

## SECTION 7

### *The Pioneer Anomaly*

#### REVIEW OF THE PIONEER ANOMALY

The "anomalous acceleration" of the Pioneer 10 and 11 spacecraft was first reported in 1998. A weak, long-range acceleration toward the Sun had been observed in the Pioneer spacecraft. No satisfactory explanation has been found in spite of diligent efforts by a number of groups of scientists.

Pioneer 10 and 11 were launched in approximately opposite directions relative to the Sun and on paths that were to take them out of the Solar system. They were launched in 1972 and 1973 respectively and provided data into July 1998 and July 2000 respectively when they were far out at the extreme of the Solar System.

Each of them was spin stabilized with the spin axes running through the center of the dish antennae. That and their great distances from the Earth minimized the number of Earth-attitude reorientation maneuvers required, which enabled the precision of the acceleration data.

Conclusions reported with regard to the "Pioneer anomalous acceleration", notated as  $a_p$ , are as follows.

1. It is a real acceleration not pseudo.
2. It occurs in both Pioneer 10 and Pioneer 11 and is the same in both.
3. The researchers can find no mechanism or theory that explains it.
4. It is a line of sight constant acceleration of the spacecraft toward the Sun; that is, while always directed toward the Sun the magnitude of the acceleration, unlike the Sun's Newtonian gravitation, does not vary with distance from the Sun.
5. The measured magnitude of the acceleration was found to be per equation (7-1).

$$(7-1) \quad a_p = (8.74 \pm 0.94) \times 10^{-8} \text{ cm/s}^2.$$

6. That result is in agreement, within its precision, with the anomalous acceleration  $a_A = 8.4 \cdot 10^{-8} \text{ cm/sec}^2$ , for the galactic rotation curves of Figure 6-5.

7. Sources of systematic error:

- external to the spacecraft [e.g. solar wind, radiation]; and
- internal to the spacecraft [e.g. gas leakage]; and
- in the computational system [e.g. model accuracy, consistency]

have all been thoroughly addressed and are reflected in the equation (7-1) error range.

The Pioneer Anomalous Acceleration

The Pioneer Anomaly is a small acceleration of  $(8.74 \pm 0.94) \times 10^{-8} \text{ cm/sec}^2$ , centrally directed [toward the Sun], constant, distance independent, and of unknown cause. The evidence for it is abundant tracking data that have been reviewed and re-reviewed in search of error with the result that the effect is highly validated.

If caused by the universal exponential decay the anomalous acceleration would be the same as the rate of change [decay] of the speed of light,  $c$ , as follows. The decay of  $c$  is as equation (7-2) and its rate of change is equation (7-3).

$$(7-2) \quad c(t) = c(0) \cdot e^{-t/\tau}$$

$$(7-3) \quad \frac{d[c(t)]}{dt} = -\frac{c(0)}{\tau} \cdot e^{-t/\tau}$$

$$\frac{d[c(\text{now})]}{dt} \equiv \frac{dc}{dt} = -\frac{c(\text{now})}{\tau} \cdot e^{-[0/\tau]} = -\frac{c(\text{now})}{\tau} = -\frac{c}{\tau}$$

Its value, using the value for  $\tau$  of equation (3-10), is equation (7-4).

$$(7-4) \quad \frac{dc}{dt} = -\frac{c}{\tau} = -\frac{2.99792458 \cdot 10^{10} \text{ cm/s}}{3.57532 \cdot 10^{17} \text{ s}} = -8.38505 \cdot 10^{-8} \text{ cm/s}^2$$

That result is in agreement, within their precision, with the reported anomalous acceleration inward of equation (7-1) and with the inward anomalous acceleration  $a_A = 8.4 \cdot 10^{-8} \text{ cm/sec}^2$ , for the galactic rotation curves of Figure 6-5. That validates that the effect is caused by the universal decay and validates the factor,  $F$ , and the time constant,  $\tau$  of Section 3.

The only difference between the Pioneer Anomaly acceleration and the galactic rotation curve anomalous acceleration is that in the Pioneer case the acceleration is directed toward the Sun, the dominant factor in the mechanics of the Pioneer spacecrafts' motion whereas the galactic rotation curve anomalous acceleration is directed toward the rotational center of the galaxy, the dominant factor in the mechanics of galaxy rotation.

Next: The Flybys Anomaly



