Exoplanetary Astrophysics

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Papers
arXiv.org > astro-ph

Five new hot-Jupiter transits investigated with Swift-UVOT

- Submitted on 4 Oct 2021 by Lia Corrales
- Accepted to AAS Journals
- Earth and Planetary Astrophysics
- arXiv:2110.01579v1 **[astro-ph.EP]**

Measuring titanium isotope ratios in exoplanet atmospheres

- Submitted on 5 Oct 2021 by Dilovan Serindag
- Accepted to A&A
- Earth and Planetary Astrophysics
- arXiv:2110.01908v1 **[astro-ph.EP]**

Retrieving Exoplanet Atmospheres using Planetary Infrared Excess: Prospects for the Nightside of WASP-43 b and other Hot Jupiters

- Submitted on 5 Oct 2021 by Jacob Lustig-Yaeger
- Accepted to ApJ Letters
- Earth and Planetary Astrophysics
- arXiv:2110.02247v1 **[astro-ph.EP]**

Retrieving the transmission spectrum of HD 209458b using CHOCOLATE: A new chromatic Doppler tomography technique.

- Submitted on 5 Oct 2021 by Emma Esparza-Borge
- Accepted for publication in Astronomy and Astrophysics
- Earth and Planetary Astrophysics, Instrumentation and Methods for Astrophysics, Solar and Stellar Astrophysics
- arXiv:2110.02028 **[astro-ph.EP]**

Transiting Hot-Jupiters - 1

- More than than 75% of the 4,500 confirmed exoplanets today have been detected via the transit method

- By combining transit measurements from multiple wavelengths, the apparent radius of a planet as a function of wavelength can be measured, for a description of the planetary atmosphere's absorbant properties

- Hot Jupiters are the ideal first targets for transmission spectroscopy because of their deep transits and short orbital periods

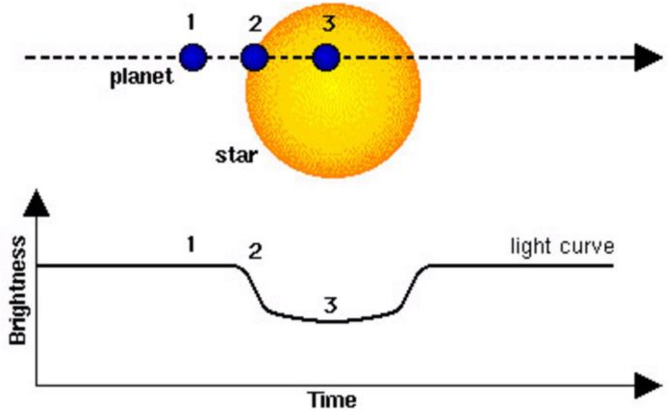
Transiting Hot-Jupiters - 2

- Short wavelength transits are much deeper than observed in the optical and provide evidence that planetary exospheres are extended beyond the Roche lobe

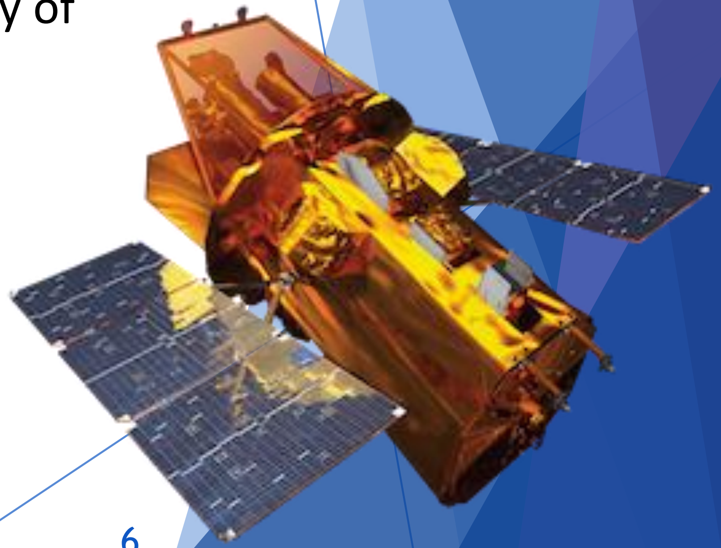
- Swift Observatory UVOT instrument to obtain transit depths with 0.5% precision

- Deep NUV transits might be correlated with mass-loss rates and their measurements may provide some insights into exoplanets atmospheric aerosols, forming hazes and clouds to be investigated by short wavelength spectroscopy.

Fact sheet - 1

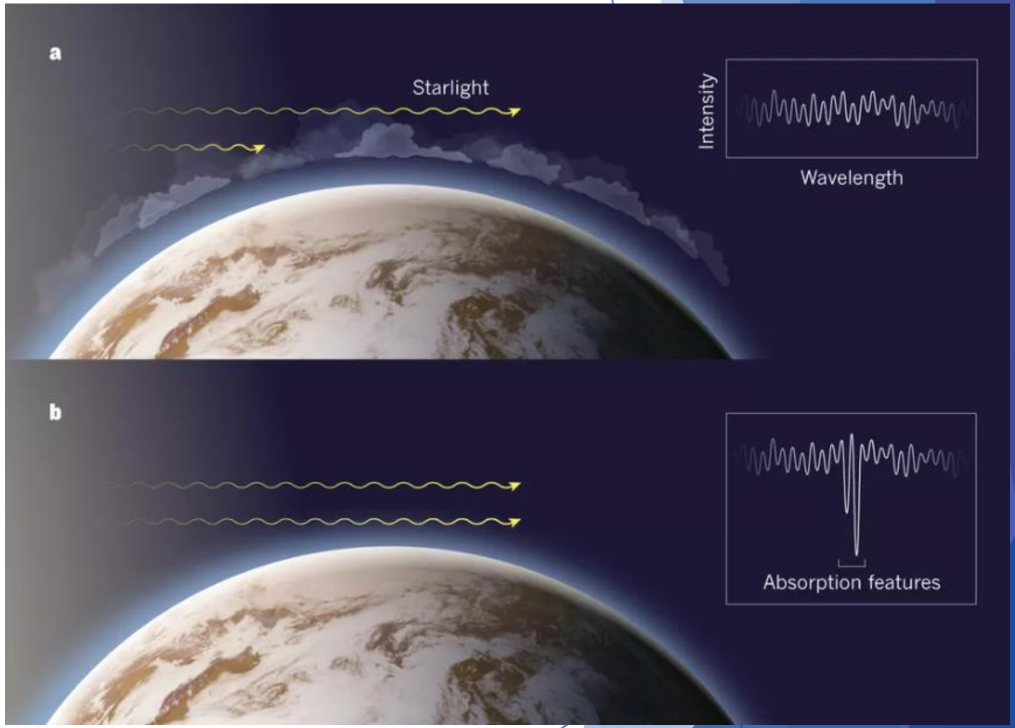


- The transit method is a photometric method that aims to indirectly detect the presence of one or more exoplanets in orbit around a star
- (Neil Gehrels) Swift is a multi-wavelength observatory dedicated to the study of GRBs; UVOT (UltraViolet/Optical Telescope) is one of the three instruments onboard the space observatory and works in photon counting mode
- Hot Jupiters are giant planets with orbital period less than 10 days, usually orbiting less than 0.1 AU from their host stars



Fact sheet - 2

- The transit spectroscopy method is the most successful method for measuring chemical composition of an exoplanetary atmosphere (transmission spectroscopy)
- During their evolution, short-period exoplanets such as Hot Jupiters may lose envelope mass through atmospheric escape owing to intense XUV radiation from their host stars
- Clouds and hazes are commonplace in the atmospheres of solar system planets and are likely ubiquitous in the atmospheres of extrasolar planets as well, affecting every aspect of a planetary atmosphere

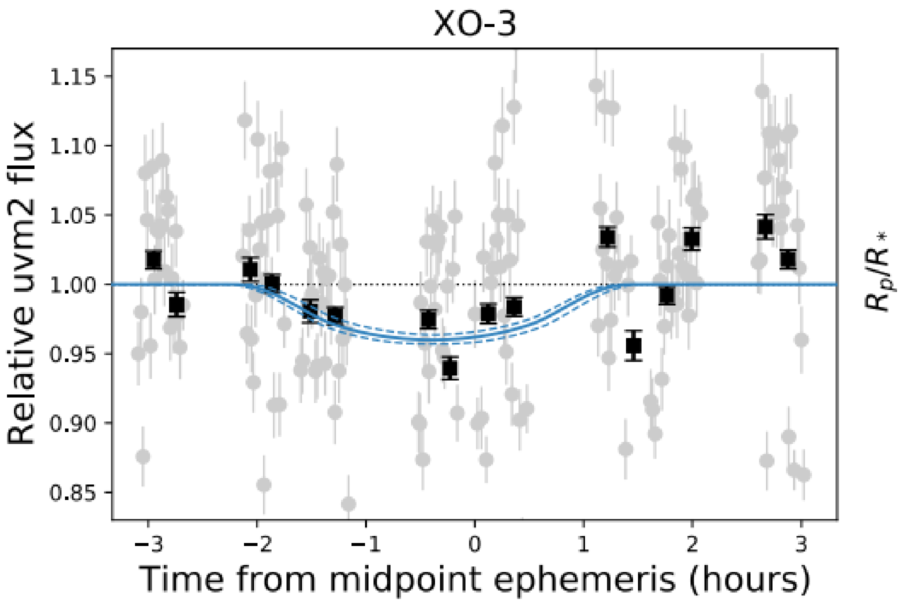


Hot Jupiters orbiting five UV-bright F-type stars: XO-3, KELT-3, WASP-3, WASP-62, and HAT-P-6

Target	Mass loss rate $(\mathrm{g\ s^{-1}})$	$R_*^{\dagger}$ $(R_\odot)$	$R_P(\mathrm{NUV})$ $(R_J)^{\ddagger}$
XO-3 b	$< 2 \times 10^{10}$	1.452 ± 0.098	2.54 ± 0.22
KELT-3 b	$< 1.5 \times 10^{11}$	$1.604^{+0.058}_{-0.136}$	$2.50^{+0.33}_{-0.38}$
WASP-3 b	$< 2 \times 10^{11}$	$1.299^{+0.063}_{-0.075}$	≤ 2.53
HAT-P-6 b	$< 3 \times 10^{11}$	$1.610^{+0.041}_{-0.157}$	≤ 2.51
WASP-62 b	5×10^{11}	$1.299^{+0.064}_{-0.153}$	≤ 1.39

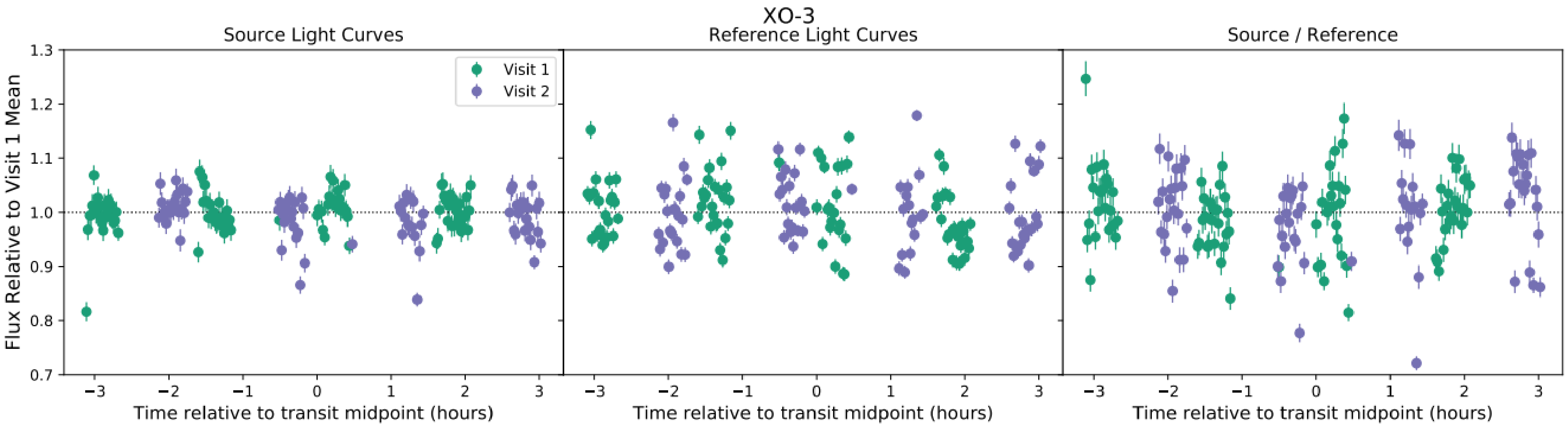
- XO-3b has the largest value for NUV radius relative to the host star in the sample
- The particularly high mass of XO-3b prevents it from experiencing significant mass-loss: lowest mass-loss rate from photoevaporation
- Short wavelength spectroscopy may probe how atmospheric aersols UV absorptivity causes a deeper UV transit

XO-3b



- Transit depth of 3.2 ± 0.4%
- Most likely transit in the sample (3σ transit detection)
- XO-3b is particularly massive (11.7 ± 0.4 M_J), has a large eccentricity (e = 0.28), and its orbital plane is highly inclined (λ = 37.3°) relative to the equatorial plane of its host star
- Optical radius of 1.280 ± 0.087 R_J
- Its peculiar orbital parameters probably arise from planet-planet interactions early in the system's history, hence making XO-3b an important subject for understanding the role of tidal forces in planetary evolution
- The atmospheric heating due to tidal forces on XO-3b is roughly equal to the heating from stellar irradiation.

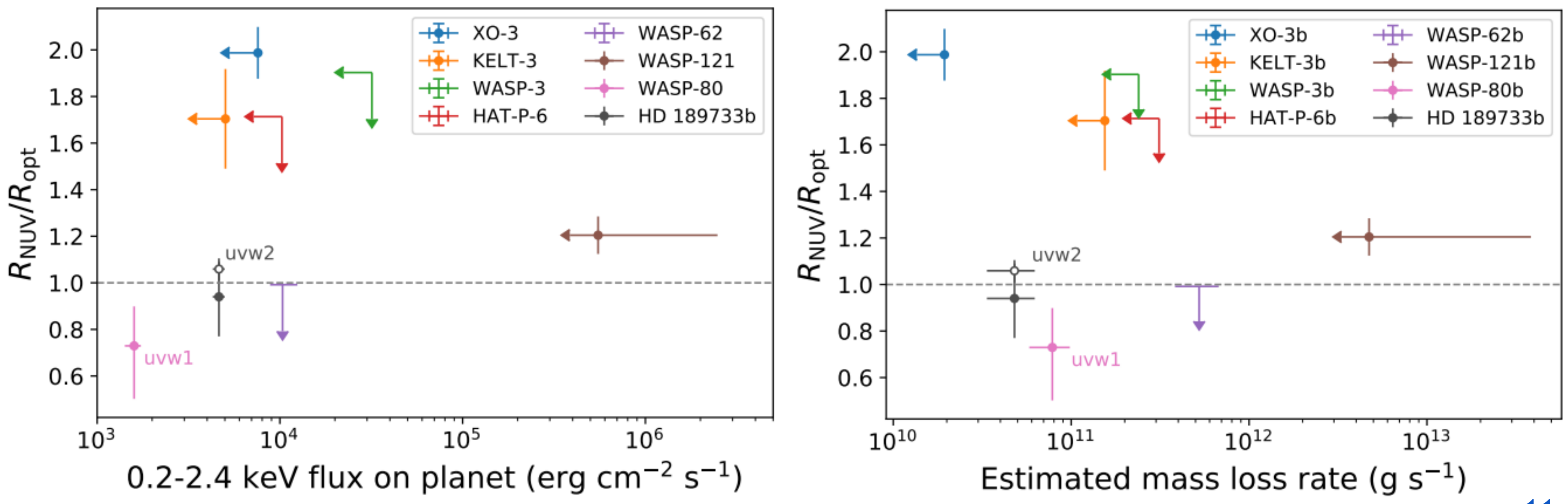
Lightcurves



- *Swift*-UVOT NUV transit lightcurves to investigate hot Jupiters global properties such as insolation, mass-loss, and equilibrium temperature
- One positive 3σ transit detection for XO-3b
- Each target star light curve has been normalized by a reference light curve from field stars
- Up to three visits from the target sources

NUV transits as a probe of atmospheric mass-loss

- The ratio of the NUV and optical planet radius (R_{NUV}/R_{opt}) is obtained by dividing the square-root of the transit depth (R_p/R_*) observed in the NUV versus that in the optical
- Rayleigh scattering, which leads to an increase in the apparent radius of the planet at shorter wavelengths, is not enough to explain the observed NUV transit depths
- NUV transit depth provides a probe of atmospheric escape and is negatively correlated with photoevaporative mass loss



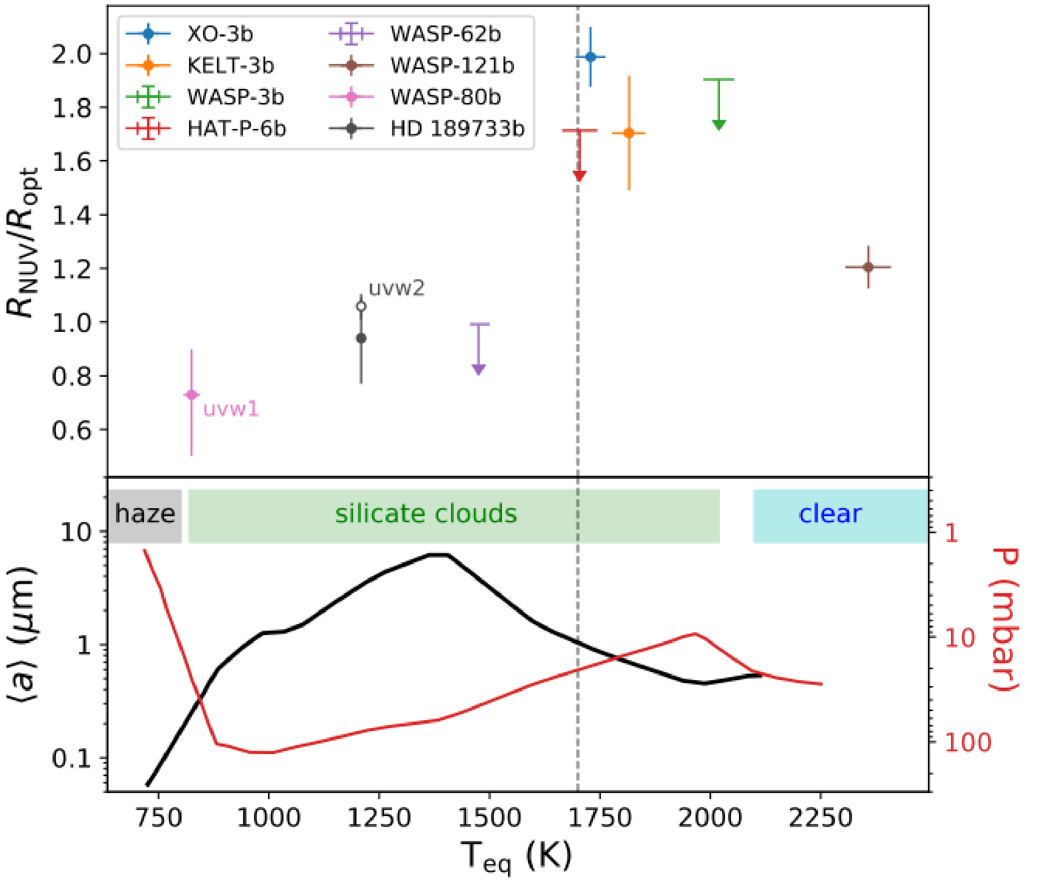
NUV transits as a probe of atmospheric aerosols

- The presence of aerosols with particle sizes < 1 μm, which are highly efficient at attenuating NUV light, may explain the observed larger NUV radius relative to the optical

- Onset of clouds formation: clouds are expected to form more easily in environments with T < 2000 K

- Highest temperature at which water obscuring cloud particles > 1 μm can form is 1700 K and coincides with the peak R_{NUV}/R_{opt} value

- Exoplanets with Teq ≈ 1700−2100 K have high altitude cloud decks dominated by ≤ 1 µm sized silicate particles, efficient at attenuating NUV light. Below 1700 K, the cloud particles grow so large that they obscure both NUV and optical light equally and sink lower in the atmosphere



Summary

- Five NUV exoplanets transit signals detected by Swift-UVOT
- Short wavelengths observations of planetary radii crucial to investigate processes of atmospheric evolution such as photoevaporative mass-loss and cloud formation.
- NUV transit depth is not positively correlated with photoevaporative mass loss as previously thought
- $R_{\mathrm{NUV}}/R_{\mathrm{opt}}$ as a function of exoplanet equilibrium temperature shows a peak around T = 1700 K
- For $T_{eq} > 1700$ K high altitude clouds and aerosols particles $\leq 1\ \mu$m in size in exoplanets atmosphere contribute to obscure NUV light

References

- https://arxiv.org/list/astro-ph/
- https://www.esa.int/
- https://swift.gsfc.nasa.gov/