

# The 'Pioneer Anomaly'

From G to Delta G

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## **ABSTRACT**

The 'Pioneer Anomaly' describes a deviation from predicted decelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed about  $13 \times 10^9$  kilometres on their trajectories out of the Solar System. This conundrum has been studied widely as it may be due to some unexpected new physical phenomenon, or it may be due to a peculiarity of the satellites. This paper analyses the possibility that the anomaly presents a unique opportunity to study a possible variation in the value of the Gravitation Constant G throughout the universe.

## **Keywords:**

Pioneer Anomaly, Pioneer 10, Pioneer 11, Gravitation Constant, G, V616, V616 Monoceros, V1487 Aquilae, Fundamental Force Particles

## **1) INTRODUCTION:**

It is interesting to note the 'Pioneer Anomaly' is an observed deviation from predicted decelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed about 20 astronomical units ( $13 \times 10^9$  km) on their trajectories out of the Solar System. This has been explained by Herb Rose (1) as:

*"The apparent change in velocity of the pioneer and other satellites after they leave our solar system is not from a change in their energy (where does the energy go or come from?) but the changing of the speed of the radio (electromagnetic waves) they are transmitting in the different electric and magnetic fields outside our solar system. As the satellites travelled through the diminishing strength of the fields in our solar system this was interpreted as greater distance. Once they left these fields emitted by the sun and entered the fields of a neighbouring system their radio signals experience a shift similar to the red and blue shift of light from distant stars. The anomaly is not a result of a change in speed of the satellites but a change in the speed of the radio waves they use to communicate with us."*

And by NASA (2) as:

*"The unexpected slowing of NASA's Pioneer 10 (P10) and 11 (P11) spacecraft – the so-called "Pioneer Anomaly" – turns out to be due to the slight, but detectable effect of heat pushing back on the spacecraft, according to a recent paper. The heat emanates from electrical current flowing through instruments and the thermoelectric power supply. The results were published on June 12 in the journal Physical Review Letters. "The effect is something like when you're driving a car and the photons from your headlights are pushing you backward," said Slava Turyshev, the paper's lead author at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "It is very subtle."*

*Launched in 1972 and 1973, Pioneer 10 and 11 are on an outward trajectory from our sun. In the early 1980s, navigators saw a deceleration on the two spacecraft, in the direction back toward the sun, as the two spacecraft were approaching Saturn. They dismissed it as the effect of dribbles of leftover propellant still in the fuel lines after controllers had cut off the propellant. But by 1998, as the spacecraft kept travelling on their journey and were over 8 billion miles (13 billion kilometers) away from the sun, a group of scientists led by John*

*Anderson of JPL realized there was an actual deceleration of about 300 inches per day squared (0.9 nanometres per second squared, or 9E-010 m/sec/sec). They raised the possibility that this could be some new type of physics that contradicted Einstein's general theory of relativity."*

And,

*"They saw that what was happening to Pioneer wasn't happening to other spacecraft, mostly because of the way the spacecraft were built. For example, the Voyager spacecraft are less sensitive to the effect seen on Pioneer because its thrusters align it along three axes, whereas the Pioneer spacecraft rely on spinning to stay stable.*

*With all the data newly available, Turyshev and colleagues were able to calculate the heat put out by the electrical subsystems and the decay of plutonium in the Pioneer power sources, which matched the anomalous acceleration seen on both Pioneers."*

This raises the question. Why would the heat emissions be directional and pointed in the direction of travel? EM communication transmissions directed back towards Earth should have an accelerating effect?

Despite the technical differences between the two types of satellite craft (Voyager and Pioneer), it is worth considering if a variation in the value of G might provide another explanation to the 'Pioneer Anomaly'.

See conversation with NASA Pioneer Anomaly Investigator Viktor T. Toth at **Appendix-A**

## **2) AN UNIQUE OPPORTUNITY:**

The Pioneer Anomaly provides a unique opportunity to review whether Newton's gravitational constant G only applies to the Solar System, or might G have a different value beyond the Solar System (say G')?

Figure 1, originally appeared in the "Big Bang or Steady State?" paper (3) and depicts the location of the Solar System in relation to our largest and closest black hole at AO620-00/V616 Monoceros. This was calculated to be 3,343 light years from the Sun, and V616 was considered to be the possible source of Earth's primary gravitation field and, is further discussed in the paper, "Natural Gravity". (4)

Currently P10 is heading in the general direction of black hole V616 Monoceros, and P11 is heading towards black hole V1487 Aquilae.

We can concentrate on P10, and assume P11 has a similar experience, but travelling towards a different black hole.

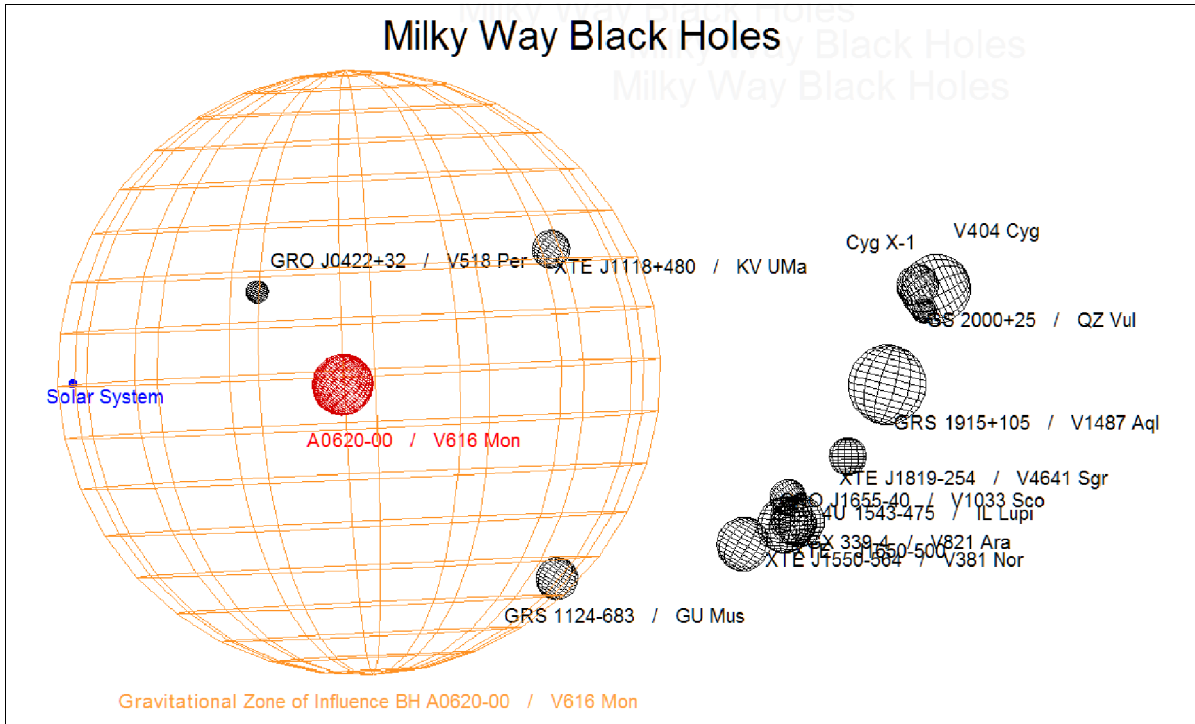


Figure 1.

Satellite slowing possibly occurs, because the P10 G' factor has become slightly higher when applied in the Newton gravity equation  $F=G'Mm/r^2$ . As a result, F becomes larger, and force F in this application is a decelerating force, hence the slowing satellites.

Our Gravispheres paper (5) calculates the influence variations to G can have on mass and time, as illustrated in Figure 2.

It is important to note that only the starting point in the solar system and the end point at V616 are used to construct Figure 2. The intermediate points are proportional positions between the two end points, and in reality may not follow a straight line path.

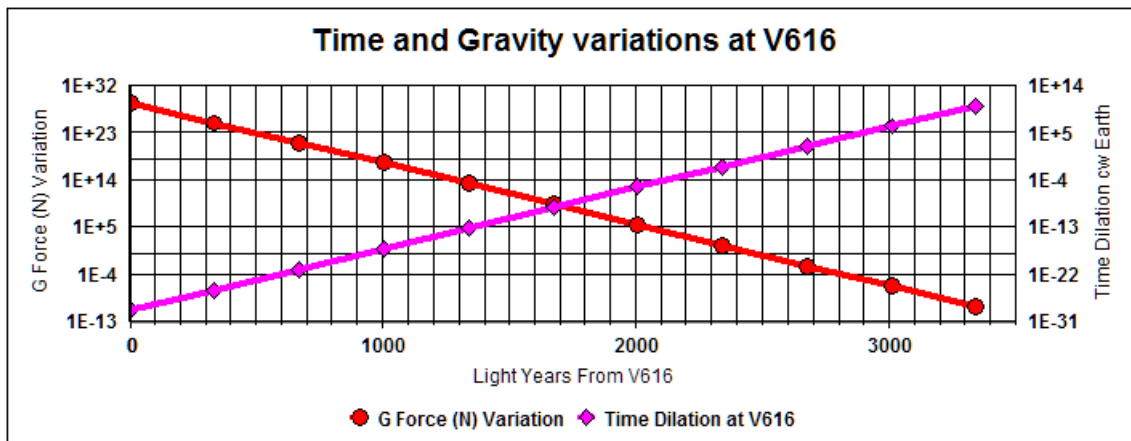


Figure 2.

The G' factor follows Newtonian gravity logic, and the Inverse Square Law. This produces the following exponential curve fit:

$$G' = 6.67428E-011 \times \text{EXP}(Y \times 2.8398479E-018) \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2} \text{ (say N')}$$

where Y is the component distance from the Sun towards V616 in metres. In the P10 example the component distance is close to a vector pointing directly towards V616. A direct heading is therefore assumed.

The P10 distance from the Sun was close to 13 billion kilometres (1.3E+013 metres). This translates to a calculated P10 G' value of 6.67453E-011 N'.

The G constant on Earth is quoted (6) as 6.67428E-011 N' with an error margin of [15], so calculated P10 G' is above the high field error value of 6.67443E-011 N'.

The NASA document reports that P10 satellite showed a slowing anomaly of 9E-010 m/sec<sup>2</sup> which is a comparable scale to P10 G' calculated value of 6.67453E-011 N'. This is relevant as variations to the value of G' are directly related to deceleration, because of the Force = Mass times Acceleration relationship.

The exponential curve fit calculation is one of several possible curves joining the Figure 2 end points. Figure 1 plots locations for several suspected black holes in the Milky Way, all of which add a vector component to the gravity strength of V616, therefore it is unsurprising that the satellite slowing value, and the P10 G' calculated value, are not identical. Satellites heading at right angles to a major black hole are not expected to experience noticeable changes to G.

If P10 G' data is a point on the exponential curve distribution towards V616, at R<sup>2</sup> = 0.99935, the value for G' is:

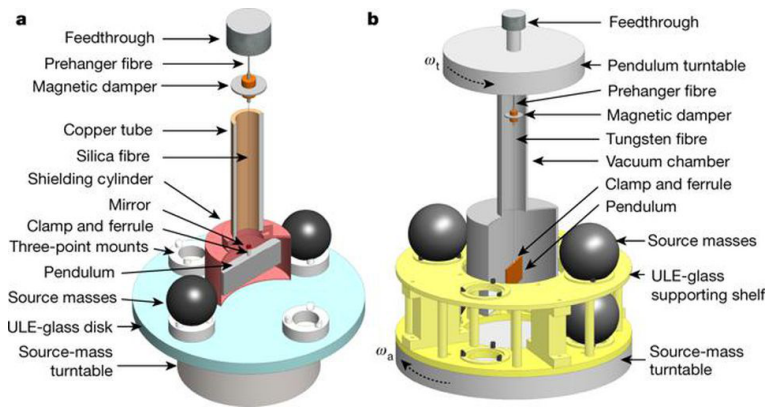
$$G' = 2.4508E-010 \times \text{EXP}(Y \times 2.7987E-018) \text{ N'}$$

The Pioneer satellites will continue to slow while the G vector points towards the Sun, but will start to accelerate again when the G vector direction turns towards V616.

### 3) MEASURING G:

It is noted there is considerable uncertainty in measuring the value of G in a repeatable form as discussed at (7).

*“Torsion balances and torsion pendulums, both inspired by the original Cavendish experiment, continue to lead the way in measurements of G, outpacing the more recent technique of atom interferometry experiments. In fact, just last week, a team from China claimed to get the most precise measurement of G yet from two independent measurements: 6.674184 × 10<sup>-11</sup> N/kg<sup>2</sup>·m<sup>2</sup> and 6.674484 × 10<sup>-11</sup> N/kg<sup>2</sup>·m<sup>2</sup>, with uncertainties of just 11 parts-per-million on each.*



The two methods of experimental setup published at the end of August, 2018, in *Nature*, which yielded the most precise (claimed) measurements of  $G$  to date. Q. Liu et al., *Nature* Vol. 560, 582–588 (2018)

These values may agree with one another to within two standard deviations, but they don't agree with other measurements performed by other teams over the past 15 years, which range from as high as  $6.6757 \times 10^{-11} \text{ N/kg}^2 \cdot \text{m}^2$  and as low as  $6.6719 \times 10^{-11} \text{ N/kg}^2 \cdot \text{m}^2$ . While the other fundamental constants are known to precisions of anywhere between 8 and 14 significant digits, uncertainties are anywhere from thousands to billions of times greater when it comes to  $G$ .”

This issue alone justifies discretion when considering  $G$  as a universal constant. If it is so hard to define an exact figure for  $G$ , then maybe it is not a constant, but a value that varies over time, due to natural causes.

The Gravispheres paper suggests that  $G$  be regarded as a vector force directed towards V616. While V616 is many light years away, gravity is recognised as one of two fundamental force particles which have infinite range as shown in Figure 3,(8) with the second being the force of electromagnetism.

#### Fundamental Force Particles

Force	Particles Experiencing	Force Carrier Particle	Range	Relative Strength*
<b>Gravity</b> acts between objects with mass	all particles with mass	graviton (not yet observed)	infinity	much weaker ↓ much stronger
<b>Weak Force</b> governs particle decay	quarks and leptons	$W^+, W^-, Z^0$ (W and Z)	short range	
<b>Electromagnetism</b> acts between electrically charged particles	electrically charged	$\gamma$ (photon)	infinity	
<b>Strong Force**</b> binds quarks together	quarks and gluons	$g$ (gluon)	short range	

Figure 3.

#### **4) CONCLUSIONS:**

- 4.1 Gravitational attraction experienced throughout the universe appears to be a combination of the fundamental force particles of Gravity and Electromagnetism.
- 4.2 The “Pioneer Anomaly” may prove to be the first verified manifestation of the variable nature of the ‘Newtonian Constant’ G. This would constitute a ‘new form of physics’, and show significant impact on astrophysics.
- 4.3 The space distribution for the value of G appears to be a complicated array of vectors associated with black hole influences, relative to their size and distance.
- 4.5 The Pioneer satellites will continue to slow while the G vector points towards the Sun, but will start to accelerate again when the G vector direction turns towards V616.

#### **5) REFERENCES:**

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## Appendix - A

Viktor T. Toth NASA Pioneer Anomaly Investigator discussion:

-----Original Message-----

From: Robert Beatty <bobbeatty@tpg.com.au>

Sent: Monday, April 13, 2020 2:13 AM

To: vttoth@vttoth.com

Subject: Pioneer Anomaly

Dear Viktor,

I see you have studied this subject extensively and wondered if you considered possible variations in the value of the universal constant  $G$ ?

My work on this subject is available at <https://bosmin.com//PSL/PioneerAnomaly.pdf>

Best regards,

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14/4/2020

Dear Robert,

Indeed, the possibility of variable- $G$  was considered. Temporal variations of  $G$  are excluded by other solar system data (in particular, precision monitoring of Cassini put extreme stringent limits on an temporal variability.) Spatial variations of  $G$  (or "effective  $G$ ", as it appears in modified gravity theories) can, of course, play a role, but it is still not easy to reconcile with the orbits of the outer planets and Kuiper-belt objects.

I caution you though that the Pioneer anomaly is really dead. It arose in the first place because the nature of the thermal behavior of the spacecraft was misunderstood. First, it was naively assumed that a thermal recoil force should follow the temporal behavior of the Pu-238 fuel (this is not the case, the much more complex behavior of the electrical system on board and its time-varying efficiency must be accounted for) and second, the magnitude of the thermal recoil force was significantly underestimated using essentially "hand waving" arguments. Once these errors in the analysis are corrected, the spacecraft's trajectory is consistent with known physics and no anomaly remains.

Viktor