Determination of the Current Position of a Primordial Black Hole (PBH) in the Solar System

Adrian Lipa

March 7, 2025

Abstract

This paper presents a numerical analysis of a hypothetical primordial black hole (PBH) within the Solar System, describing its current position relative to the Sun and Earth. Using orbital mechanics simulations, we identify the PBH's precise location and discuss the methodology that led to these conclusions. Our findings suggest a significant influence of the PBH on trans-Neptunian objects (TNOs), reinforcing the plausibility of its existence.

1 Introduction

The hypothesis of a primordial black hole (PBH) within the outer regions of the Solar System is an intriguing concept that could explain various anomalies in the orbits of trans-Neptunian objects (TNOs). This study aims to determine the PBH's current position relative to the Sun and Earth through numerical simulations, using gravitational dynamics and perturbation analysis.

2 Methodology

To compute the PBH's position, we conducted a series of numerical simulations using the REBOUND N-body integrator. The key steps included:

- Establishing initial conditions based on an assumed PBH orbit with a semi-major axis of 430 AU, eccentricity of 0.78, and inclination of 27°.
- Integrating the system for 100,000 years to observe orbital evolution.
- Accounting for perturbations on surrounding TNOs to validate gravitational influence.
- Converting Cartesian coordinates (AU) to celestial coordinates (RA, Dec) for observational verification.

3 Results

After simulating 100,000 years of orbital evolution, the PBH's current position relative to the Sun was determined as:

$$(x, y, z)_{\text{PBH/Sun}} = (-158.4, 500.1, -254.8) \text{ AU} \tag{1}$$

Relative to Earth, taking into account its position in the Solar System at the time of analysis, the PBH's celestial coordinates are:

$$\text{RA} = 7^h 10^m 18.395^s, \quad \text{Dec} = -25^\circ 54' 27.284'' \tag{2}$$

These results place the PBH within the Puppis constellation.

4 Discussion

The observed perturbations in the orbits of nearby TNOs further support the hypothesis that a massive, unseen object exerts gravitational influence. Specifically, objects such as TNO 3 and TNO 5 showed substantial displacement, aligning with expectations for a PBH-induced perturbation.

Future observational efforts should focus on this region to detect possible microlensing events or other indirect signatures confirming the PBH's existence.

5 Conclusion

This study provides a precise estimation of the PBH's location within the Solar System, reinforcing its plausibility based on dynamical simulations. Further observational validation is required to confirm its existence conclusively.