Characterizing exoplanetary atmospheres in the TESS era

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+ KESPRINT + others from HST program #15434

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Introduction

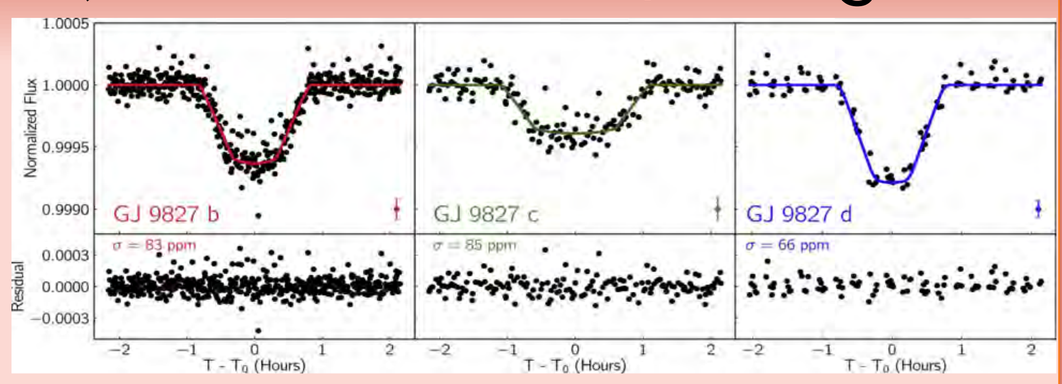
The characterization of exoplanet atmospheres will be a major scientific endeavor in the coming decades, in particular the search for biosignatures in the atmospheres of temperate, rocky exoplanets. It is a primary science driver for upcoming space-based (e.g., JWST) and ground-based (e.g., GMT) facilities. Observations of exoplanetary atmospheres provide an opportunity to not only measure the current conditions in the planetary atmosphere, but also put constraints on formation history and interior structure (Owen et al. 1999), interactions with host star (Cauley et al. 2017), and atmospheric and planetary evolution (Öberg et al. 2011). One such research direction is the characterization of extended exoplanetary atmospheres with different spectral absorption lines, namely Lyman-α, Hα, or HeI at different wavelengths. Since its launch in April 2018, TESS has already identified hundreds of planetary candidates. A natural path will be to confirm these candidates through a RV follow-up and characterize their atmospheres.

GJ9827

The system

Three super-Earths (Niraula et. al 2017, Rodriguez et al. 2018)

Vmag = 10.39
D ~ 30 pc
SpT = K6V



Nearest star hosting planets in the Kepler/K2 sample.

near a 1:3:5 mean motion resonance

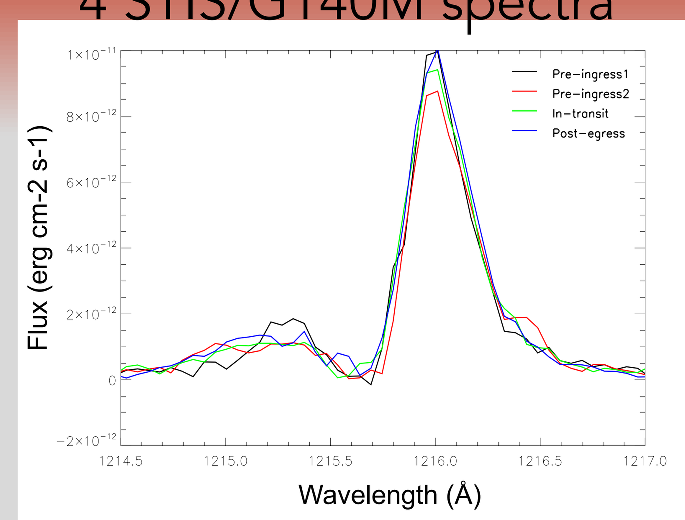
Planet	Radius (R_E)	P_{orb} (days)	T_{eq} (K)
b	1.75	1.21	1075
c	1.36	3.65	744
d	2.11	6.20	623

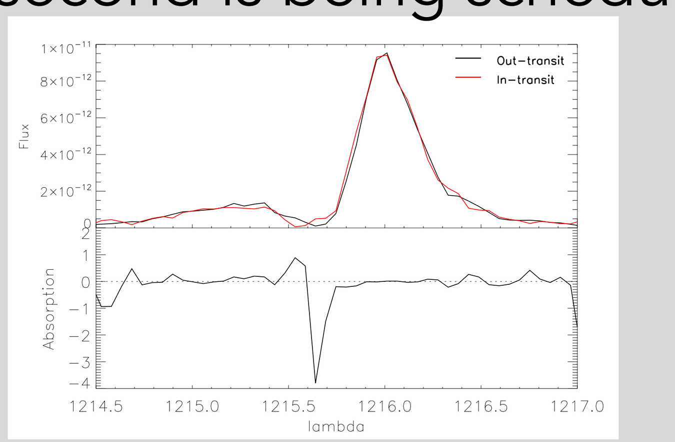
GJ9827b has a relatively hot atmosphere, which makes it an ideal target for measuring atmospheric escape, particularly given the high activity of its host star.

Ly-α HST data

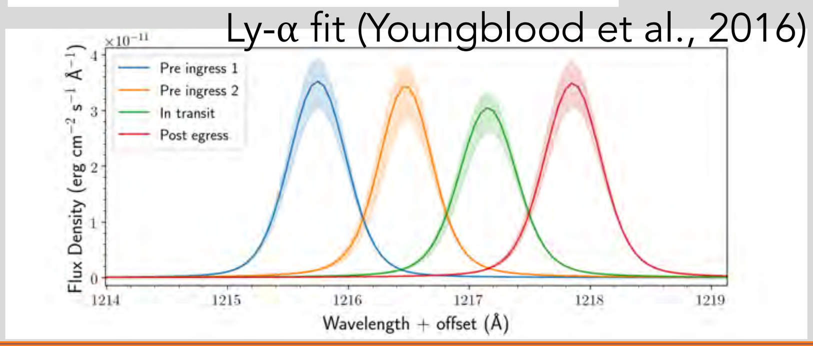
We were approved for two transits to search for an extended hydrogen atmosphere using Ly-α. One transit has been obtained and the second is being scheduled.

4 STIS/G140M spectra





Ly-α fit (Youngblood et al., 2016)

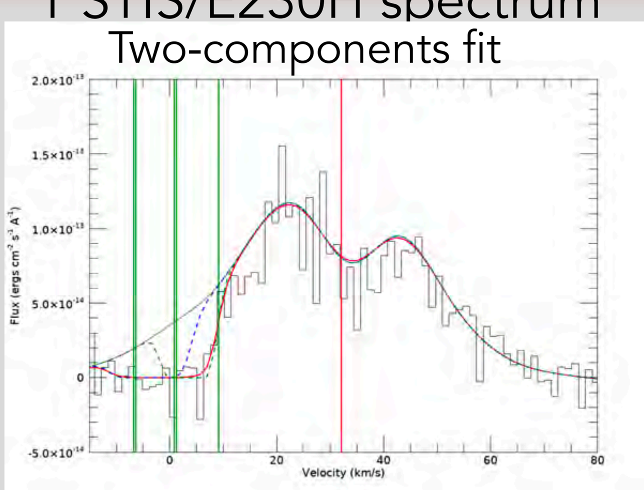


We do not see a strong Ly-α absorption associated with the planet, although we continue to refine our data reduction procedure.

We are able to make an initial estimate of the intrinsic Ly-α flux of the host star assuming a simple Gaussian profile.

MgII HST data

1 STIS/E230H spectrum
Two-components fit

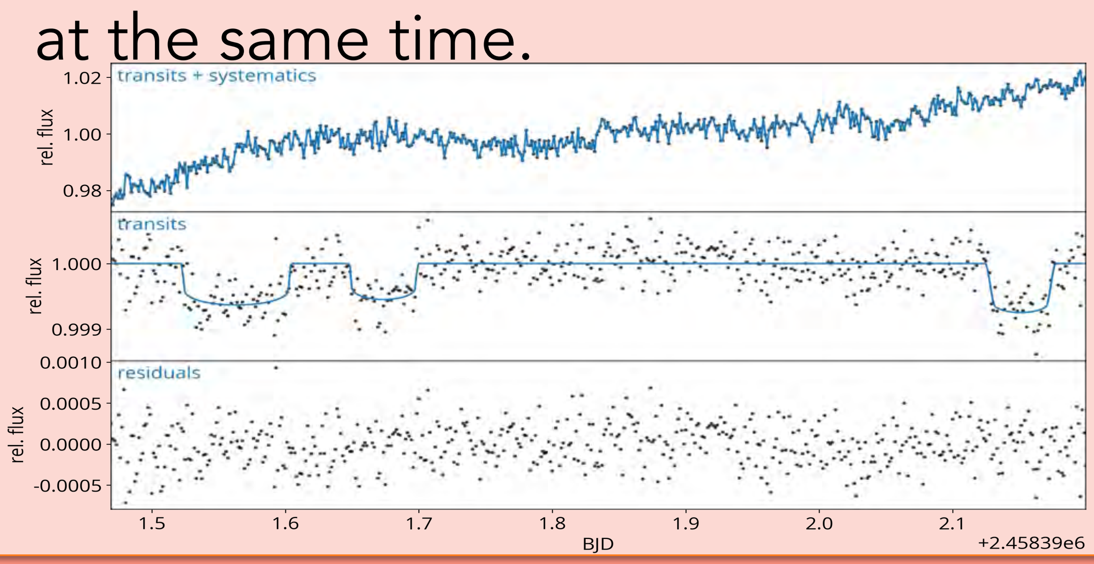


LISM Kinematic Calculator (Redfield & Linsky 2008)

We obtained high resolution spectra of the MgII chromospheric emission line in order to measure the absorption from the local ISM and to get an initial estimate for the Ly-α profile. Evidence of ISM absorption on the far blue side.

Spitzer data

We obtained a long Spitzer exposure in order to measure all three transits at the same time.



Fit (Livingston et al. 2019)

- Free transit parameters
- Circular orbit assumption

We see clear evidence of TTVs for planet d

Upcoming CHEOPS observations

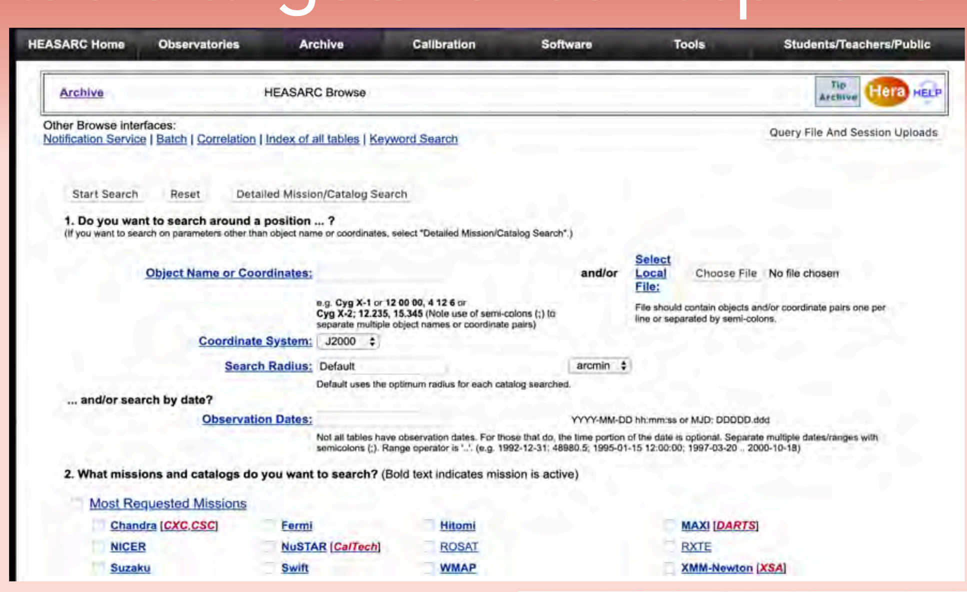
Selection from TESS candidates list

Identify most suitable targets for atmospheric characterization

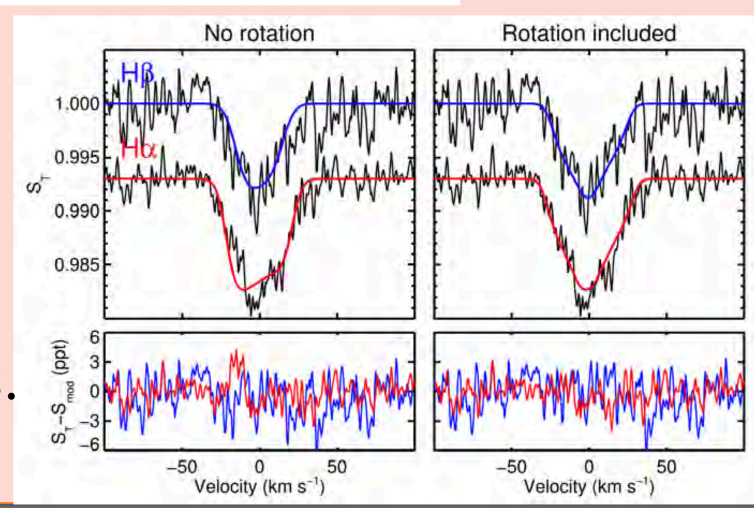
Method

Our algorithm is written in Python and, using `astroquery`, inserts the TESS list candidates in the NASA database.

- XUV flux information (Approach by González-Álvarez et al 2019)
  - XMM-Newton, Chandra, ROSAT
  - Filtering process:
    - Multiples in different databases
    - Multiples in the same catalogue
    - <0.5′ radius
- From XUV flux to Mass loss rate (Kubyshkina et al 2018)



Hα detection in Kelt-9 b:
KELT is finding TESS-like systems.



Cauley et al, 2019

- Planetary and stellar radius, orbital period, effective and equilibrium temperatures are necessary for the mass loss rate calculation
- Calculation of Mass loss rate for targets without the XUV flux information

Future work

- From Mass loss rate to spectral line estimation (Ly-α, Hα, HeI)

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