

Mach's Principle and the Anomalous Force on Pioneer 10 and 11 Spacecraft

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Figure 1. Pioneer 10 and 11 Spacecraft [1].

[First published March 31, 2014 in Chapter 11 of the book **The Universal Force Volume 1, Version 5—Derived from a More Perfect Union of the Axiomatic and Empirical Scientific Methods [2]**. First presented at a Natural Philosophy Alliance (NPA) international video conference on February 1, 2014 [3]].

Abstract. In a previous paper [4] Mach's Principle was shown to originate from one of the weaker terms in the hierarchy of electromagnetic interactions involving vibrating neutral electric dipoles. From the derivation of the forces of inertia and gravity from the universal electrodynamic force, mass was no longer found to be a fundamental entity. What was called mass in the past represents a grouping of nearly constant electrodynamic parameters associated with vibrating neutral electric dipoles. The derived value of the inertial mass changes with distance from the center of the universe in accordance with Mach's Principle. Local asymmetries also cause inertial mass to change with distance from the center of spiral galaxies, with distance from a star at the center of the solar system, and with distance from a planet to its moon. The anomalous force on the Pioneer

10 and 11 spacecraft at the outer edge of our solar system is in full agreement with Mach's Principle as defined in electrodynamics.

Introduction. The Standard Model of Cosmology based on General Relativity Theory and the Copenhagen version of quantum mechanics are both based upon the point particle idealization plus the idealization that space is homogeneous and isotropic with no structure or organization. As a result these theories are unable to explain the higher than expected constant velocities of the outer spiral arms of spiral galaxies and the expansion of the universe without introducing dark matter and dark energy comprising about 95 percent of the universe. Dark matter and dark energy are additional idealizations. Dark matter has not been seen in any laboratory experiments. In some sense one could say that the introduction of dark matter was used as a gigantic fudge factor to rescue General Relativity Theory.

In competition with the Standard Model of Cosmology is the derived electrodynamic force for real finite size charge structures which appears fully capable of replacing Maxwell's electrodynamics, Einstein's Special and General Relativity Theories, and the Copenhagen version of quantum mechanics. It has been declared to be the universal force following Newton's rules for arriving at the universal force. In **The Universal Force Volume 1** [2] this universal electrodynamic force was able to explain very precisely the velocity, luminosity and other properties of the outer spiral arms of spiral galaxies, not by introducing more idealizations, but by removing them so that the physical structure and symmetry of the universe is taken into account!

Now NASA has released data concerning an anomalous force observed on both Pioneer 10 and 11 spacecraft in our solar system. The dark matter and dark energy introduced to explain the higher than expected velocity of the outer spiral arms of spiral galaxies does not predict this data. Can the electrodynamic approach also explain this data without introducing fudge factors? **The answer is yes!**

Pioneer 10 and 11. Pioneer 10 and 11 spacecraft were launched in the early 1970's. As they traveled away from the Sun, they slowed down. Most of this slowing was expected due to the gravitational pull of the Sun and other massive objects in the solar system. But even when everything in the solar system whose mass could have had any effect on the Pioneers was accounted for, both spacecraft were found to be slowing more than expected. The excess slowing was very tiny, but measurable.

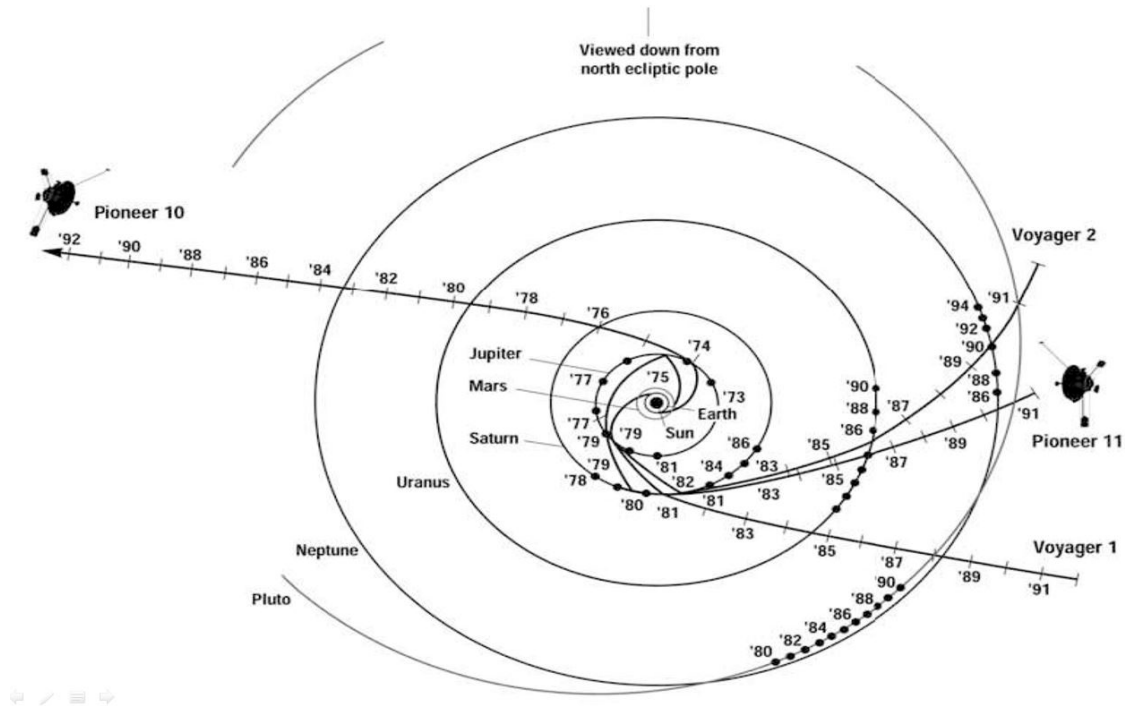


Figure 2. Pioneer 10 and 11 Trajectories [5]

Figure 2 is a diagram of the orbits of the Pioneer 10 and 11 plus Voyager 1 and 2 space craft. Note that Pioneer 10 is going to the left in its orbit about the sun. Pioneer 11 is going to the right in its orbit about the sun. Pioneer 11 is going by a number of the planets, but Pioneer 10 is not.

When Pioneer 10 had travelled a long way from the sun NASA scientists first noticed the anomalous acceleration. By that time it had reached a constant maximum value. This experimental data was very upsetting, because this anomalous acceleration measured by NASA could not be explained by any accepted theory. The dark matter solution for the spiral galaxies did not seem to help in this case.

Then in 2012 a solution was announced. There was an anisotropic (not symmetric in all directions) thermal radiation being emitted by the spacecraft plutonium power supply. [6] Calculations showed that this effect would be relatively constant but slowly decaying over time as the nuclear power diminished over time. However, when the Pioneer 11 data was released, it showed that the anomalous acceleration was inconsistent with the prediction of constant value slowly decaying with time (or distance from the sun) due to anisotropic heat dissipation.

Note from Figure 3 the rise of the anomalous acceleration from 5 to 20 AU before the slow decline. This rise was inconsistent with the thermal explanation.

UNMODELED ACCELERATIONS ON PIONEER 10 AND 11
Acceleration Directed Toward the Sun

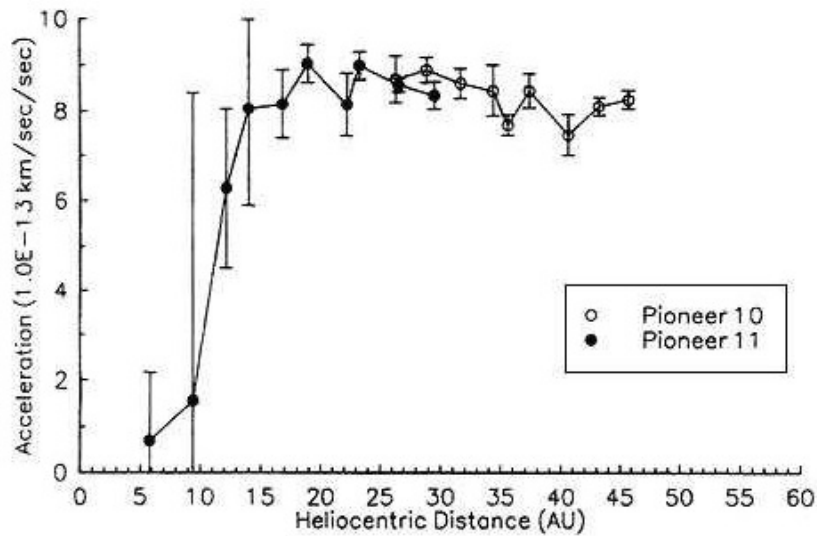


Figure 3. Anomalous Acceleration on Pioneer 10 and 11 [7]

Thus the Standard Model of Cosmology and General Relativity Theory still have a problem to be resolved. Does the universal electrodynamic force approach have a solution based on the structure and symmetry of the universe? **Yes!**

Electrodynamic Solution. From the previous paper on “Mach’s Principle and the Concept of Mass” the inertial and gravitational forces are written in terms of local anisotropic terms and distant universal isotropic terms. See equations 4-10 in that paper [4]. There the total acceleration is expanded in terms of the small isotropic acceleration a_s divided by the local anisotropic acceleration a_0 . In general one does not expect any significant contribution to the anomalous acceleration until the local anisotropic acceleration weakens to be more comparable to the smaller universal isotropic acceleration term. The rapid rise of the curve after a certain distance from the sun to a maximum with a slow decline as a function of distance from the sun after that would be predicted. In the Pioneer 10 and 11 missions the anomalous acceleration was measured as shown in Figure 3 [7]. It was found to have a constant value of $(8.74 \pm 1.33) \times 10^{-10} \text{ m/s}^2$. This is of similar magnitude as the acceleration of $6.0 \times 10^{-11} \text{ m/s}^2$ observed in the spiral galaxies. See Figure 4. Also the acceleration increases with distance from the center of our solar system until it reaches a maximum in the same manner as the difference between the MOND and Newtonian velocities of Figure 4. Thus Mach’s Principle along with the electrodynamic definition of the inertial and gravitational mass appears to be able to explain both the spiral galaxy and the Pioneer anomaly phenomena.

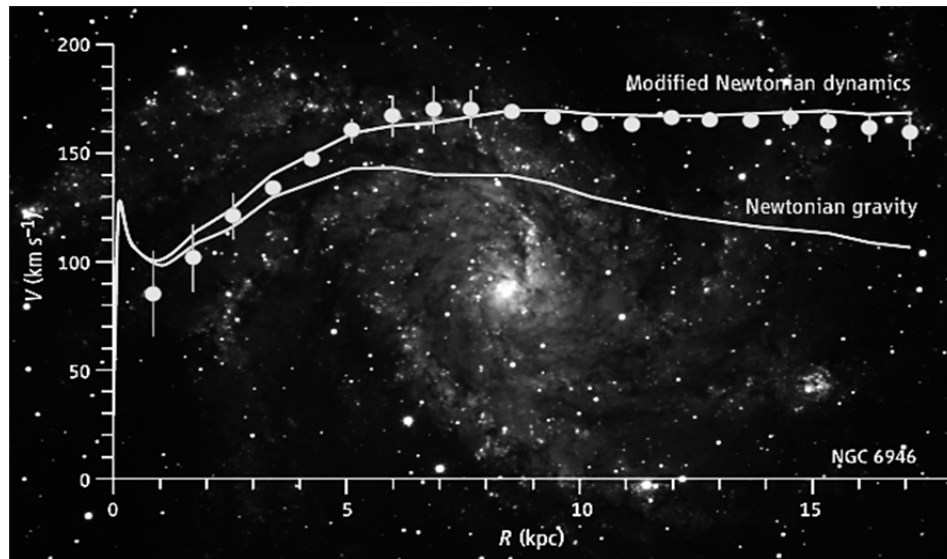


Figure 4. NGC 6946 Spiral Galaxy Graph of Rotational Velocity vs. Distance from Center [8]

The difference in the magnitude of the observed accelerations is due to different distances from the center of the universe and the fact that our solar system is part of the central disk of the Milky Way galaxy, instead of an outer spiral arm, since our sun is not in the outer spiral arms of the Milky Way galaxy. Thus we need to take into account the contribution of the rest of the Milky Way galaxy to the local anisotropic terms for Mach's Principle. This causes the anomalous acceleration to be larger than observed much farther out in other spiral galaxies.

Conclusions. Mach's Principle originates in the electromagnetic force involving vibrating neutral electric dipoles. This force was not noticed by experimenters in the past because the dipole-dipole force is a weak $(v/c)^4$ effect that is only 10^{-39} as strong as the electrostatic Coulomb force.

General Relativity Theory assumes that the universe is homogeneous and isotropic without any shape. The Microwave Cosmic Background Radiation plus the associated Doppler red and blue shifts of Atomic Spectra reveals that the universe does have a structure. Mach's Principle reveals that Einstein's **Principle of Equivalence** in General Relativity Theory is invalid by showing how the structure of the universe enters into the physical laws for gravity and inertia. Gravitational and inertial mass are not the same and do not have the same values. General Relativity Theory's imperfections are further revealed in the necessity to have over 95% of the universe consisting of dark matter and dark energy in order to explain the phenomena that Mach's Principle explains so simply. Also dark matter and energy, unlike regular mass and energy, are not observable in the laboratory.

Thus we see those theories like Einstein's Special and General Relativity Theory totally miss the grand structure and symmetry of the universe by being based on idealizations such as the point particle idealization and the idealization that the universe is homogeneous and isotropic.

The Copenhagen version of quantum mechanics also uses these same two idealizations in order to be able to describe the universe in terms of the universal wave function. In a future paper we will show that black bodies made of various atoms do *not* all act the same following Planck's Law, but instead are unique for each material. Thus the notion that nature can be described by an idealized universal wave function is not valid. A true quantum mechanical theory must be built in terms of the finite size structures in atoms and their symmetry.

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