The Development of Gravitational Theories from the Perspective of TRAPPIST-1e (Postprint)

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Abstract

Contrary to the solar system, most exoplanet systems detected hitherto are close-in and compact. One typical system is TRAPPIST-1, which has seven nearly co-planar terrestrial planets all within the orbit of Mercury, including three in the habitable zone. To evaluate the differences in developing sophisticated gravity theories from the solar system, we use N-body integrations to simulate ephemeris and reproduce some important astronomy phenomena observed on the potentially habitable planet TRAPPIST-1e. Retrograde motions of other planets last 1–2 orders of magnitude shorter than in the solar system, but occur much more frequently. Transit events of all inner planets can be observed steadily. Except for Kepler' s first law, which is hard to notice for low eccentricities of planets, the other two laws can then be precisely verified in 102 days, because the areas swept by planets vary by 0.01% and the observed semimajor axes and periods result in constants with theoretical and observation accuracies both 2%. However, the mean motion correlation implies that the Great Inequality is not always apparent between one pair of planets like Jupiter and Saturn. Furthermore, general relativity can hardly be discovered because it gives rise to perihelion precession of inner planets only ~0.1% of gravity precession, dozens of times smaller than Mercury. Our results support the possibility of developing part of gravity theories by potential exo-civilizations in compact systems like TRAPPIST-1.

Full Text

Preamble

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2.1. Data Reduction

The data reduction pipeline processes Stokes parameters to extract polarization fractions, including linear polarization L/I, circular polarization V/I, and absolute circular polarization |V|/I. The analysis employs equations (1)–(2) and (3)–(8) to model the polarization behavior across the pulse profile. A characteristic timescale appears in the formulation as Te = GMe/c^3, with mp normalized to 1 in natural units. The reduced data products enable construction of polarization profiles for subsequent classification.

2.2. Pulsar Polarization Profiles

This section addresses the polarization profiles of pulsars, referencing equations (3), (7), and (8) for profile modeling. The analysis incorporates measurements of both linear and circular polarization components as functions of rotational phase. The profiles serve as diagnostic tools for understanding the emission geometry and magnetic field structure of the neutron star.

3.3. Pulsars with Ultra-light Companions

Ultra-light companion systems are characterized by effectively negligible companion masses (mc ~ 0 Me) and orbital periods exceeding 5 days. The classification criteria include constraints on eccentricity, though the extracted text shows contradictory conditions ($e < 0$ and $e > 0$) that likely reflect corruption of the original inequalities. These systems represent a population with extremely low-mass companions, possibly planetary-mass objects or low-mass white dwarfs.

3.4. Pulsars with Main Sequence Star Companions

This category encompasses binary systems where the companion is a main sequence star. The orbital parameters and companion masses distinguish these from other binary pulsar populations, though specific classification criteria are corrupted in the extracted text.

3.5. Pulsars with NS Companions

Neutron star companions form a distinct subclass of binary pulsars with characteristic mass distributions and orbital dynamics. The text indicates these systems have well-defined parameters, but the specific constraints are not recoverable from the corrupted fragments.

3.6. Pulsars with a Helium MS Companion

Systems featuring helium main sequence companions show correlations between spin-down rate P and orbital evolution. The analysis of these systems involves tracking period derivatives and companion mass estimates to understand the binary evolution history.

3.7. Pulsars with Undetermined Companions

For systems with undetermined companion types, the classification applies criteria including spin period constraints (P < 3 ms) and eccentricity bounds. Companion mass estimates range from 4 Me to 8 Me, depending on orbital period Pb and other system parameters. The spin-down rate P and its time derivative provide additional diagnostics for inferring companion properties when direct detection is not possible.
