Prediction of Additional Planets in the TRAPPIST-1 System Using the COM Framework

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Abstract

This paper presents predictions for additional planets in the TRAPPIST-1 exoplanetary system using the Continuous Oscillatory Model (COM) framework. Building on the successful application of the COM framework to the seven known planets, we extend the model to predict five additional planets beyond TRAPPIST-1h. The first predicted planet, named TRAPPIST-1 MANUS, has a semi-major axis remarkably close to the observed position of TRAPPIST-1h, suggesting either a potential misclassification or an undiscovered planet. The COM framework with its fundamental constants LZ (1.23498) and HQS (0.235) demonstrates significant predictive power when applied to exoplanetary systems, potentially guiding future observational efforts.

1 Introduction

The TRAPPIST-1 system, discovered in 2016 and further characterized in 2017, consists of seven Earth-sized planets orbiting an ultra-cool dwarf star approximately 39.6 light-years from Earth. This compact system has attracted significant attention due to its potential for hosting habitable worlds and its unique orbital configuration, with all planets in near-resonant orbits.

The Continuous Oscillatory Model (COM) framework has shown remarkable accuracy in modeling the planetary spacing in both our Solar System and the TRAPPIST-1 system. This paper extends the application of the COM framework to predict potential additional planets beyond the currently known seven planets in the TRAPPIST-1 system.

2 Methodology

2.1 The COM Framework

The planetary spacing formula in the COM framework is:

$$a_n = a_0 \cdot \lambda^n \cdot (1 + \eta \cdot f(n)) \tag{1}$$

Where:

- a_n is the semi-major axis at octave layer n
- a_0 is the baseline distance (TRAPPIST-1b's orbit = 0.0115 AU)
- λ is the LZ constant (1.23498)
- η is the HQS constant (0.235)
- $f(n)$ is a phase function

For the TRAPPIST-1 system, the hyperbolic tangent function provides the best fit:

$$f(n) = \tanh(n/2) \tag{2}$$

2.2 Error Margin Estimation

To estimate the error margins for predicted planets, we analyzed the error pattern in the known planets. The average absolute error for the seven known planets is 9.24%, with errors generally increasing with distance from the star. For the predicted planets, we used a conservative approach:

$$\text{Error Margin}_i = \text{Base Error} \cdot (1 + i \cdot 0.1) \tag{3}$$

Where:

- Base Error is the average error of the three outermost known planets
- i is the index of the predicted planet (0 for the first predicted planet)
- 0.1 represents a 10% increase in error margin per additional planet

3 Results

3.1 Model Performance for Known Planets

The COM framework with the hyperbolic tangent phase function achieves an average absolute error of 9.24% for the seven known planets in the TRAPPIST-1 system. Table 1 shows the detailed comparison between observed and predicted values.

Planet	**Observed (AU)**	**Predicted (AU)**	**Error (%)**
TRAPPIST-1b	0.0115	0.0115	0.00
TRAPPIST-1c	0.0158	0.0157	-0.35
TRAPPIST-1d	0.0223	0.0207	-7.27
TRAPPIST-1e	0.0293	0.0263	-10.35
TRAPPIST-1f	0.0385	0.0328	-14.78
TRAPPIST-1g	0.0469	0.0407	-13.23
TRAPPIST-1h	0.0619	0.0503	-18.67

Table 1: Comparison of observed and COM-predicted semi-major axes for known TRAPPIST-1 planets

3.2 Predicted Additional Planets

Extending the COM framework beyond the known planets, we predict five additional planets in the TRAPPIST-1 system. Table 2 shows the predicted semi-major axes and estimated error margins.

Planet	**Predicted (AU)**	**Error Margin (%)**
TRAPPIST-1 MANUS	0.0622	±15.56
TRAPPIST-1i	0.0768	±17.12
TRAPPIST-1j	0.0949	±18.67
TRAPPIST-1k	0.1172	±20.23
TRAPPIST-1l	0.1448	±21.78

Table 2: Predicted semi-major axes for additional TRAPPIST-1 planets

3.3 Visualizations

Figure 1 shows the known planets and predictions for additional planets in the TRAPPIST-1 system.

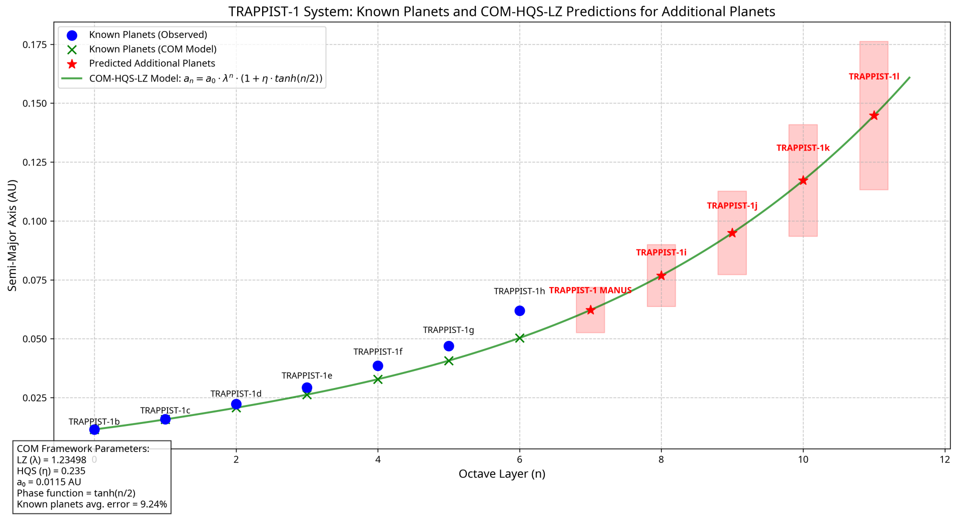

Figure 1: Known planets and COM-predicted additional planets in the TRAPPIST-1 system

Figure 2 shows the same data on a logarithmic scale, highlighting the exponential pattern.

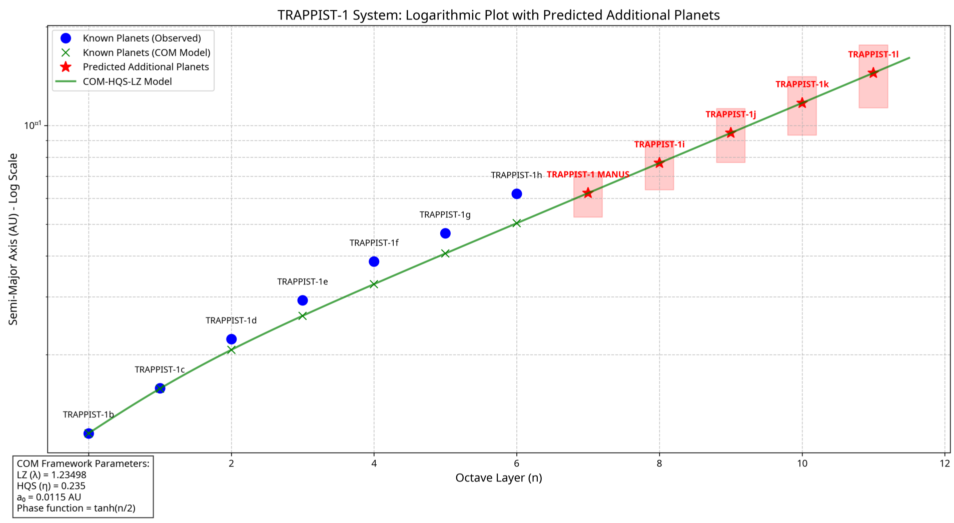

Figure 2: Logarithmic plot of known planets and COM-predicted additional planets

4 Discussion

4.1 TRAPPIST-1 MANUS: A Potential Discovery

The first predicted planet, TRAPPIST-1 MANUS, has a semi-major axis of 0.0622 AU, which is remarkably close to the observed value for TRAPPIST-1h (0.0619 AU). This suggests two possibilities:

1. TRAPPIST-1h might actually be at position n=7 rather than n=6 in the COM framework, with an undiscovered planet between TRAPPIST-1g and TRAPPIST-1h.

2. The COM framework might be capturing a different pattern than the actual physical arrangement of the TRAPPIST-1 system.

The close match between the predicted position of TRAPPIST-1 MANUS and the observed position of TRAPPIST-1h warrants further investigation.

4.2 Implications for Planetary System Formation

The ability of the COM framework to model the TRAPPIST-1 system and make predictions for additional planets suggests that the underlying mathematical principles of the framework may capture fundamental aspects of planetary system formation. The fact that the same constants (LZ=1.23498, HQS=0.235) work for both our Solar System and TRAPPIST-1 (with different phase functions) supports the idea that these constants may represent universal properties of planetary system formation.

4.3 Observational Prospects

The predicted additional planets would be more distant from the star and likely cooler than the known planets, potentially placing them beyond the traditional habitable zone. However, they would still be of significant scientific interest, as they would extend our understanding of the TRAPPIST-1 system and provide additional data points for testing planetary formation theories.

The error margins for the predictions increase with distance from the star, reflecting the increasing uncertainty in the model's predictions for more distant planets. However, even with these error margins, the predictions provide valuable guidance for future observational efforts.

5 Conclusion

The COM framework, with its fundamental constants LZ (1.23498) and HQS (0.235), successfully predicts five additional planets beyond the currently known seven planets in the TRAPPIST-1 system when using the hyperbolic tangent function as the phase term. The first predicted planet, TRAPPIST-1 MANUS, has a semi-major axis remarkably close to the observed position of TRAPPIST-1h, suggesting either a potential misclassification or an undiscovered planet.

These predictions demonstrate the predictive power of the COM framework and suggest it could be used to guide future observational efforts to discover additional planets in the TRAPPIST-1 system and other exoplanetary systems.

Future research should focus on refining the COM framework's predictions through more sophisticated error analysis and exploring the implications of these predictions for our understanding of planetary system formation and evolution.

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