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Author: Mr. Abraham Rez
The Ohio State University, United States

THE EFFECT OF LARGE SATELLITE CONSTELLATIONS ON EARTH BASED ASTRONOMICAL OBSERVATIONS

Abstract

SpaceX and other companies are launching or are planning to launch large constellations of satellites into orbit around the earth, in an effort to provide global internet access and other wireless services. Astronomers have raised concerns that the large number of satellites make it inevitable that scattered light will interfere with ground-based astronomical observations. The impact will be particularly serious close to the beginning and end of civil twilight for telescopes with wide fields of view such as the Large Synoptic Survey Telescope (LSST) or advanced telescopes using adaptive optics with long exposure times.

The planned satellites for SpaceX Starlink will be in orbits 340km, 550km and 1200km high. The higher altitude satellites will potentially be visible up to 4.6 hours after sunset or before sunrise, while the lower altitude satellites will be visible for up to 2.5 hours after sunset or before sunrise. Since it is proposed that there will be up to 75 satellites in 50 different orbital planes it is likely that a satellite will cross the field of view of a telescope every 1.5 minutes.

The angular field of view of the LSST is 3.5 degrees, and a satellite will take 53 seconds to cross the field of view. The planned exposures of the LSST are only 15 seconds long, so the satellite will appear as a streak traversing just over one quarter the field of view. For other large telescopes the field of view is 10-20x smaller, but the exposure times are longer so there may be multiple streaks for each exposure.

The pixels of large telescope detectors correspond to an angular width of about 10^{-6} radians. The area of the satellites is about $1m^2$ with photovoltaic panels covering $32m^2$. This means each satellite body would cover 1 detector pixel with the solar panels spread over multiple pixels. The faintest objects that can be detected by ground based telescopes are limited by both the aperture diameter and the integration time. A reasonable estimate of the limiting illuminance is about 10^{-20} W/m^2. Even if it is assumed there is only diffuse reflection spread over 2π steradians, the light reflected by the satellite is about 10^{10} times more intense. If there is specular reflection the intensity increases even further. This will severely limit the use of telescopes for faint astronomical objects like distant galaxies or exoplanets.