Kilonova Detection in LSST

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Abstract

The first observation of gravitational waves (GW) from a binary neutron star collision, known as GW170817, was made by the Laser Interferometer Gravitational-Wave Observatory (LIGO) and Virgo GW observatories, with the discovery of a kilonova, marking the beginning of multi-messenger astronomy. This event occurs when two neutron stars or a neutron star and a black hole collide. The Vera C. Rubin Observatory, located on Cerro Pachón in Chile, a powerful new observatory under construction, will be used to study a wide range of astronomical objects and phenomena, including kilonovae. Its main goal is to conduct the 10-year Legacy Survey of Space and Time (LSST). Our work is done within the Dark Energy Science Collaboration (DESC), one of several science collaborations preparing for the LSST data release. Our project focuses on assessing how well kilonovae will be detected in LSST. To achieve this, we use theoretical models of kilonova light emission known as Kasen models (Kasen et al. 2017). These models predict the ultraviolet (UV) to infrared (IR) spectrum at intervals of 0.1 days after the neutron star merger, taking into account various factors, such as ejecta mass, ejecta velocity, and lanthanide fraction, influencing the kilonova's luminosity. By utilizing Kasen models, we generated kilonovae light curves for four of the six LSST bands (u, g, r, i) at increasing redshifts. These light curves depict how the observed brightness of a neutron star merger changes over time. Through an analysis of these light curves, we find that the number of kilonova models that would be detectable in LSST rapidly decreases with increasing redshift. The findings demonstrate that kilonovae falling below LSST's limiting magnitude remain too faint for detection in single exposure images. However, those that did surpass the threshold can be observed in LSST, holding the potential for groundbreaking discoveries.