

# Signal Travel Time Anomaly between Earth and Solar Planets

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## Abstract

Travel time anomaly in the communication of spatial instruments installed in solar planets and Earth are investigated in a model of gravity impact on radio signal propagation. Resulting travel times anomaly shows variations less than  $10^{-3}$  seconds to and from Venus and Mars while Sun provides anomaly travel times of about  $-2 \times 10^{-2}$  sec as backward signal needs more times than emitted signal from Earth. In the current explorations on Mars, the travel time anomaly may reach  $1.8 \times 10^{-4}$  sec as orbital Mars position pass through its minimum distance with respect to Earth. Implications of the difference between one and two-way travel times may be related to redshift/blueshift while travel time of received signal is less or greater than emitted signal.

## Keywords

Radio Signal, Travel Times, Gravity, Solar Planets, Redshift

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## 1. Introduction

Anomaly in space recording data has been observed such as Pioneer anomaly which may have a gravitational origin [1], and has been explained in term of conformal gravity [2]. Galaxie clusters of high magnitude of redshift ( $>2$ ) were observed [3] [4] while very small scale redshift within solar system cannot be easily obtained. Solar gravitational redshift is suggested from photon and electrons interactions [5]. Many explorations on Mars are now experienced by several institutions to record new data. Nasa perseverance [6] and Chinese Zhurong [7] reached Mars surface in June 2021 and they send and received signals from and to Earth. These experiences are now worked while distance to Mars is at its minimum relative to Earth. It is then an opportunity to examine the travel times of signals based on UHF or X-band in one or two ways. Based on gravity impact

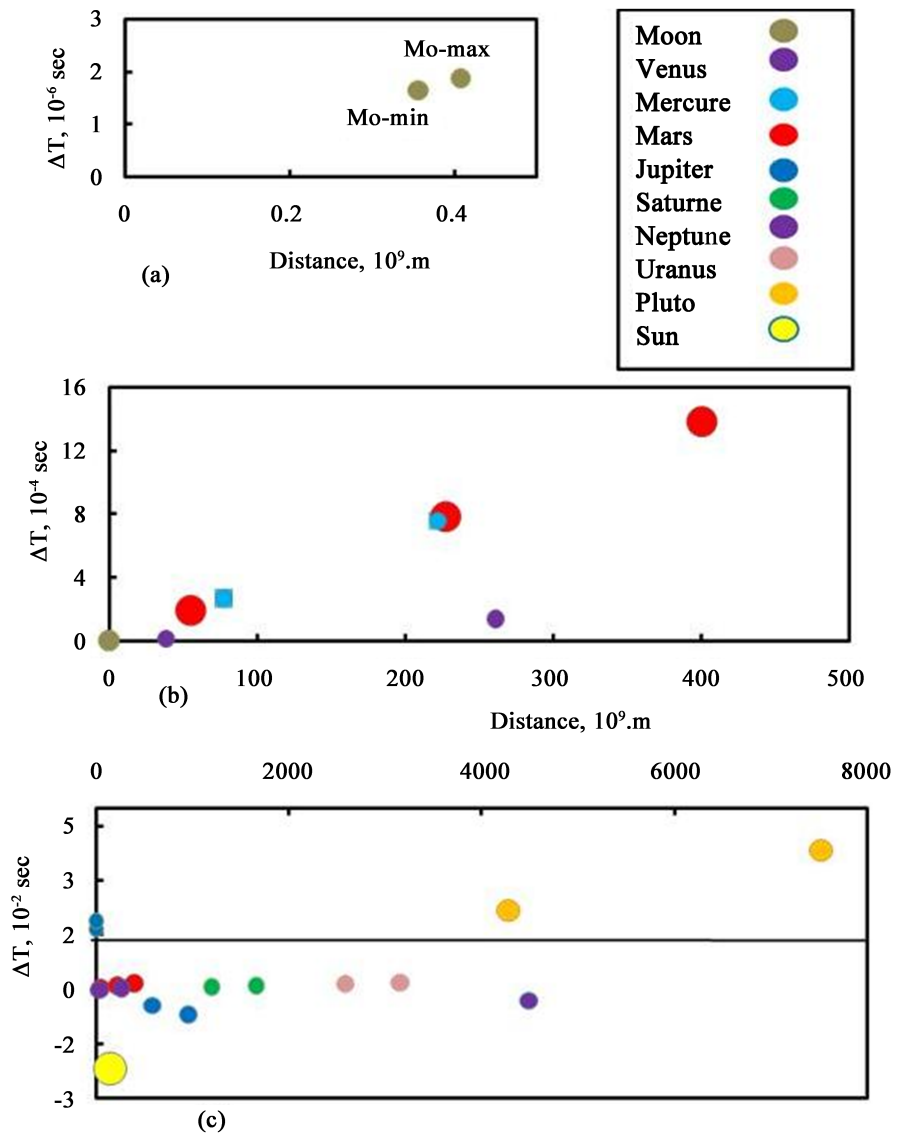
on velocity of light [8] variations in travel times may be caused as gravity field vary on Mars and solar planets with respect to Earth. Changes in signal frequency and Doppler effect that also contribute to redshift are not addressed. The estimation of changes in travel times of transmitted signals based on velocity variations is here addressed between Earth and planets of the solar system.

## 2. Data and Results

Data from photon travel times inside solar planets are based on initial velocity acquired by photons in a particular planet gravity field. Distances to Earth from Moon and Mars and other solar planets provide both maximum and minimum values related to orbital positions [9]. While radio signal traveltimes emitted from Earth will be received on Mars by  $T_{em} = D/C_e$ , where  $C_e$  is initial velocity acquired on Earth to Mars on one forward way (Table 1). The signal traveltime from Mars to Earth will be then  $T_{me} = D/C_m$ , where  $C_m$  is velocity dependant Mars gravity [8]. Two way travel times of a signal emitted to Mars and back to Earth then will be  $[T_{em} + T_{me}]$ . Resulting variation  $\Delta T [T_{em} - T_{me}]$  are shown in Figure 1 in addition to travel time estimates of light from Earth to Sun, Venus and Moon

**Table 1.** Travel time estimates of signals between solar system planets and Earth based on initial velocity acquired by their specific planet gravity field. Variation in the emitted and received signals are indicated.

Planet Orbit	Distance to Earth [ $10^9 \cdot m$ ]	$T_1$ from Earth [s]	$T_2$ to Earth [s]	$T_1 - T_2$ [s]	$T_1 + T_2$ [s]	$T_1 + T_2$ [mn]
Mars-min	55.7	185.795201	185.7950096	0.000191416	371.5902106	6.193170177
Mars-max	401.3	1338.592714	1338.591335	0.001379087	2677.184049	44.61973415
Mars-average	227.943824	760.3387541	760.3379707	0.00078334	1520.676725	25.34461208
Sun	149.5978707	499.0047838	499.0269644	-0.022180575	998.0317482	16.63386247
Moon min	0.357	1.19082382	1.190822172	1.64759E-06	2.381645992	0.0396941
Moon max	0.407	1.357605867	1.357603989	1.87835E-06	2.715209857	0.045253498
Venus min	38.2	127.4214844	127.4214646	1.97955E-05	254.8429489	4.247382482
Venus max	261	870.6022885	870.6021532	0.000135252	1741.204442	29.02007403
Mercure-max	77.3	257.8450456	257.8447799	0.000265678	515.6898255	8.594830425
Mercure-min	221.9	740.1787272	740.1779646	0.000762664	1480.356692	24.67261153
Jupiter max	968.1	3229.234006	3229.241219	-0.007213733	6458.475225	107.6412537
Jupiter min	588.5	1963.0247	1963.029085	-0.004385169	3926.053786	65.43422976
Saturn-min	1195.5	3987.758758	3987.758206	0.000552022	7975.516964	132.9252827
Saturn-max	1658.5	5532.160519	5532.159753	0.000765812	11064.32027	184.4053379
Uranus-max	2581.9	8612.291374	8612.289745	0.00162885	17224.58112	287.076352
Uranus-min	3157.3	10,531.61918	10,531.61719	0.001991854	21063.23636	351.0539394
Neptune average	4496.6	14,999.0431	14,999.04607	-0.002966864	29998.08918	499.9681529
Pluto-min	4284.7	14,292.22079	14,292.19885	0.021939411	28584.41963	476.4069939
Pluto-max	7528.7	25,113.04004	25,113.00149	0.038550013	50226.04152	837.100692



**Figure 1.** Relative signal travel time variations  $\Delta t$  versus varying range of distances to Earth is less than  $10^{-6}$  sec between forward and backward signal Earth-Moon (a). This value reaches about  $10^{-4}$  sec for some solar planets according to both their minimum and maximum orbital distances to Earth (b). It increases by more than 20 times to about  $10^{-2}$  when gravity of Sun and Pluto are considered (c).

and other solar planets. At short distance as between maximum and minimum distances to the Moon the travel time variation is about  $10^{-6}$  sec (Figure 1(a)). Maximum and minimum values at intermediate distances (Figure 1(b)) are in the range of  $10^{-3}$  to  $10^{-4}$  sec (Mars, Venus, Uranus). While this variation increased to  $\pm 0.02$  seconds from travel times to Sun and Pluto due to their respective gravity (Figure 1(c)). Figure 1(c) shows that other solar planets seem not significant in the travel time difference between forward and backward signals compared to Pluto and Sun. Doppler effect may be observed due to orbital position of planets during travel times between forward and backward signals. In this model, the Doppler effect is not considered in the two way radio signal but

**Table 2.** Spectral effect  $z$  estimated in term of velocity from solar planets and Earth based on planet gravity related by assuming stationary of planets during two way travel times of an emitted signal from earth.

Planet	V (g), m/s	$z \cdot 10^{-4}$	Spectrum effect
Earth	299,792,458	0	-
Sun	299,779,132.9	0.44	redshift
Mars/Mercure	299,792,766.9	-0.01	blueshift
Venus	299,792,504.6	-0.0015	blueshift
Jupiter	299,791,788.3	0.023	redshift
Saturn	299,792,499.5	-0.0013	blueshift
Uranus	299,792,514.7	-0.0005	blueshift
Neptune	299,792,398.7	0.002	redshift
Pluto	299,792,918.2	-0.015	blueshift
Moon	299,792,872.8	-0.013	blueshift

rather only the changes in velocity acquired by the gravity environment. **Table 2** shows  $z$  factor of both red and blueshift which is assumed to represent  $(1-Vg/Vc)$ , where  $Vg$  is the photon velocity in a particular gravity field while  $Vc$  is this light velocity on Earth. Negative values of  $z$  represent spectral blueshift obtained for signal reflected from Venus, Mars, Uranus, Pluto and Mercure. Positive  $z$  represents redshift that correspond to signals coming from Sun, Jupiter and Neptune. Both shifted values are separated by 0-line shown in **Figure 1(c)**. High magnitude shifting is perceptible to signals directed to Pluto and Sun.

### 3. Discussions and Conclusions

Distance to Earth also has a moderate impact on travel time difference. Signals coming from Sun and Mars are affected by Earth's gravity in the last 100 km to reach Earth. As 100 km appears negligible compared to distance to Mars and Sun the changes will be very low to consider. Signal propagation also may be affected by electrical charges due to solar wind that may reduce the vacuum character of the space between solar planets. At greater distance outside the solar system, the distance seems not to play a critical role but rather the state of gravity of the planet from which the signal is emitted. Assuming that the signal has been not reflected by another planet which transmits to it the speed related to its gravity field. Distance travelled by Planets during the two-way travel times is also small to consider. Maximum one way travel times to Pluto is about 6 hours. During this time Pluto's distance to Earth varies. This variation in distance is an additional factor as Doppler effects contributing to blueshift. Moon, Mars and Venus are at a shorter distance to Earth where variation in distance to Earth during signal travel times may be reduced and the critical factor contributing to blueshift is due to gravitational velocity of the photons. In this model, the space time referential is the solar system with varying local gravity field related planets.

The expansion of universe is here considered as the solar system is moving as a whole stationary system. The current presence of in situ measurements in Mars may be an opportunity to explore the validity of changes in travel times of radio signals due to velocity gravity dependent in solar system.

### Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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