Ground-Based Light Curve Follow-Up Validation Observations of TESS Object of Interest TOI 5612.01

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Abstract

The primary objective of this paper was to provide one of the first confirmations and validations regarding the candidate exoplanet TOI 5612.01 discovered in 2022 by the transit method. All observations used in this study were from ground-based telescope observations at the George Mason University Observatory. Utilizing AstroImageJ to complete the necessary data processing steps, we plotted a light curve based on over a hundred sets of viable data. However, after analyzing the given processed and graphed data, we were unable to reach any conclusive decision regarding whether there was truly a transit for our data at our specific observation period. This paper aims to outline our methodology and analysis in reaching such a conclusion; we also provide suggestions for future research.

1. Introduction

Ever since the dawn of humankind, humans have been fascinated by the potential for extraterrestrial life and the unknowns of our enormous universe. The reality is that the Earth is only a small fraction of our universe, and much of the universe requires further study. The rapid growth in our world's population directly challenges the limited supply of materials on Earth. Thus, scientists aim to explore exoplanets, planets that orbit other stars outside of our universe, to see whether such planets are habitable, or if they can provide any context for habitable regions other than Earth.

The NASA TESS (Transiting Exoplanet Survey Satellite) mission launched on April 18 2018 to explore the unknown planets outside of our solar system, exoplanets. This mission is a continuation of the Kepler mission. The TESS and Kepler missions use the transit method to identify, confirm, or verify exoplanets. The transit methodology works when the exoplanet's host star's light is slightly obscured due to the exoplanet itself orbiting the star, leading to a dip in light flux. This dip in light can often mean the identification of a transit.

Being only about three decades since the original discoveries of exoplanets in our universe, humankind has uncovered more than five thousand exoplanets ever since (*How Many Exoplanets Are There?*, n.d.). In addition, there are several more thousands of planets classified as exoplanet candidates. The TESS Object of Interest 5612.01, or TOI 5612.01, is the candidate exoplanet determined by TESS that we are investigating. Since the discovery of TOI 5612.01 in 2022, there has been very limited literature published in terms of truly verifying if TOI 5612.01 is an exoplanet. This, in turn, will be one of the first ground-based light curve follow-ups on TOI 5612.01. Thus, this paper aims to provide deeper context into TOI 5612.01 and to potentially offer a conclusion based on our observations and analysis.

To provide the necessary follow-ups on TOI 5612.01, we analyzed the observations made by George Mason University Observatory on February 20, 2022. The radius of this planet relative to the Earth is 8.0. The orbital period of this planet is 7.13 days. Our ultimate goal is to investigate whether a transit truly occurs on the expected star at the expected time, with the expected duration and depth.

2. Observations

We referenced all our collected data on TOI 5612.01 from the George Mason University Observatory on February 20, 2024. Section 2.1 will go in-depth about the specific exoplanet candidate properties and its host star. Section 2.2 will go in-depth about the specific observations we made.

2.1 Properties of TOI 5612 01 and TOI 5612

TOI 5612.01 has an equilibrium temperature of 759 kelvins. The host star's stellar effective temperature is 4701.56 kelvins. The period of TOI 5612.01 is 7.13 days. The transit depth is 7.5 ppt. The predicated ingress and egress times of TOI 5612.01 are 10361.6274 and 10361.7445, respectively. The RA and DEC of our target star are 11:29:38.655 and +38:56:11.4, respectively

2.2 Our Observations

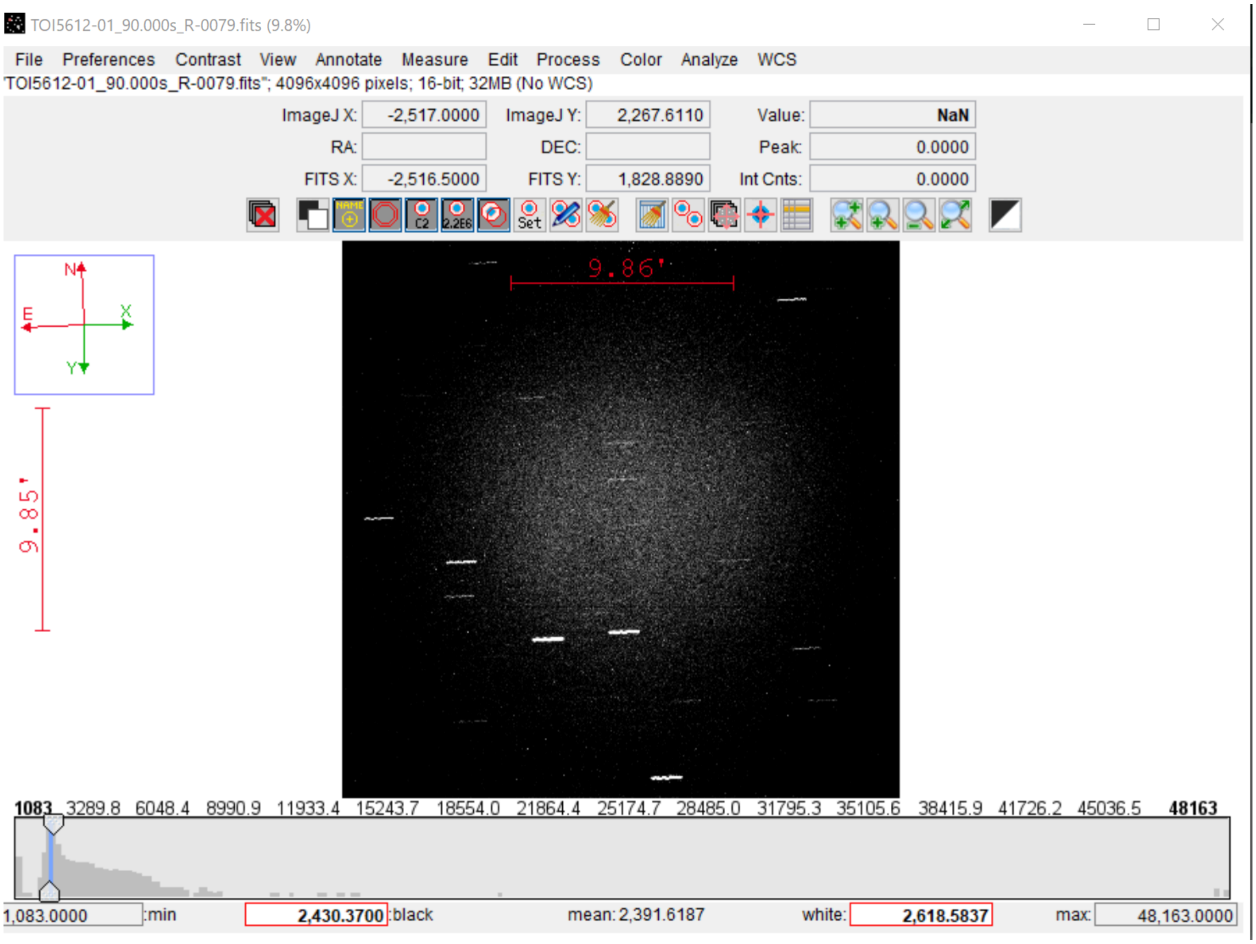
We collected a total of 264 science images with an exposure of 90 seconds. We also had a folder of ten flat images, with exposures of 3.5 seconds. Additionally, there were two sets of ten dark images. One set was 90 seconds exposure, and one set was 3.5 seconds exposure. We used the R (red) filter for our telescope observations.

3. Analysis

This section presents several figures we encountered throughout our analysis, providing our commentary and displaying our methods in data processing and reduction. We used AstroImageJ throughout this process, from the initial data reduction and plate solving to the multiple aperture photometry and light curve analysis.

3.1 Initial Data Reduction and Platesolving

To officially begin the analysis, we analyzed every one of our 264 science images, checking for bad quality such as excessive smearing or no stars. Figure 1 is a great example of a bad science image, with barely any visible stars and excessive smearing. There were 108 viable images to reduce and platesolve towards the end, meaning 156 bad images were removed.



'TOI5612-01_90.000s_R-0079.fits"; 4096x4096 pixels; 16-bit; 32MB (No WCS)

ImageJ X: -2,517.0000
ImageJ Y: 2,267.6110
Value: NaN
RA:
DEC:
Peak: 0.0000
FITS X: -2,516.5000
FITS Y: 1,828.8890
Int Cnts: 0.0000

1,083.0000 :min
2,430.3700 :black
mean: 2,391.6187
white: 2,618.5837
max: 48,163.0000

Figure 1: Example of a Bad Science Image (Generated from AstroImageJ)

Using AstroImageJ (CCD Data Processor Tool), we created a master dark file and a master flat file in our dark and flat folders. This master file will be used when we reduce our science images. After this step, we could start the reduction and plate solving by importing our images into AstroImageJ.

We used the master dark and flat files with similar exposure times when creating our reduced and plate-solved science images. After inputting RA and DEC coordinates of my target star and completing all the necessary modifications in AstroImageJ, we were ready to start the plate-solving process. The plate-solving process ultimately creates an image with the coordinates of the target star–this will be useful for aperture photometry later on.

3.2 Aperture Photometry

Using our RA and DEC coordinates, 11:29:38.655 and +38:56:11.4, respectively, we located our target star. We first opened up a seeing profile on our target star to check on some measurements such as radius (Figure 2). We adjusted our aperture settings according to the values shown in the seeing profile. We created a radius of 2.5 around our target star and imported a Gaia star file onto the target star (Figure 3). The purpose of the green stars is to assess the possibility of a near eclipsing binary near the target star. This will later be used for false-positive analysis.

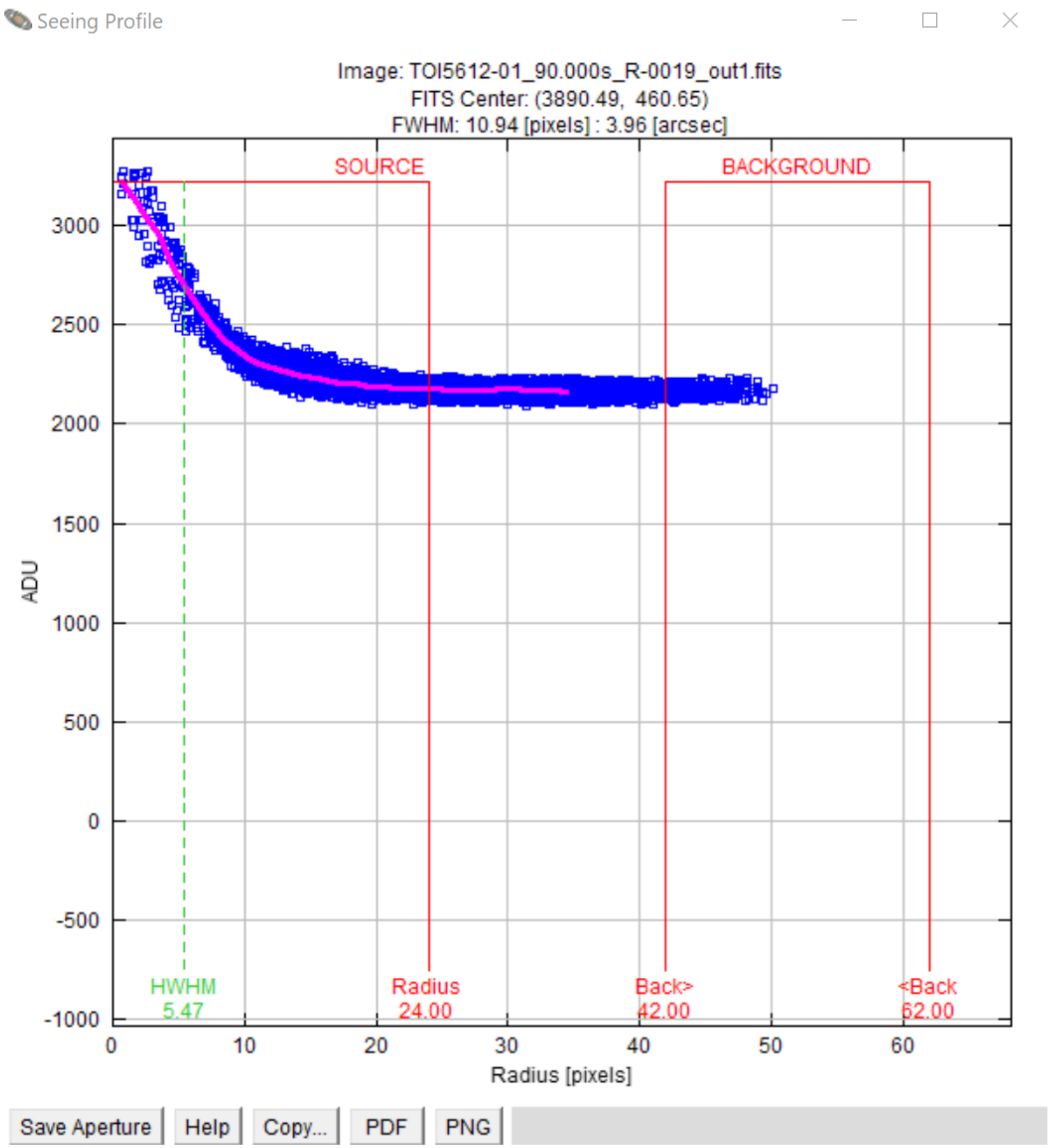


Figure 2: Seeing Profile of Target Star (Generated from AstroImageJ)

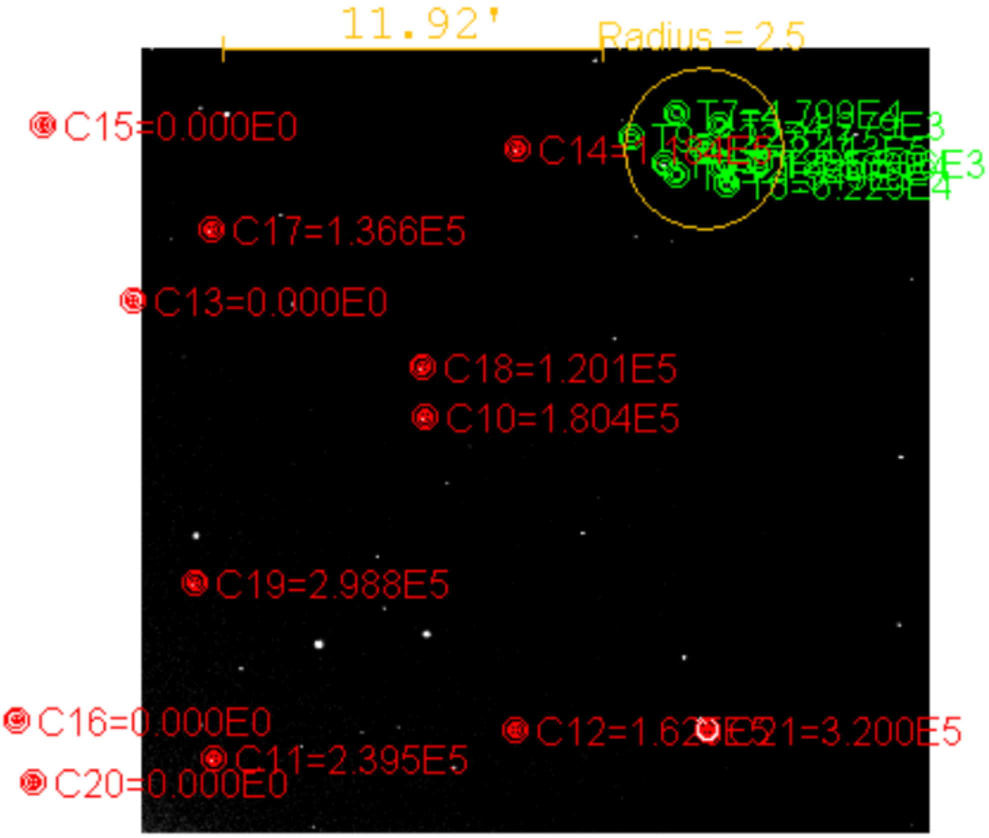
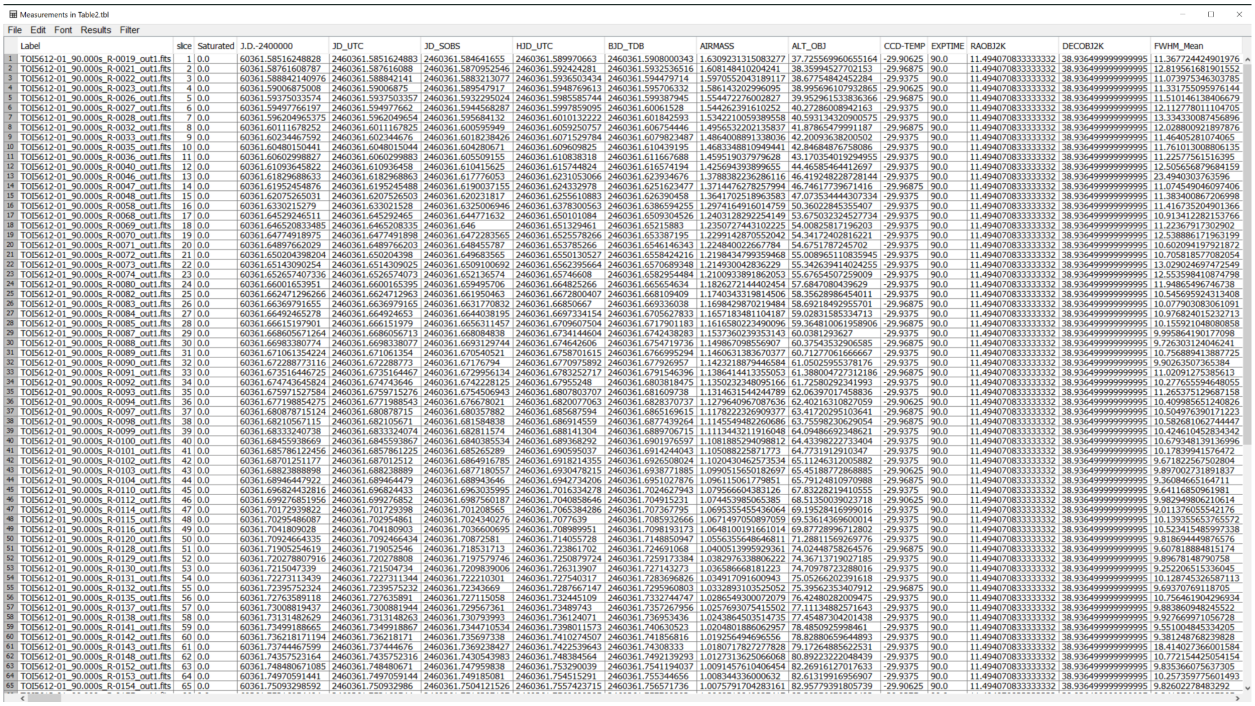


Figure 3: Aperture Locations (Generated from AstroImageJ)

We began multiple aperture photometry using the tool from AstroImageJ. A measurement table was generated shortly after we began multiple aperture photometry (Figure 4). The data in this table ultimately generates our light curve plot later on which will give us important information on transits.



	Label	slice	Saturated	J.D.-2400000	JD_UTC	JD_SOBS	HJD_UTC	BJD_TDB	AIRMASS	ALT_OBJ	CCD-TEMP	EXPTIME	RAOBJ2K	DECOBJ2K	FWHM_Mean
1	TOI5612-01_90.000s_R-0019_out1.fits	1	0.0	60361.58516248828	2460361.5851624883	2460361.584641655	2460361.589970663	2460361.5908000343	1.6309231315083277	37.725569960655164	-29.90625	90.0	11.494070833333332	38.936499999999995	11.367724424901976
2	TOI5612-01_90.000s_R-0021_out1.fits	2	0.0	60361.58761608787	2460361.587616088	2460361.5870952546	2460361.592424281	2460361.5932536516	1.608148410204241	38.35994527702153	-29.96875	90.0	11.494070833333332	38.936499999999995	12.819561681901552
3	TOI5612-01_90.000s_R-0022_out1.fits	3	0.0	60361.588842140976	2460361.588842141	2460361.5883213077	2460361.5936503434	2460361.594479714	1.5970552043189117	38.67754842452284	-29.9375	90.0	11.494070833333332	38.936499999999995	11.073975346303785
4	TOI5612-01_90.000s_R-0023_out1.fits	4	0.0	60361.59006875008	2460361.59006875	2460361.589547917	2460361.5948769613	2460361.595706332	1.586143202996095	38.995696107932865	-29.90625	90.0	11.494070833333332	38.936499999999995	11.331755095976144
5	TOI5612-01_90.000s_R-0026_out1.fits	5	0.0	60361.59375033574	2460361.5937503357	2460361.5932295024	2460361.5985585744	2460361.599387945	1.554472276002827	39.952961533836366	-29.96875	90.0	11.494070833333332	38.936499999999995	11.510146138406679
6	TOI5612-01_90.000s_R-0027_out1.fits	6	0.0	60361.59497766197	2460361.594977662	2460361.5944568287	2460361.5997859095	2460361.60061528	1.544262391610252	40.27286008942163	-29.9375	90.0	11.494070833333332	38.936499999999995	12.112778011104705
7	TOI5612-01_90.000s_R-0028_out1.fits	7	0.0	60361.596204965375	2460361.5962049654	2460361.595684132	2460361.6010132222	2460361.601842593	1.5342210059389558	40.593134320900575	-29.9375	90.0	11.494070833333332	38.936499999999995	13.334330087456896
8	TOI5612-01_90.000s_R-0032_out1.fits	8	0.0	60361.60111678252	2460361.6011167825	2460361.600595949	2460361.6059250757	2460361.606754446	1.4956532202135837	41.87865479991187	-29.96875	90.0	11.494070833333332	38.936499999999995	12.028800921897876
9	TOI5612-01_90.000s_R-0033_out1.fits	9	0.0	60361.60234467592	2460361.602344676	2460361.6018238426	2460361.6071529784	2460361.6079823487	1.4864008891338036	42.20093638200502	-29.9375	90.0	11.494070833333332	38.936499999999995	11.46405281074065
10	TOI5612-01_90.000s_R-0035_out1.fits	10	0.0	60361.60480150441	2460361.6048015044	2460361.604280671	2460361.609609825	2460361.610439195	1.4683348810949441	42.84684876758086	-29.9375	90.0	11.494070833333332	38.936499999999995	11.761013008806135
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12	TOI5612-01_90.000s_R-0040_out1.fits	12	0.0	60361.61093645822	2460361.610936458	2460361.610415625	2460361.615744824	2460361.616574194	1.425694393899655	44.46585464412697	-29.9375	90.0	11.494070833333332	38.936499999999995	12.505656879684159
13	TOI5612-01_90.000s_R-0046_out1.fits	13	0.0	60361.61829688633	2460361.6182968863	2460361.617776053	2460361.6231053066	2460361.623934676	1.3788382236286116	46.419248228728144	-29.9375	90.0	11.494070833333332	38.936499999999995	23.4940303763596
14	TOI5612-01_90.000s_R-0047_out1.fits	14	0.0	60361.61952454876	2460361.6195245488	2460361.6190037155	2460361.624332978	2460361.6251623477	1.3714476278257994	46.74617739671416	-29.96875	90.0	11.494070833333332	38.936499999999995	11.074549046097406
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16	TOI5612-01_90.000s_R-0058_out1.fits	16	0.0	60361.6330215279	2460361.633021528	2460361.6325006946	2460361.6378300563	2460361.6386594255	1.2974164916014759	50.36022845355407	-29.9375	90.0	11.494070833333332	38.936499999999995	11.416735204901366
17	TOI5612-01_90.000s_R-0068_out1.fits	17	0.0	60361.64529246511	2460361.645292465	2460361.644771632	2460361.650101084	2460361.6509304526	1.2403128292254149	53.675032324527734	-29.9375	90.0	11.494070833333332	38.936499999999995	10.913412282153766
18	TOI5612-01_90.000s_R-0069_out1.fits	18	0.0	60361.646520833485	2460361.6465208335	2460361.646	2460361.651329461	2460361.65215883	1.2350727443102225	54.00825817196203	-29.9375	90.0	11.494070833333332	38.936499999999995	11.22367917302902
19	TOI5612-01_90.000s_R-0070_out1.fits	19	0.0	60361.64774918975	2460361.6477491898	2460361.6472283565	2460361.6525578266	2460361.653387195	1.2299142870552042	54.34172402816221	-29.9375	90.0	11.494070833333332	38.936499999999995	12.538886171963199
20	TOI5612-01_90.000s_R-0071_out1.fits	20	0.0	60361.64897662029	2460361.6489766203	2460361.648455787	2460361.653785266	2460361.6546146343	1.224840022667784	54.6751787245702	-29.9375	90.0	11.494070833333332	38.936499999999995	10.602094197921872
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26	TOI5612-01_90.000s_R-0083_out1.fits	26	0.0	60361.66369791655	2460361.6636979165	2460361.6631770832	2460361.66850667	2460361.669336038	1.1698429870219484	58.69218492955701	-29.96875	90.0	11.494070833333332	38.936499999999995	10.077903083061091
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37	TOI5612-01_90.000s_R-0097_out1.fits	37	0.0	60361.680878715124	2460361.680878715	2460361.680357882	2460361.685687594	2460361.6865169615	1.1178222326909377	63.41720295103641	-29.96875	90.0	11.494070833333332	38.936499999999995	10.504976390171223
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41	TOI5612-01_90.000s_R-0101_out1.fits	41	0.0	60361.685786122456	2460361.6857861225	2460361.685265289	2460361.690595037	2460361.6914244043	1.105088225871773	64.7731912910347	-29.9375	90.0	11.494070833333332	38.936499999999995	10.17839941576472
42	TOI5612-01_90.000s_R-0102_out1.fits	42	0.0	60361.68701251177	2460361.687012512	2460361.6864916785	2460361.6918214355	2460361.6926508024	1.1020430462573534	65.11246312005882	-29.9375	90.0	11.494070833333332	38.936499999999995	9.671822567502804
43	TOI5612-01_90.000s_R-0103_out1.fits	43	0.0	60361.68823888898	2460361.688238889	2460361.6877180557	2460361.6930478215	2460361.6938771885	1.0990515650182697	65.45188772868885	-29.90625	90.0	11.494070833333332	38.936499999999995	9.897002731891837
44	TOI5612-01_90.000s_R-0104_out1.fits	44	0.0	60361.68946447922	2460361.689464479	2460361.688943646	2460361.6942734206	2460361.6951027876	1.096115061779851	65.79124810970988	-29.96875	90.0	11.494070833333332	38.936499999999995	9.36084665164711
45	TOI5612-01_90.000s_R-0110_out1.fits	45	0.0	60361.696824432816	2460361.696824433	2460361.6963035995	2460361.7016334278	2460361.7024627943	1.079566604383126	67.83228219410555	-29.9375	90.0	11.494070833333332	38.936499999999995	9.64116850961981
46	TOI5612-01_90.000s_R-0112_out1.fits	46	0.0	60361.699276851956	2460361.699276852	2460361.6987560187	2460361.7040858646	2460361.704915231	1.074453985065385	68.51350039023718	-29.90625	90.0	11.494070833333332	38.936499999999995	9.982949806210614
47	TOI5612-01_90.000s_R-0114_out1.fits	47	0.0	60361.70172939822	2460361.701729398	2460361.701208565	2460361.7065384286	2460361.707367795	1.0695355455436064	69.19528416999016	-29.9375	90.0	11.494070833333332	38.936499999999995	9.011376055542176
48	TOI5612-01_90.000s_R-0115_out1.fits	48	0.0	60361.70295486087	2460361.702954861	2460361.7024340276	2460361.7077639	2460361.7085932666	1.0671497050897059	69.53614369600014	-29.9375	90.0	11.494070833333332	38.936499999999995	10.139355653765572
49	TOI5612-01_90.000s_R-0116_out1.fits	49	0.0	60361.7041809028	2460361.704180903	2460361.7036600695	2460361.708989951	2460361.7098193173	1.0648100191661014	69.87728996712802	-29.9375	90.0	11.494070833333332	38.936499999999995	10.523415485997338
50	TOI5612-01_90.000s_R-0120_out1.fits	50	0.0	60361.70924664335	2460361.7092466434	2460361.70872581	2460361.714055728	2460361.7148850947	1.0556355648646811	71.28811569269776	-29.9375	90.0	11.494070833333332	38.936499999999995	9.818694449876576
51	TOI5612-01_90.000s_R-0128_out1.fits	51	0.0	60361.71905254619	2460361.719052546	2460361.718531713	2460361.723861702	2460361.724691068	1.0400513995929361	74.02448758264576	-29.96875	90.0	11.494070833333332	38.936499999999995	9.607818884815174
52	TOI5612-01_90.000s_R-0129_out1.fits	52	0.0	60361.720278807916	2460361.720278808	2460361.7197579746	2460361.7250879724	2460361.7259173384	1.0382976338806222	74.36713719027185	-29.9375	90.0	11.494070833333332	38.936499999999995	9.89678148790758
53	TOI5612-01_90.000s_R-0130_out1.fits	53	0.0	60361.7215047339	2460361.721504734	2460361.7209839006	2460361.726313907	2460361.727143273	1.036586668181223	74.70978723288016	-29.9375	90.0	11.494070833333332	38.936499999999995	9.252206515336045
54	TOI5612-01_90.000s_R-0131_out1.fits	54	0.0	60361.72273113439	2460361.7227311344	2460361.722210301	2460361.727540317	2460361.7283696826	1.034917091600943	75.05266202391618	-29.9375	90.0	11.494070833333332	38.936499999999995	10.128745326587113
55	TOI5612-01_90.000s_R-0132_out1.fits	55	0.0	60361.72395752324	2460361.7239575232	2460361.72343669	2460361.7287667147	2460361.7295960803	1.0332893103525052	75.39562353407912	-29.96875	90.0	11.494070833333332	38.936499999999995	9.69370769118705
56	TOI5612-01_90.000s_R-0135_out1.fits	56	0.0	60361.72763589118	2460361.727635891	2460361.727115058	2460361.732445109	2460361.7332744747	1.0286549300072079	76.42480282009475	-29.9375	90.0	11.494070833333332	38.936499999999995	10.756461904296934
57	TOI5612-01_90.000s_R-0137_out1.fits	57	0.0	60361.73008819437	2460361.7300881944	2460361.729567361	2460361.73489743	2460361.7357267956	1.0257693075415502	77.11134882571643	-29.9375	90.0	11.494070833333332	38.936499999999995	9.883860948245522
58	TOI5612-01_90.000s_R-0138_out1.fits	58	0.0	60361.73131482629	2460361.7313148263	2460361.730793993	2460361.736124071	2460361.736953436	1.0243864503514735	77.45487304201438	-29.9375	90.0	11.494070833333332	38.936499999999995	9.927669971056728
59	TOI5612-01_90.000s_R-0141_out1.fits	59	0.0	60361.73499188665	2460361.7349918867	2460361.7344710534	2460361.7398011573	2460361.740630523	1.0204801886062957	78.4850925998461	-29.9375	90.0	11.494070833333332	38.936499999999995	9.551004845334205
60	TOI5612-01_90.000s_R-0142_out1.fits	60	0.0	60361.736218171194	2460361.736218171	2460361.735697338	2460361.7410274507	2460361.741856816	1.019256494696556	78.82880659644893	-29.9375	90.0	11.494070833333332	38.936499999999995	9.381248768239828
61	TOI5612-01_90.000s_R-0143_out1.fits	61	0.0	60361.73744467599	2460361.737444676	2460361.7369238427	2460361.7422539643	2460361.74308333	1.0180717827277828	79.17264885622531	-29.9375	90.0	11.494070833333332	38.936499999999995	18.414027366001584
62	TOI5612-01_90.000s_R-0148_out1.fits	62	0.0	60361.74357523164	2460361.7435752316	2460361.7430543983	2460361.748384564	2460361.7492139293	1.0127313625066068	80.89223222048439	-29.9375	90.0	11.494070833333332	38.936499999999995	10.772154425054154
63	TOI5612-01_90.000s_R-0152_out1.fits	63	0.0	60361.748480671085	2460361.748480671	2460361.747959838	2460361.753290039	2460361.7541194037	1.0091457610406454	82.26916127017633	-29.9375	90.0	11.494070833333332	38.936499999999995	9.835366075637305
64	TOI5612-01_90.000s_R-0153_out1.fits	64	0.0	60361.74970591441	2460361.7497059144	2460361.749185081	2460361.754515291	2460361.755344656	1.008344336000632	82.61319916956907	-29.9375	90.0	11.494070833333332	38.936499999999995	10.257359775601493
65	TOI5612-01_90.000s_R-0154_out1.fits	65	0.0	60361.75093298592	2460361.750932986	2460361.7504121526	2460361.7557423715	2460361.756571736	1.0075791704283161	82.95779391805739	-29.90625	90.0	11.494070833333332	38.936499999999995	9.82602278483292

Figure 4: Sample of Measurements Taken (Generated from AstroImageJ)

Ultimately to analyze the lightcurve, we manipulated various star’s flux on the plot regarding ingress/egress times, transit parameters, scaling, etc.

4. Results

This section presents the results of our ground-based light curve and RMS vs dmag plot of Gaia reference stars. Figure 5 is our light curve generated through AstroImageJ. Figure 6 is our RMS vs dmag plot.

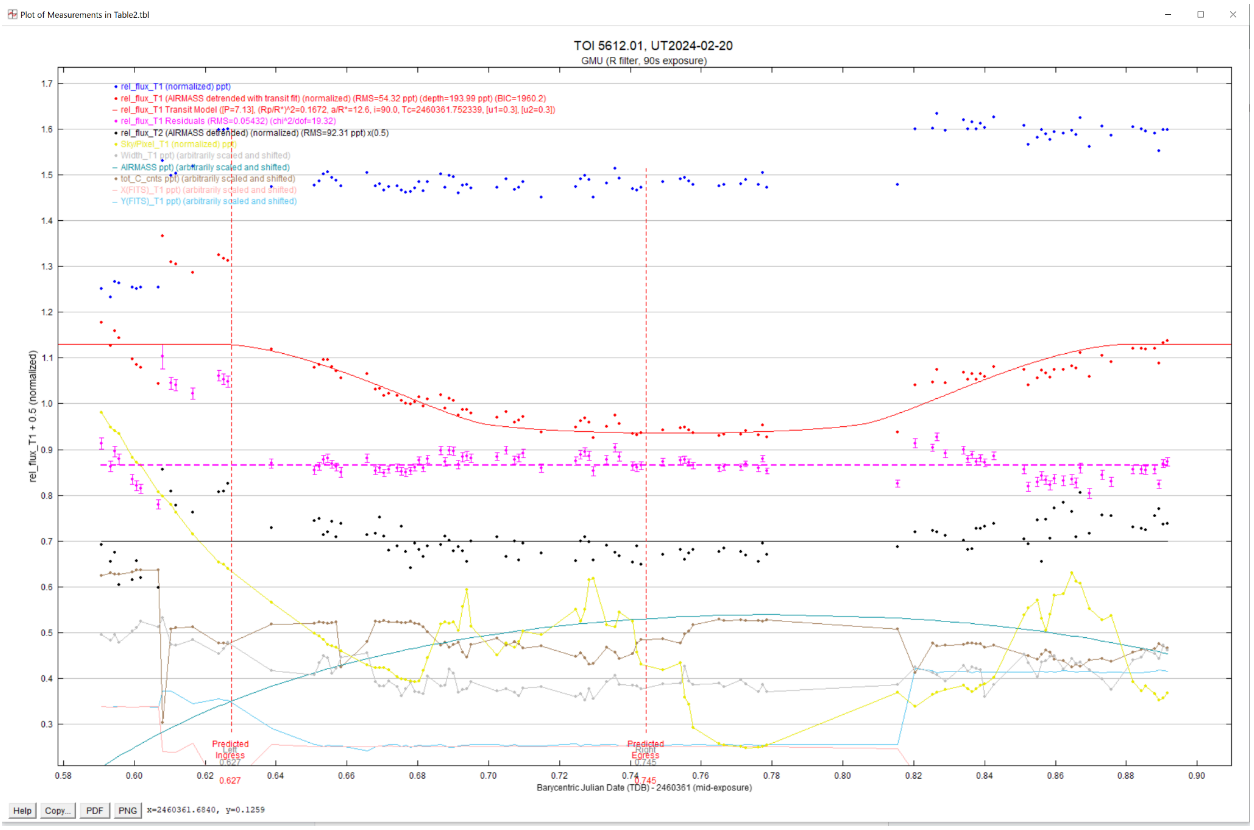

Figure 5: Light Curve Plot (Generated from AstroImageJ)

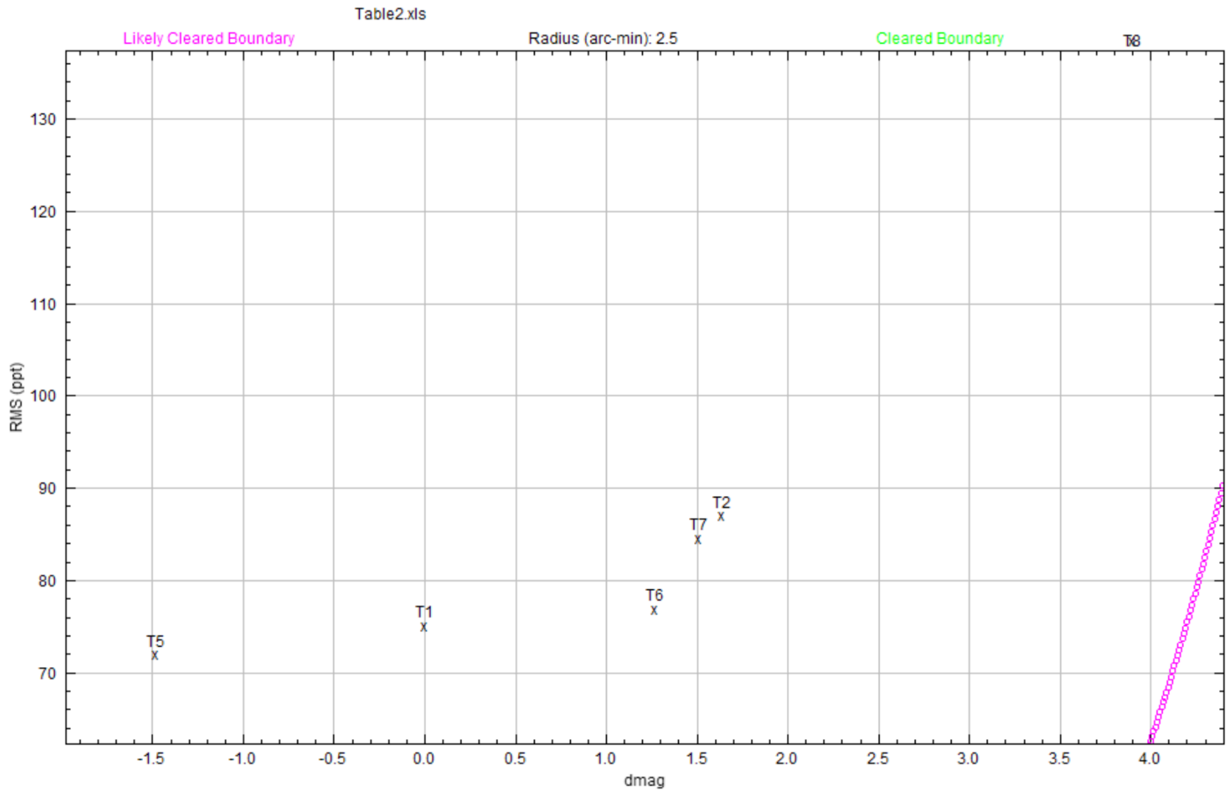

Figure 6: RMS vs dmag (Generated from AstroImageJ)

5. Discussions

Our results were not optimal, as many of our observations in our predicted time of transit were bad photos (cloud cover, streaks).

Looking at our generated light curve (Figure 6), there does not seem to be a transit in our predicted ingress and egress times. There, however, seems to be potentially a transit after our predicted times, as seen by a noticeable dip in flux from 0.64 to 0.87. However, that is still difficult to say because we do not have much data during that dip. If the ingress or egress times are incorrect, this means there could be even more inconsistencies with our predicted characteristics of TOI 5612.01. This could, however, be something future research looks at.

Additionally, there seems to be a large fluctuation in the transit depth generated from our light curve and the transit depth we once predicted. This may be attributed to the timing of the transit in the first place or other inconsistencies in our predicted characteristics of TOI 5612.01.

There is an overall high RMS of 54.32, suggesting a large margin of error and scatter in our data. This makes it difficult to truly make any conclusive decision.

Referencing Figure 6, RMS vs dmag, we were also unable to conclude if there was an NEB. The target stars are all outside of the boundaries. In general, we can not make a conclusive decision with our RMS vs dmag plot either.

6. Conclusions and Future Work

We were unable to reach a definitive conclusion on whether a transit truly occurred on TOI 5612l.01 at the expected time, with the expected duration and depth. This paper will be one of the first ground-based light curve follow-ups on TOI 5612.01, so we do not have any research to base on from the past. We do, however, have suggestions for future work. First, we suggest to collect a larger quantity of quality data. Ideally, this data is not only in the predicted ingress and egress times–having some data outside of those times is great in case the transit does not happen at the expected times. From our work, we believe that there is a possibility that the transit does not occur at the original expected times. In turn, there also may potentially be errors with the expected duration and depth of the transit if the predicted ingress and egress times were wrong. We do not, however, conclude with such a statement as our collected data is not substantial enough to reach such a conclusion, especially with our RMS. In all, we believe that if more quality data were used in the analysis, TOI 5612.01's transit could be pinpointed, which would lead us our way to determining if TOI 5612.01 is an exoplanet.

References

(n.d.). NASA Exoplanet Archive. Retrieved August 16, 2024, from https://exoplanetarchive.ipac.caltech.edu/index.html

(n.d.). MAST Home | MAST. Retrieved August 17, 2024, from https://archive.stsci.edu/

How many exoplanets are there? (n.d.). NASA Science. Retrieved August 16, 2024, from https://science.nasa.gov/exoplanets/how-many-exoplanets-are-there/