Transients and Variable Stars with LSST

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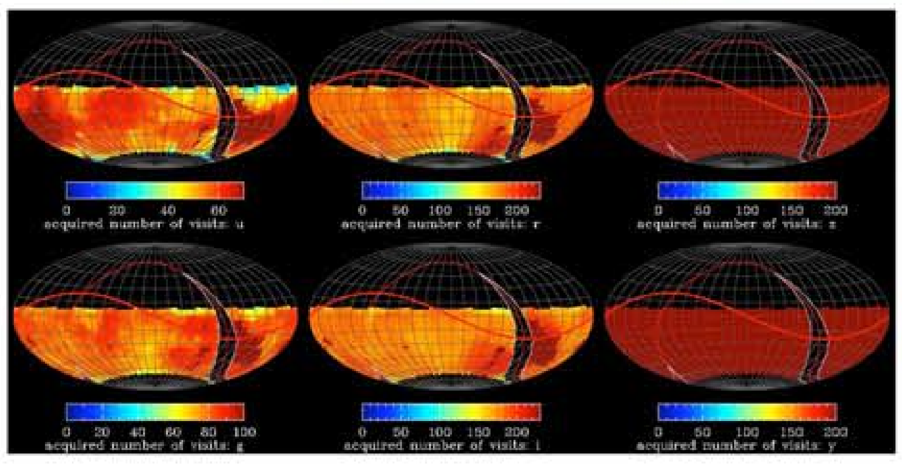
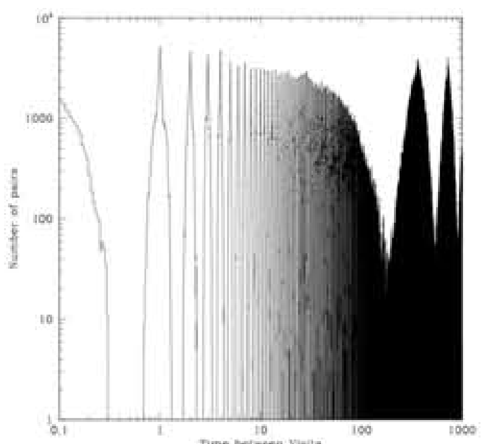
LSST will open an unprecedented window into the optical transient sky. It will cover more of the sky, more often, and to a deeper limiting magnitude than has previously been possible. Samples of known variable stars, such as cataclysmic variables (including exotic AM CVn), will be expanded by at least an order of magnitude due to LSST's temporal sampling of variability combined with multi-color photometry. Samples of known transient events, such as microlensing and gamma-ray burst afterglows, will be similarly expanded. Optical counterparts to gravitational events detected with LIGO or LISA will be found, as well as X-Ray Novae. With extremely accurate photometry (0.5% relative accuracy at the bright end) LSST will discover many more pulsating stars, improving our understanding of their respective instability strips, and also enable the characterization of variability throughout the H-R diagram, including M-dwarf flare rates. With continual monitoring over many years, planetary transits and eclipsing binary systems will be detected throughout the 20,000 square degrees of LSST sky coverage.

Most intriguingly, LSST will also discover new types of transient and variable phenomena. LSST will generate 'alerts' within 60 seconds of detecting a new transient, permitting the community to follow up unusual events in greater detail. The increase in sample size and diversity of transient and variable objects provided by LSST will lead to a greater understanding of the structure and life cycle of stars, particularly through their explosive, eruptive, mass loss stages and the end stages leading to supernovae, neutron stars or black holes.

Frequent Time Sampling over 20,000 square degrees

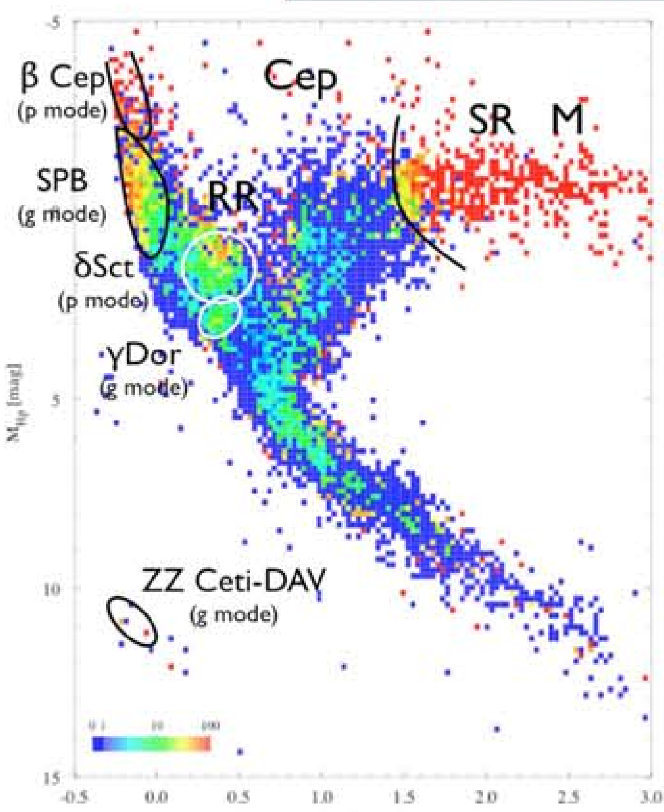


Estimates of the number of visits per field over the planned 10 year LSST survey, as generated in current Operations Simulations.



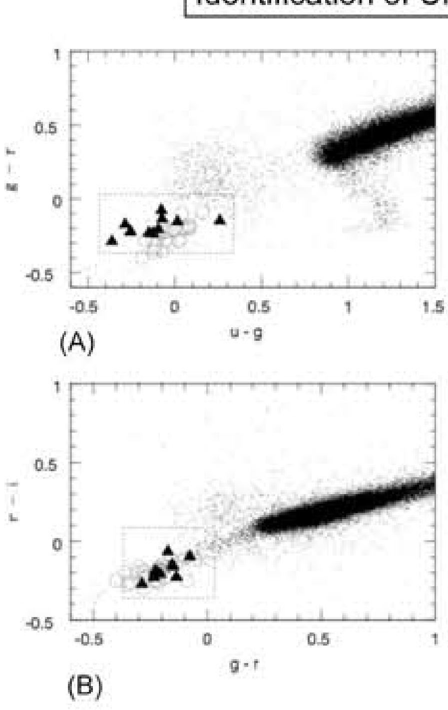
Time interval between visits to the same sky pointing.

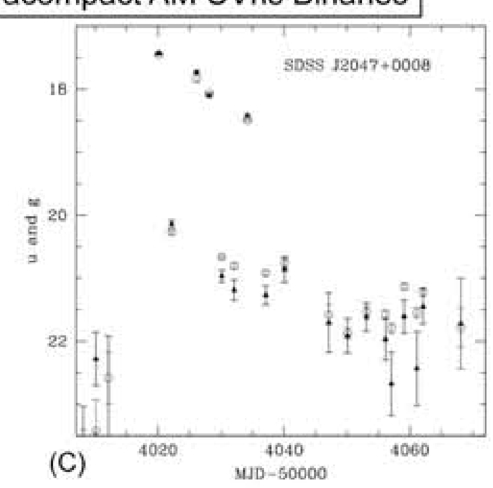
Characterization of Variability Across the HR Diagram



Fraction of variable stars across the HR diagram, as seen by Hipparcos (Eyer & Mowlavi, 2007). With frequent time monitoring and high quality photometry, LSST will provide larger samples for studies of variability, throughout the galactic thick and thin disk, as well as the galactic halo.

Identification of Ultracompact AM CVns Binaries





Figures A and B are color-color plots from SDSS data, showing AM CVns as solid triangles; WD DBs cohabit the same region of color-color (open circles). Figure C illustrates the time variability which identified SDSS J2047+008 as an AM CVn. Figures from Anderson et. al. 2008, AJ.

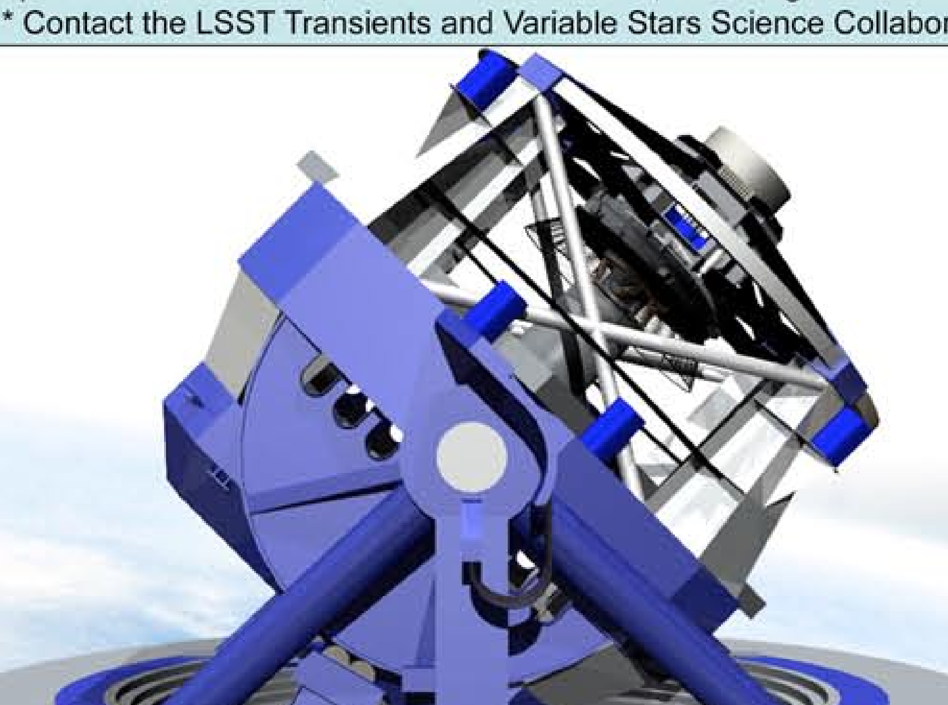
While AM CVns reside in a small region in the color-color diagram, a color-color plot alone is not sufficient to uniquely identify these variable stars. The addition of temporal coverage to identify outbursts and variability is required. LSST will extend the sample of known AM CVns by an order of magnitude. Other types of variables will experience similar benefits.

Challenges facing LSST in identifying and characterizing transients and variable stars:

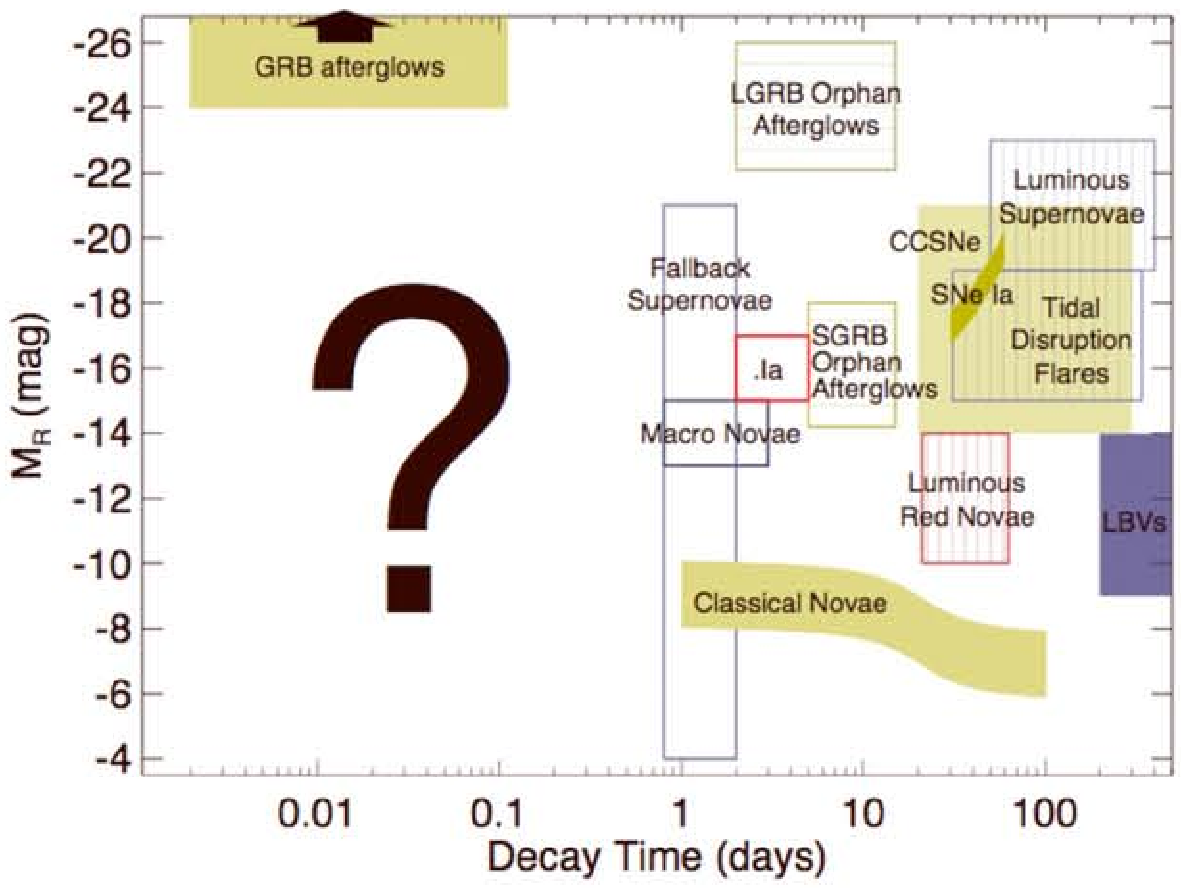
* Identifying and classifying known transients and variables, to allow identification of new and unknown objects.
* Developing followup plans, including how to deliver Alerts.
* Understanding the systematics in the LSST survey system, from detector to calibration software to cadence design to classification algorithms.

To meet these challenges, the science collaboration will be developing estimates of the rates of detection of variables and transients, developing classification algorithms and analyzing the output of the LSST operations simulations, calibration simulations, and image simulations.

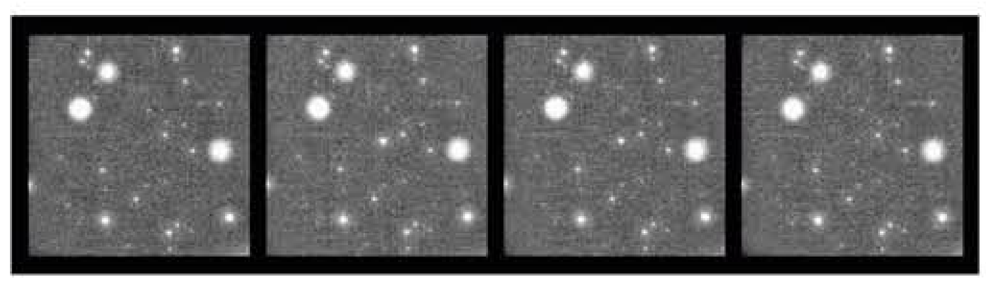
* Contact the LSST Transients and Variable Stars Science Collaboration at lsst-transient@lsstcorp.org

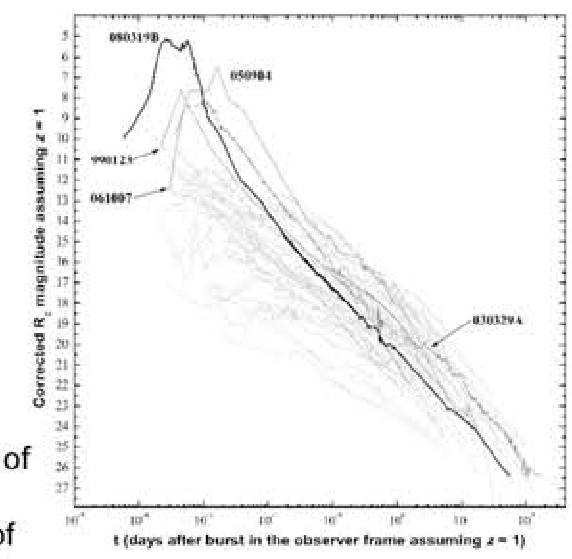


Detecting known and unknown types of Transient and Nonperiodic Events



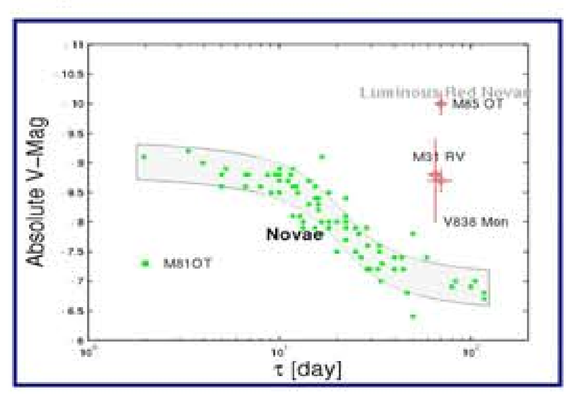
With time coverage ranging from 15 seconds to 10 years, LSST will detect many kinds of nonperiodic and transient events. By covering the entire sky to a typical limiting magnitude of r=24.7, the numbers of these events will permit statistically significant evaluation of these types of events. Many of these detections will represent completely unknown classes of transients and nonperiodic variables. LSST will issue "Alerts" (VOEvents) 60 seconds after each visit to enable followup of these 'unknown unknowns'. Figure to left modified from Rau et. al. 2009.





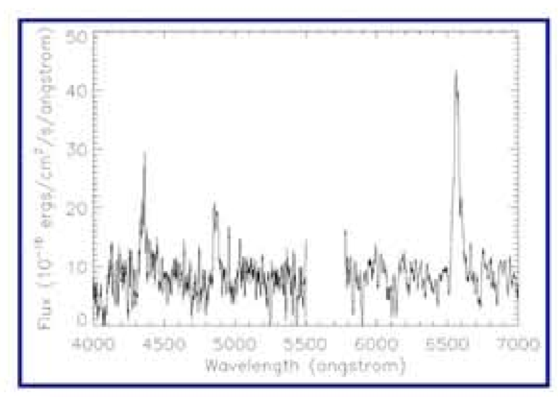
Identifying Gamma Ray Burst Counterparts

LSST will detect optical counterparts of GRBs, many of which will be observed at other wavelengths with other telescopes; most will be detected at multiple times during their decay, permitting characterization of luminosities and decay rates. Shown here is GRB080319B, the most distant source ever detected at naked eye brightness. (Images from 'Pi of the Sky'. Figure to the right illustrating GRB decay rate from Bloom et. al. 2008).

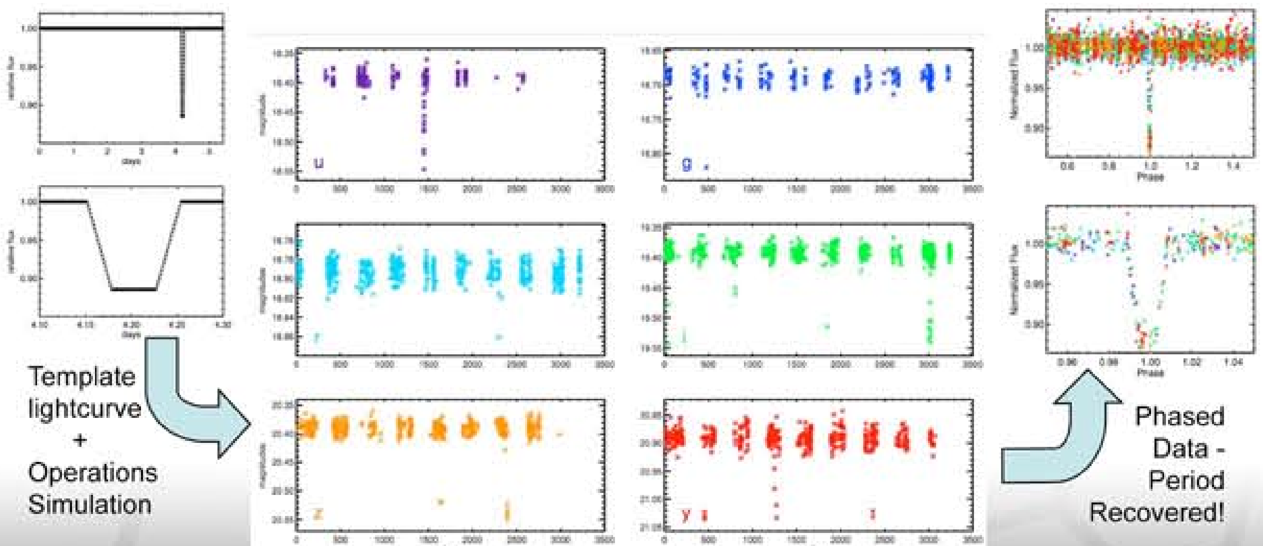


New kinds of Transients

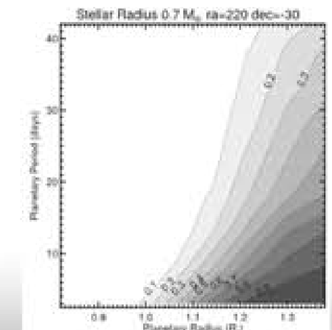
M810T is an example of an unusual nova discovered in the P60-FaSTING project. Its brightness declined faster than expected; spectroscopy confirmed its nova nature. Figures provided by Kasliwal & Kulkarni.



Evaluation of LSST Cadence - Planetary Transits



Evaluation of the LSST observing cadence shows that discovery of transiting planets is possible. Figures from Claire & Bochanski, 2009.



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