Studying TDEs in the era of LSST

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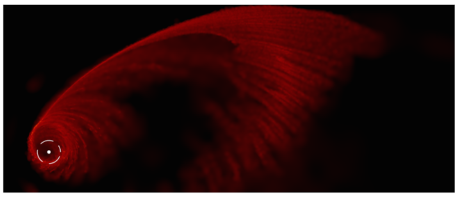
Abstract

The observing strategy with continuous scanning and large sky coverage of the upcoming ground-based Large Synoptic Survey Telescope (LSST) will make it a perfect tool in search of rare transients, such as Tidal Disruption Events (TDEs). Bright optical flares resulting from tidal disruption of stars by their host supermassive black hole (SMBH) can provide us with important information about the mass of the SMBH involved in the disruption and thus enable the study of quiescent SMBHs, which represent a large majority of SMBHs found in centres of galaxies. These types of transients are extremely rare, with only about few tens of candidates discovered so far. It is expected that the LSST will provide a large sample of new TDE light curves. Here we present simulations of TDE observations using an end-to-end LSST simulation framework. Based on the analysis of simulated light curves we estimate the number of TDEs with good quality light curves the LSST is expected to discover in 10 years of observations. In addition, we investigate whether TDEs observed by the LSST could be used to probe the SMBH mass distribution in the universe.

Tidal Disruption Events

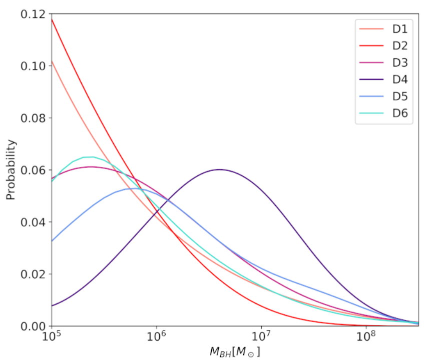
TDEs occur when a star in a center of a galaxy is scattered onto an orbit leading it close to the SMBH in the core of its host, in vicinity of which strong tidal forces can tear the star apart [1, 2]. Typical signatures of TDEs are bright flashes of light, which fade slowly on time scales from months to years. TDEs are rare, with only a few tens of candidates discovered so far. The observed emission depends on different parameters, such as M_{BH}, R_*, M_*, and β. Therefore observing TDEs is crucial for studies of SMBHs. TDE rate is believed to be 10^{-5}/galaxy/year [3], hence large surveys monitoring thousands of galaxies, such as the LSST, will be crucial in enlarging the observed TDE sample.



A simulation of a Tidal Disruption Event. Credit: Aurora Clerici.

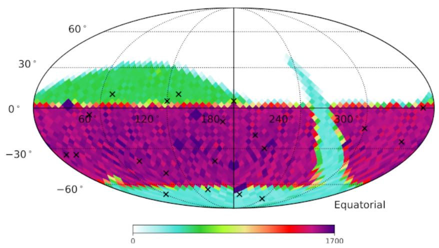
SMBH mass distribution

SMBH mass largely influences the observed TDE emission. Observed TDE sample might provide some insights about the SMBH mass distribution in the Universe. We use 6 different SMBH mass distributions for our simulations.



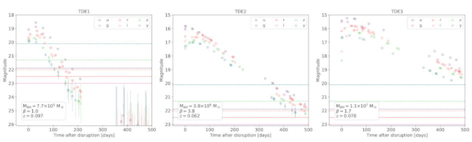
Input SMBH mass probability distributions D1-D6.

LSST simulation setup



Number of visits in all LSST bands according to cadence `minion_1016` together with coordinates of 20 simulated fields.

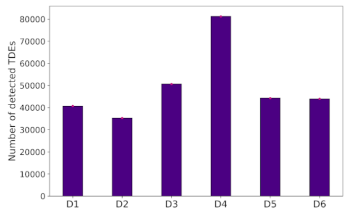
Our simulations were done on 20 fields on the sky, each of size 20.25 deg^2. For each field we randomly chose TDE host galaxies from `CatSim` catalogs [4], and assigned them a Solar type TDE with different parameters (M_{BH}, β). Using `MOSFiT` we calculated SEDs at different times after the disruption [5, 6]. We queried the observation database `minion_1016` for all the pointings in our simulated areas. Each time the host galaxy was observed, if the TDE was still active, a new point in the light curve was calculated.



Simulated detected light curves of three different 1 $M_\odot$ TDEs in all six LSST bands. Error-bars (vertical lines) are plotted together with cut-off magnitudes for each filter (horizontal lines).

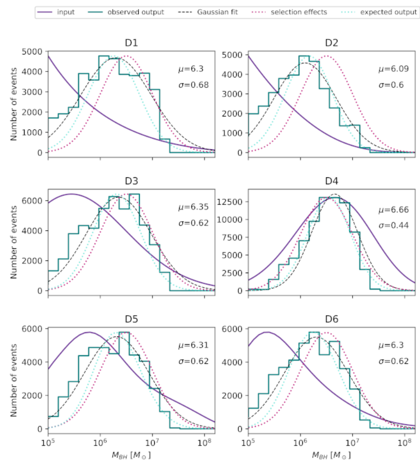
Results

To include only well sampled TDEs, we define a positive TDE detection if the simulated light curve had more than 10 observing points above the (limiting − 2) cut-off magnitude in any of the LSST bands. Scaling the number of detections from 20 fields to the entire observable sky, we find that the **LSST should discover between 35 000 and 80 000 TDEs in 10 years of observations**. The exact number depends on the assumed SMBH mass distribution. Our results are in agreement with previous estimates [7, 8].



Number of detected TDEs in 10 years with LSST for 6 SMBH mass distributions.

From our results it seems that it will not be straightforward to deduce the mass distribution of SMBHs in spite of a large number of detected TDEs. There is no clear parameter with which we could distinguish among different initial distributions. This is due to the selection effects which are biased against low-mass black hole TDEs.



Distribution of detected TDEs over their SMBH mass for six input SMBH mass distributions D1-D6 (green histograms).

References

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