 elements, and analyze the underlying causes (Griffith et al. 2023).*

### III. Variable Universe:

a) Transients: LBT is regularly used for follow-up photometry and spectroscopy of transients for source characterization and population studies. Sensitivity is sufficient to enable study of faint sources, and late-time behavior.

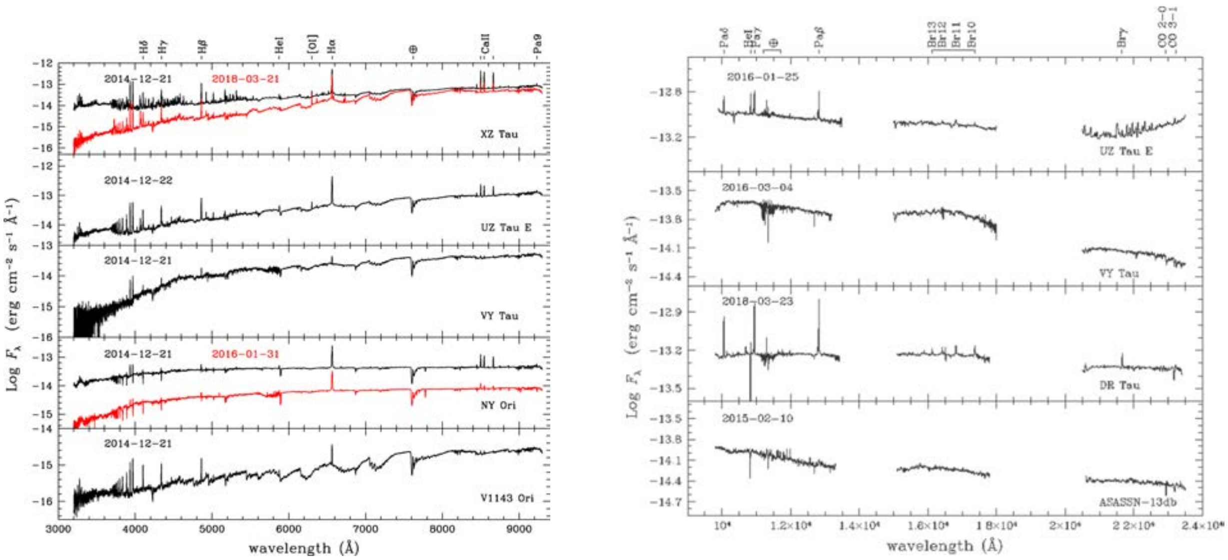



*Light curve for SN2015da compared to other reference sources. Most of the measurements beyond 1100 days were obtained with the MODS instrument on LBT (Smith et al. 2024).*



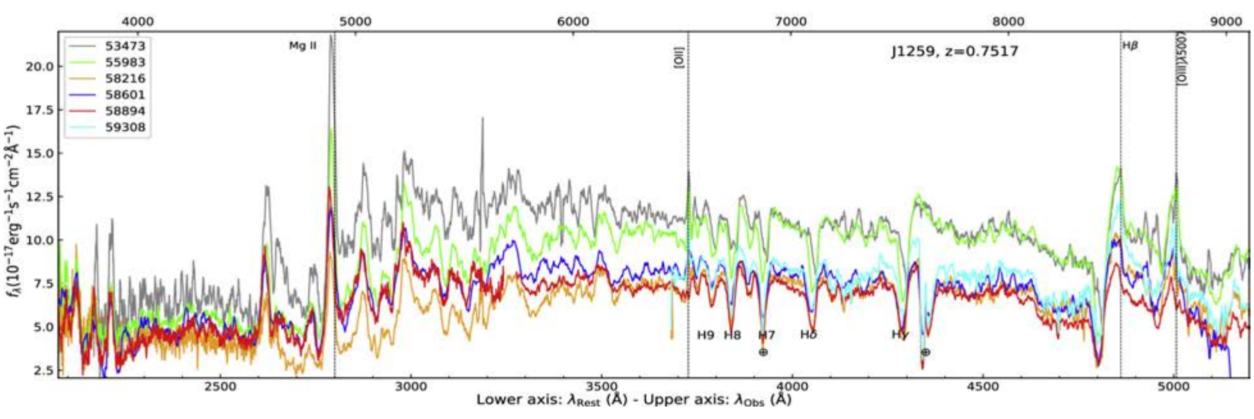

*Spectra from multiple telescopes for SN 2015da. The spectra obtained on days 97 and 2603 post-explosion were obtained with LBT MODS (Smith et al. 2024).*

b) Variable Stars: Rubin will be a rich resource for identification of variable star samples to probe stellar physics. LBT provides important capabilities for spectroscopic follow-up and characterization.




*MODS and LUCI spectra for EXor objects, which are pre-main sequence stars showing episodes of eruptive accretion linked to magnetospheric events. Spectra obtained with MODS (left) and LUCI (right) enable measurement of emission lines tracing variation in both accretion and mass loss (Giannin et al. 2022).*

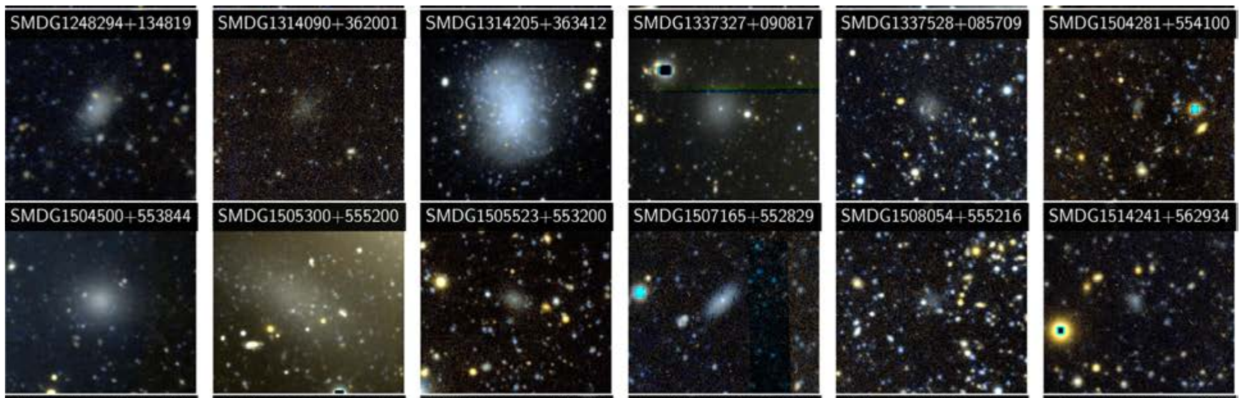
c) Active Galactic Nuclei: The Rubin survey will yield large numbers of quasar candidates and active galactic nuclei, with information on their temporal behavior. Follow-up spectra will be important for selected samples of interest, including objects with peculiar colors; candidate high-z quasars; and sources with unusual variability, which may be linked to accretion events, changing-look variability in broad lines, or changes in outflows traced by broad absorption lines (BALs).




*Multi-epoch spectra from multiple telescopes for a BAL quasar (z=0.7517, r = 18.5 mag) showing changes in BALs, including evidence of velocity shifts. The red spectrum was obtained with LBT MODs (Weimin Yi et al. 2024).*

*IV. Evolution of Galaxies:*

Rubin will discover galaxy populations and clusters that will require deeper imaging than is achieved by the survey to fully characterize these systems. LBT provides wide-field optical imaging capability as well as the opportunity to extend imaging measurements to infrared wavelengths.




*A subset of low surface brightness candidate satellite images in a survey of galactic halos and tidal structures obtained with the LBCs. The data achieve a limiting surface brightness in g-band of ~28 mag arcsec$^{-2}$, which approaches that of the full 10-year Rubin survey (Zaritsky et al. 2023).*

<u>Opportunities for LBT Access</u>

The LBT Observatory currently has opportunities available for institutions to access the telescope, under scenarios offering varying amounts of time. Details are provided in an announcement available at this link, and specific arrangements are open to negotiation. Further information is available by contacting LBTO Director Joe Shields (jshields@lbto.org) or LBT Corporation President Adriano Fontana (adriano.fontana@inaf.it).

Observers can collect their data on-site at Mt Graham, at the LBTO Remote Observing Room in Tucson, remotely with assistance of Service Observers, or via a full queue mode.