A few remarks about the Pioneer anomaly

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Abstract

Some features of the Pioneer anomaly are discussed in context of author's explanation of this effect as a deceleration of the probes in the graviton background. It is noted that if the model is true then the best parameter of the anomalous acceleration should be not the distance to the Sun but a cosine of the angle between a velocity of the probe and its radius-vector.

As it was reported by the authors of the discovery, NASA deep-space probes Pioneer 10/11 experience an anomalous constant acceleration directed towards the Sun (the Pioneer anomaly) [1, 2]. A possible origin of the effect remains unknown. In my model [3], any massive body must experience a constant deceleration $w \simeq Hc$, where H is the Hubble constant and c is the light velocity, of the same order of magnitude as observed for cosmic probes. This effect is an analogue of cosmological redshifts in the model. Their common nature is forehead collisions with gravitons. I would like to consider here the main known features of this anomaly in context of my explanation keeping in mind present and future efforts to verify the reality of this effect and to understand it.

The observed anomaly has the following main features: 1) in the range 5 − 15 AU from the Sun it is observed an anomalous sunward acceleration with the rising modulus which gets its maximum value, leastwise for Pioneer 11 (see Fig. 3 in [2]); 2) for greater distances, this maximum sunward acceleration remains almost constant for both Pioneers [1, 2]; 3) also it is observed an unmodeled annual periodic term in residuals for Pioneer 10 [4] which is obviously connected with the motion of the Earth.

If my conjecture [3] about the quantum nature of this acceleration is true then an observed value of the projection of the probe's acceleration on the sunward direction w_s should depend on accelerations of the probe, the Earth and the Sun relative to the graviton background. If we assume that the Sun moves relative to the background slowly enough, then anomalous accelerations of the Earth and the probe will be directed almost against their velocities in the heliocentric frame, and in this case: $w_s = \quad w \quad \cos \quad$, where is an angle between a radius-vector of the probe and its velocity in the frame. For a terrestrial observer, an additional term should be taken into account which is connected with its own motion relative to the background.

By the very elongate orbits of the both Pioneers (see Fig. 3 in [2]), it would explain the second (and main) peculiarity. For example, for Pioneer 10 at the distance 67 AU from the Sun one has sin $\quad 0.11$ (it is a visual estimate with Fig. 3 of [2]), i.e. cos $\quad 0.994$: If for big distances from the Sun we use the conservation laws of energy and angular momentum in the field of the Sun only, then in the range 6.7 − 67 AU a value of cos changes from 0.942 to 0.994, i.e. approximately on 5 per cent only. Due to this fact, a projection of the probe's acceleration on the sunward direction would be almost constant.

As Toth and Turyshev report [5], they intend to carry out an analysis of newly recovered data received from Pioneers, with these data are now available for Pioneer 11 for distances 1.01 − 41.7 AU. If the serious problem of taking into account the solar radiation pressure at small distances is precisely solved (modeled) [6], then this range will be very lucky to confront the expression $w_s = \quad w \quad \cos$ of the considered model with observations for small distances when Pioneer 11 executed its planetary encounters with Jupiter and Saturn. In this period, a value of cos was changed in the non-trivial manner, and the projection of anomalous acceleration should behave itself similar. For example, when the spacecraft went to Saturn, cos was negative during some time. If this model is true, the anomaly in this small period should have the opposite sign. I think, it would be the best of all to compare the two functions of the probe's proper time: the projection of anomalous acceleration of Pioneer 11 and cos for it. These functions should be very similar to each other if my conjecture is true. At present, a new mission to test the anomaly is planned [7]. It is seen from this consideration that it would be desirable to have a closed orbit for this future probe (or the one with two elongate branches where the probe moves off the Sun and towards it).

Leaving for the future the question about the stability and form of the Earth orbit by such the anomalous acceleration, I note that namely this one would cause feature 3) of the anomaly. In this case, because Pioneers 10 and 11 have different trajectories, it is possible to compute a sign of the projection of Earth's anomalous acceleration contribution: when the Earth moves after a probe, we should observe a minimum of the periodic term, and we should see a maximum when they move in opposite directions. For the twins, these maximums-minimums will appear in different time intervals, that is important to test the model.

The observed very tiny anomaly in the probe motion may be the first egress beyond the applicability limits of general relativity in the solar system. If my explanation of the one is true then this effect may turn out to be and the first observable macroscopic manifestation of low-energy quantum gravity.

References

[1] Anderson, J.D. et al. Phys. Rev. Lett. 1998, 81, 2858.

[2] Anderson, J.D. et al. Phys. Rev. 2002, D65, 082004; [gr-qc/0104064 v4].

[3] Ivanov, M.A. General Relativity and Gravitation 2001, 33, 479; Erratum: 2003, 35, 939; [astro-ph/0005084 v2].

[4] Turyshev, S.G. et al. XXXIV-th Rencontres de Moriond Meeting on Gravitational Waves and Experimental Gravity. Les Arcs, Savoi, France (January 23-30, 1999); [gr-qc/9903024 v2].

[5] Toth, V.T. and Turyshev, S.G. "III Mexican Meeting on Mathematical and Experimental Physics," Mexico City, Mexico, 10-14 Sept. 2007, arXiv:0710.2656v1 [gr-qc].

[6] Anderson, J.D. and Nieto, M.M. Contemp. Phys. 2007, 48, No. 1. 41-54; arXiv:0709.3866v1 [gr-qc].

[7] Dittus, H. et al. In: Trends in Space Science and Cosmic Vision 2020, Proceedings of the 39th ESLAB Symposium, eds. F. Favata and A. Gimenez, ESA Special Pub. 588, 3–10 (2005); [gr-qc/0506139].