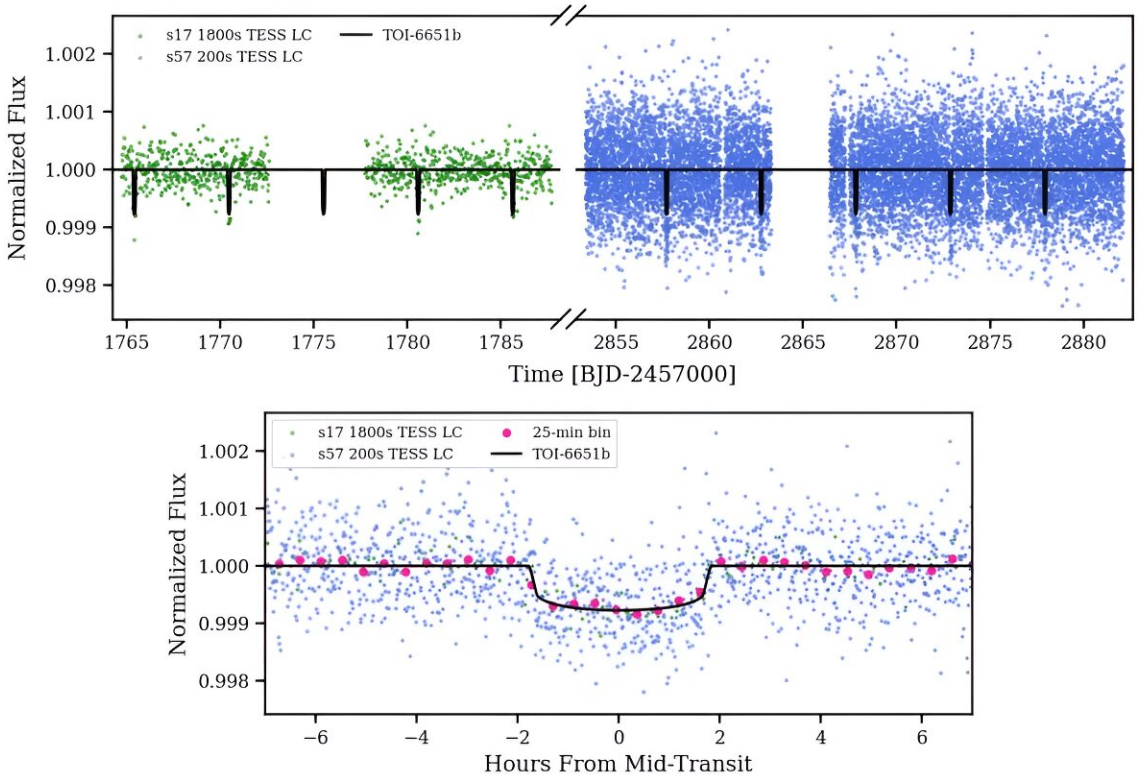
New dense sub-Saturn exoplanet discovered

September 10 2024, by Tomasz Nowakowski



Detrended TESS light curve (LC) of TOI-6651 from sector 17 (1800-second cadence) and 57 (200-second cadence) shown in green and blue points, respectively. The upper panel displays the full TESS LC plotted against time, while the lower panel presents the phase-folded LC with pink dots representing 25-minute binned data points. The black solid line in both panels represents the best-fit transit model for TOI-6651 b from the joint fit analysis. Credit: Baliwal et al., 2024.

Using the Transiting Exoplanet Survey Satellite (TESS), astronomers from the Physical Research Laboratory (PRL) in Ahmedabad, India and elsewhere, have detected a new sub-Saturn exoplanet with a relatively high density. The finding was reported in a research paper published September 2 in the *Astronomy & Astrophysics* journal.

TESS is conducting a survey of about 200,000 of the brightest stars near the sun with the aim of searching for transiting exoplanets. So far, it has identified over 7,200 candidate exoplanets (TESS Objects of Interest, or TOI), of which 545 have been confirmed so far.

Now, a team of astronomers led by PRL's Sanjay Baliwal has confirmed another TOI monitored by TESS. They found a transit signal in the light curve of TOI-6651—a subgiant G-type star located some 690 light years away and estimated to be 3.7 billion years old. The planetary nature of this signal was verified by follow-up observations using ground-based facilities.

"We presented the discovery and characterization of a dense sub-Saturn exoplanet, TOI-6651 b, transiting a metal-rich G-type sub-giant star," the researchers wrote in the paper.

According to the study, TOI-6651 b has a radius of about 5.09 Earth radii, while its mass is 61 times greater than that of our planet. This gives a bulk density at a level of 2.52 g/cm^3, which makes it the densest sub-Saturn so far detected with TESS.

TOI-6651 b orbits its host every 5.05 days on an orbit with an eccentricity of 0.09, at a distance of approximately 0.06 AU from it. The planet's equilibrium temperature is estimated to be 1,493 K.

The authors of the paper estimate that TOI-6651 b has a core mass of about 53 Earth masses. They suppose that the planet is composed

predominantly of dense materials like rock and iron, which make up around 87 percent of its total mass. The remaining mass fraction consists most likely of a low-density hydrogen/helium envelope.

When it comes to the parent star, TOI-6651, it has a radius of about 1.32 solar radii, while its mass is 1.72 solar masses. The star has an effective temperature of 5,940 K and its metallicity was measured to be 0.225 dex.

Summing up the results, the researchers underlined that the unusual properties of TOI-6651 b pose a challenge to the known planet formation theories.

"The existence of TOI-6651b challenges conventional planet formation theories and could be a result of merging events or significant atmospheric mass loss through tidal heating, highlighting the complex interplay of dynamical processes and atmospheric evolution in the formation of massive dense sub-Saturns," the scientists conclude.

More information: Sanjay Baliwal et al., Discovery and characterization of a dense sub-Saturn TOI-6651 b, *Astronomy & Astrophysics (A&A)* (2024). DOI: 10.1051/0004-6361/202450934.

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