L 98-59: A Benchmark System of Terrestrial Planets for Future Atmospheric Characterization. **Daria Pidhorodetska[1,2]**, Sarah Moran[3], Thomas Fauchez[1,4], Ravi Kopparapu[1], Knicole Colon[1], Elisa Quintana[1], Geronimo Villanueva[1], and Shawn Domagal-Goldman[1]
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1. Introduction

L 98-59 is an M3 dwarf ($M_* = 0.3M$) that hosts three terrestrial-sized planets recently discovered by TESS. The host star is bright (K = 7.1) and nearby (10.6 pc), making the system a prime target for follow-up characterization with Hubble and the upcoming James Webb Space Telescope. Herein, we present the plausibility of these planets having atmospheres that are dominated by either H_2, H_2O, CO_2, or O_2, while exploring the possibilities of the presence of clouds and hazes. The L 98-59 planets orbit close to their star with insolations ranging from 4 to 21 X that of Earth, placing the planets in the Venus-zone (Kane et al. 2014). These planets might therefore be Venus-analogs. L 98-59 is near the TESS continuous viewing zone and will be observed for an additional 3 months (~160 days total), providing a wealth of information on the three currently known planets as well as the potential to reveal additional longer-period planets. In contrast to the highly active M-dwarf TRAPPIST-1 ($M_* = 0.08M$), the host star in the L 98-59 system shows no evidence for stellar activity in the TESS data (Kostov et al. 2019a) and is likely a relatively quiet M-dwarf with a low level of XUV activity. The XUV fluxes impingent upon these planets is sufficiently

low to allow for a sustainable atmosphere around each of these worlds, given their masses. With upcoming HST observations occurring in the near-term, modeling efforts show what we can expect to measure, while exploring the additional information that can be uncovered with observations using JWST. Transiting multi-planet systems provide ideal laboratories for comparative planetary studies, and the L 98-59 system offers a unique opportunity to study an exciting system of terrestrial planets that may exhibit features similar to the planets in our Solar System.

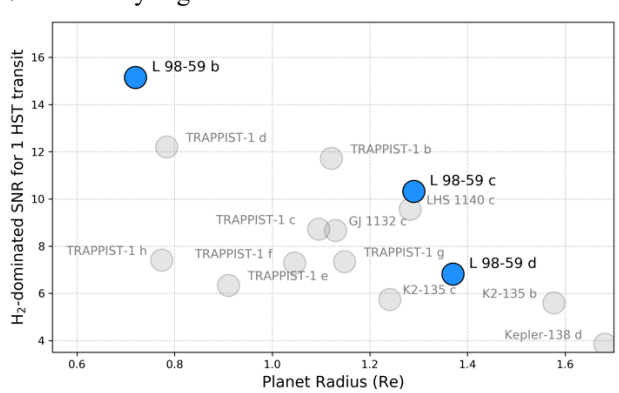
2. Methods

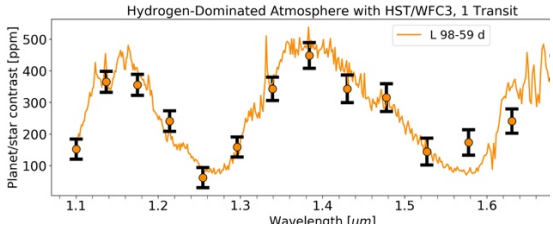
Although there is a significant parameter space to be explored regarding the potential atmospheric scenarios for this planetary system, this work considers just a few of those possibilities. These include the modeling of atmospheres that are dominated by H_2, H_2O, CO_2, or O_2, along with considering the presence of clouds and hazes. Each atmospheric configuration is created within the Planetary Spectrum Generator (PSG), an online radiative-transfer suite that computes synthetic transit spectra for a wide range of objects such as planets, moons, comets, and asteroids (Villanueva et al. 2018). In addition, PSG allows the user to explore many different instrument modes across a multitude of observatories. The atmospheres considered here do not represent the full spectrum of potential outcomes, but are merely a representation of atmospheres which have been motivated by their ability to produce measurable spectra, given the known planetary parameters.

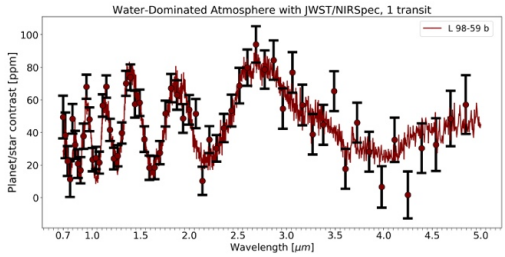
3. Results

Preliminary results highlight the strength of the SNR of the system compared to other nearby terrestrial exoplanets. In addition, initial highlights focus on the feasibility to detect the presence of an atmosphere with HST/WFC3 in merely one transit, while follow-up observations to detect additional features that may be present in a water-dominated atmosphere are noted as feasible with one transit using JWST/NIRSpec.

4. Preliminary Figures




Hydrogen-Dominated Atmosphere with HST/WFC3, 1 Transit
L 98-59 d
Planet/star contrast [ppm]
500
400
300
200
100
1.1
1.2
1.3
1.4
1.5
1.6
Wavelength [μm]


Water-Dominated Atmosphere with JWST/NIRSpec, 1 transit
L 98-59 b
Planet/star contrast [ppm]
100
80
60
40
20
0
0.7
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Wavelength [μm]