Pioneer and Flyby anomalies for almost decade later

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January 13, 2015

Abstract

Pioneer and Flyby anomalies are astrophysical anomalies in our solar system. Standard physics explanations for Pioneer anomaly have been tailored but they fail for Flyby anomalies. In this article I update almost decade old TGD inspired model for these anomalies as a direct demonstration for the existence of spherical dark matter shells associated with planets and with radii of planetary orbits. The dark matter density would be universal as also the accleration anomaly equal to Hubble acceleration. A possible test for the model is provided by Earth-Moon system. The model predicts the value of the dark matter density and it happens to be same as the value of effective surface density associated with the core like galactic dark matter halos.

1 Pioneer and Flyby anomalies and dark matter

This little contribution was inspired by a very interesting link at Thinking Allowed Original - a lot of thanks for Ulla, whose efforts have helped me in my work a lot. The linked article [E5] (http://www.technologyreview.com/view/506681/fly-by-anomaly/) was about two old anomalies discovered in the solar system: Pioneer anomaly [E1] and Flyby anomaly [E3, E2, E6, E4] with which I worked for years ago.

I remember only the general idea that dark matter concentrations at orbits of planets or at spheres with radii equal that of orbit could cause the anomalies. So I try to reconstruct all from scratch and during reconstruction become aware of something new and elegant that I could not discover for years ago.

The popular article [E5] claims that Pioneer anomaly is understood. I am not at all convinced about the solution of Pioneer anomaly. Several "no new physics" solutions have been tailored during years but later it has been found that they do not work.

Suppose that dark matter is at the surface of sphere so that by a well-known text book theorem it does not create gravitational force inside it. This is an overall important fact, which I did not use earlier. The model explains both anomalies and also allow to calculate the total amount of dark matter at the sphere.

1. Consider first the Pioneer anomaly.

   (a) Inside the dark matter sphere with radius of Jupiter's orbit the gravitational force caused by dark matter vanishes. Outside the sphere also dark matter contributes to the gravitational attraction and Pioneer's acceleration becomes a little bit smaller since the dark matter at the sphere containing the orbit radius of Jupiter or Saturn also attracts the spacecraft after the passby. A simple test for spherical model is the prediction that the mass of Jupiter effectively increases by the amount of dark matter at the sphere after passby.

   (b) The magnitude of the Pioneer anomaly is about $\Delta a/a = 1.3 \times 10^{-4}$ [K2] and translates to $M_{dark}/M \simeq 1.3 \times 10^{-4}$. What is highly non-trivial is that the anomalous acceleration is given by Hubble constant suggesting that there is a connection with cosmology fixing the value of dark mass once the area of the sphere containing it is fixed. This follows as a prediction if the surface mass density is universal and proportional to the Hubble constant.

   Could one interpret the equality of the two accelerations as an equilibrium condition? The Hubble acceleration H associated with the cosmic expansion (expansion velocity increases with distance) would be compensated by the acceleration due to the gravitational force of dark matter. The formula for surface density of dark matter is from Newton's law $GM_{dark} = H$ given by $\sigma_{dark} = H/4\pi G$. The approximate value of dark matter surface density is from $Hc = 6.7 \times 10^{-10}$ m/s^2 equal to $\sigma = .8$ kg/m^2 and surprisingly large.

   (c) The value of acceleration is $a = .8 \times 10^{-10} \times g$, $g = 9.81$ m/s^2 whereas the MOND model (`http://en.wikipedia.org/wiki/Modified_Newtonian_dynamics`) finds the optimal value for the postulated minimal gravitational acceleration to be $a_0 = 1.2 \times 10^{-10}$ m/s^2. In TGD framework it would be assignable to the traversal through the dark matter shell. The ratio of the two accelerations is $a/a_0 = 6.54$.

   (d) TGD inspired quantum biology requiring that the universal cyclotron energy spectrum of dark photons $h_{eff} = h_{gr}$ transforming to to biophotons is in visible and UV range for charged particles gives the estimate $M_{dark}/M_E \simeq 2 \times 10^{-4}$ [K3] and is of the same order of magnitude smaller than for Jupiter. The minimum value of the magnetic field at flux tubes has been assumed to be $B_E = .2$ Gauss, which is the value of endogenous magnetic field explaining the effects of ELF em radiation on vertebrate brain. The two estimates are clearly consistent.

2. In Flyby anomaly spacecraft goes past Earth to gain momentum (Earth acts as a sling) for its travel towards Jupiter. During flyby a sudden acceleration occurs but this force is on only during the flyby but not before or after that. The basic point is that the spacecraft visits near Earth, and this is enough to explain the anomaly.

The space-craft enters from a region outside the orbit of Earth containing dark matter and thus experiences also the dark force created by the sphere. After that the space craft enters inside the dark matter region, and sees a weaker gravitational force since the dark matter sphere is outside it and does not contribute. This causes a change in its velocity. After flyby the spacecraft experiences the forces caused by both Earth and dark matter sphere and the situation is the same as before flyby. The net effect is a change in the velocity as observed. From this the total amount of dark matter can be estimated. Also biology based argument gives an estimate for the fraction of dark matter in Earth.

This model supports the option in which the dark matter is concentrated on sphere. The other option is that it is concentrated at flux tube around orbit: quantitative calculations would be required to see whether this option can work. One can consider of course also more complex distributions: say $1/r$ distribution outside the sphere giving rise to constant change in acceleration outside the sphere.

A possible very simple TGD model for the sphere containing dark matter could be in terms of a boundary defined by a gigantic wormhole contact with large $h_{eff} = h_{gr}$ (at its space-time sheet representing "line of generalized Feynman diagram" one has deformation of CP_2 type vacuum extremal with Euclidian signature of induced metric) with radius given by the radius of Bohr orbit with gravitational Planck constant equal to $h_{gr} = GMm/v_0$, where v_0 is a parameter with dimensions of velocity. This radius does not depend on the mass of the particle involved and is given by $r_n = GM/v_0^3$ where $r_S = 2GM$ is Schwartschild radius equal to 3 km for Sun [K2]. One has $v_0/c \simeq 2^{-11}$ for three inner planets. For outer planets v_0 is scaled down by a factor 1/5.

The sphere should also correspond to a magnetic flux sheet with field line topology of dipole field. By flux conservation the flux must arrive along flux tube parallel to a preferred axis presumably orthogonal to the plane of planets and flux conservation should must true. This kind of structure is predicted also by the TGD model in terms of cylindrically symmetric candidate for an extremal of Kähler action representing astrophysical object [K1].

An interesting possibility is that also Earth-Moon system contains a spherical shell of dark matter at distance given by the radius of Moon's orbit (about 60 Earth's radii). If so the analogs of the two effects could be observed also in Earth Moon system and the testing of the effects would become much easier. This would also mean understanding of the formation of Moon. Also interior of Earth (and also Sun) could contain spherical shells containing dark matter as the TGD inspired model for the spherically symmetric orbit constructed for more than two decades ago [K1] suggests. One can raise interesting questions. Could also the matter in small scale systems be accompanied by dark matter shells at radii equal to Bohr radii in the first approximation and could these effects be tested? Note that a universal surface density for dark matter predicts that the change of acceleration universally be given by Hubble constant H.

2 Further progress in the understanding of dark matter and energy in TGD framework

At Thinking Allowed Original (thanks for Ulla!) there was an extremely interesting link to a popular article about a possible explanation of dark matter in terms of vacuum polarization associated with gravitation. The model can make sense only if the sign of the gravitational energy of antimatter is opposite to that of matter and whether this is the case is not known. Since the inertial energies of matter and antimatter are positive, one might expect that this is the case also for gravitational energies by Equivalence Principle but one might also consider alternative and also I have done this in TGD framework.

The popular article lists four observations related to dark matter that neither cold dark matter (CMD) model nor modified gravitation model (MOND) can explain, and the claim is that the vacuum energy model is able to cope with them.

Consider first the TGD based model.

1. The model assumes that galaxies are like pearls along strings defined by cosmic strings expended to flux tubes during cosmic expansion survives also these tests. This is true also in longer scales due to the fractality if TGD inspired cosmology: for instance, galaxy clusters would be organized in a similar manner.

2. The dark magnetic energy of the string like object (flux tube) is identifiable as dark energy and the pearls would correspond to dark matter shells with a universal mass density of .8 kg/m^2 estimated from Pioneer and Flyby anomalies assuming to be caused by spherical dark matter shells assignable to the orbits of planets. This value follows from the condition that the anomalous acceleration is identical with Hubble acceleration. Even Moon could be accompanied by this kind of shell: if so, the analog of Pioneer anomaly is predicted.

3. The dark matter shell around galactic core could have decayed to smaller shells by h_{eff} reducing phase transition. This phase transition would have created smaller surfaces with smaller values of $h_{eff} = h_{gr}$. One can consider also the possibility that it contains all the galactic matter as dark matter. There would be nothing inside the surface of the gigantic wormhole throat: this would conform with holography oriented thinking.

I checked the four observations listed in the popular article some of which CMD (cold dark matter) scenario and MOND fail to to explain. TGD explains all of them.

1. It has been found that the effective surface mass density $\sigma = \rho_0 R_0/3$ (volume density times volume of ball equals to effective surface density times surface area of the ball for constant volume density) of galactic core region containing possible halo is universal and its value is .9 kg/m^2 (see the article). Pioneer and Flyby anomalies fix the surface density to .8 kg/m^2. The difference is about 10 per cent! One must of course be cautious here: even the correct order of magnitude would be fine since Hubble acceleration parameter might be different for the cluster than for the solar system now.

Note that in the article the effective surface density is defined as $\sigma = \rho_0 r_0$, where r_0 is the radius of the region and ρ_0 is density in its center. The correct definition for a constant 3-D density inside ball is $\sigma = \rho_0 r_0/3$.

2. The dark matter has been found to be inside core region within few hundred parsecs. This is just what TGD predicts since the velocity spectrum of distant stars is due to the gravitational field created by dark energy identifiable as magnetic energy of cosmic string like object - the thread containing galaxies as pearls.

3. It has been observed that there is no dark matter halo in the galactic disk. Also this is an obvious prediction of TGD model.

4. The separation of matter - now plasma clouds between galaxies - and dark matter in the collisions of galaxy clusters (observed for instance for bullet cluster consisting of two colliding clusters) is also explained qualitatively by TGD. The explanation is qualitatively similar to that in the CMD model of the phenomenon. Stars of galaxies are not affected except from gravitational slow-down much but the plasma phase interacts electromagnetically and is slowed down much more in the collision. The dominating dark matter component making itself visible by gravitational lensing separates from the plasma phase and this is indeed observed: the explanation in TGD framework would be that it is macroscopically quantum coherent ($h_{eff} = h_{gr}$) and does not dissipate so that the thermodynamical description does not apply.

   In the case of galaxy clusters also the dark energy of cosmic strings is involved besides the galactic matter and this complicates the situation but the basic point is that dark matter component does not slow down as plasma phase does.

   CMD model has the problem that the velocity of dark matter bullet (smaller cluster of bullet cluster) is higher than predicted by CMD scenario. Attractive fifth force acting between dark matter particles becoming effective at short distances has been proposed as an explanation: intuitively this adds to the potential energy negative component so that kinetic energy is increased. I have proposed that gravitational constant might vary and be roughly twice the standard value: I do not believe this explanation now.

   The most feasible explanation is that the anomaly relates to the presence of thickened cosmic strings carrying dark energy as magnetic energy and dark matter shells instead of 3-D cold dark matter halos. This additional component would contribute to gravitational potential experienced by the smaller cluster and explain the higher velocity.

REFERENCES

Cosmology and Astro-Physics

[E1] Pioneer anomaly. http://en.wikipedia.org/wiki/Pioneer_anomaly.

[E2] J. Anderson et al. Anomalous Orbital-Energy Changes Observed during Spacecraft Flybys of Earth. *Phys. Rev.*, 100, 2008.

[E3] J. D. Anderson et al. The energy Transfer Process in Planetary Flybys. http://arxiv.org/abs/astro-ph/0608087, 2006.

[E4] J. P. Mbelek. Special relativity may account for the space-craft flyby anomalies. http://arxiv.org/ftp/arxiv/papers/0809/0809.1888.pdf, 2008.

[E5] MIT Technology Review. Outstanding problem in Astrophysics. http://www.technologyreview.com/view/506681/fly-by-anomaly/, 2014.

[E6] D. Shiga. Earth's rotation may account for wayward spacecraft. *New Scientist. http://space.newscientist.com/article/dn13411-earths-rotation-may-account-for-wayward-spacecraft.html*, March 2008.

Books related to TGD

[K1] M. Pitkänen. Basic Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time*. Onlinebook. http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#class, 2006.

[K2] M. Pitkänen. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time*. Onlinebook. http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#astro, 2006.

[K3] M. Pitkänen. Quantum gravity, dark matter, and prebiotic evolution. In *Genes and Memes*. Onlinebook. http://tgdtheory.fi/public_html/genememe/genememe.html#hgrprebio, 2014.