An Explanation of Mercury's Perihelion Shift by Asteroid Impact

Wolfgang Westenberger

SUMMARY: Heavy asteroid impacts can explain the perihelion shift of Mercury. As the kinetic energy of both Mercury and any asteroid is known, vector analysis of the deviation may be carried out. Pendulum experiments are bearing out vector analysis.

INTRODUCTION.

In 1859, Urbain Le Verrier recognized in Paris that the precession of Mercury's perihelion could only partially be explained by the gravitational influence of other planets. The cause of a deviation of 38 arcseconds was unknown. Today the exact amount of the gap was shown to be 43“. Le Verrier supposed a causal physical explanation by postulating another planet closer to the Sun than Mercury, named Vulcan. Some years before he had been successful by postulating another planet beyond Uranus. On the basis of his calculations of the deviation of Uranus, Neptun was detected. But up to now Vulcan was not detected, we know it doesn't exist.

Mercury is the planet closest to the sun.
It is the smallest of all eight planets, its diameter is 4,880 km, less than half of the Earth's, and its mass about 6 % of the Earth's. As a comparison, the mass of Jupiter is about 6,360 times greater.
Mercury's orbital period is 88 Earth days. So during 100 Earth years Mercury will orbit the Sun about 415 times. One day on Mercury will last 59 days on Earth. There is a 3 : 2 spin-orbit resonance, synchronized by the Sun's gravitational force. Thus the orbit of Mercury is gravitationally locked.

In 1974, NASA spacecraft Mariner 10 made visible the surface of Mercury for the first time, showing it is cratered by different asteroid impacts, similar to the aspect of the Moon. In the early age of the solar system, from the beginning at 4.5 billion years ago up to about 3.8 billion years ago, Mercury was heavily bombarded by asteroids. On its surface the effects are visible as huge craters and basins. The greatest of them, called the Caloris Basin, is the effect of one of the biggest impacts in the Solar System. Its diameter is about 1,550 km. This would cover the state of Texas or middle Europe.

Asteroid impacts occured during the whole period of the Solar System and they are occuring nowadays. For example the Chelyabinsk impact in 2013 by an object of about 20 m in diameter and a weight of more than 10,000 tons, exploding in the air.
The Barringer Crater in Arizona is 1,300 m in diameter, caused by an impacting body of 50 m and 500,000 tons. Today such an impact would cause millions of dead persons.
65 million years ago, the age of dinosaur was cut short by an asteroid of 10 km. Its crater was 180 km in diameter.

The asteroid that caused the Caloris Basin on Mercury was an object of 100 to 150 km in diameter and it hit Mercury about 4 billion years ago.
Asteroids of one km size are supposed to hit the Earth each 1 million years, asteroids of 10 km each 100 million years.

About 200 years ago it was nothing but an outsider idea that stones may fall from the sky to the Earth, and the scientific community smiled at this theory.

COLLISION. VECTOR ANALYSIS.
Knowing the kinetic energy of two objects we may calculate the effect of their collision.
The mass of Mercury is 3.3 * 10^23 kg and its velocity in a range of 40 to 60 km/s. Its kinetic energy we get by half mass multiplied by the square of velocity = $(m/2) * v^2$.
So it is 1.65 * 10^23 kg * 50^2 * 10^6 m^2/s^2 = 4.125 * 10^32 J.

Two objects of the same kinetic energy, colliding at an angle of 90° and uniting themselves to a single object will move on at an angle of 45° as shown by vector analysis.

The size of the Caloris Basin asteroid was calculated at 100 to 150 km in diameter according to a mass of 1.5 to 5.1 * 10^18 kg. The velocity is supposed at 85 km/s. So the kinetic energy may be calculated by 2 * 10^18 kg * 85^2 * 10^6 m^2/s^2 = 2 * 7,725 * 10^24 m^2/s^2 = 1.445 * 10^28 J.

The relation between the kinetic energy of both objects is about 10^4. Now we may calculate the deviation of Mercury by vector analysis, presupposing an angle of 90° between the tracks of collision.
So we get the kinetic energy of the asteroid as the opposite leg of the right-angled triangle and that of Mercury as the adjacent leg.
So the tangent is 1.445 * 10^28 / 4.125 * 10^32 = 0.35 * 10^-4. From that it follows that the resulting angle is 0.002°.
The resulting deviation of Mercury by the asteroid impact is 0.002°, on the preliminary assumption that the total kinetic energy of the asteroid was transformed into the deviation of Mercury.

The part of perihelion shift which is not due to gravitational influence of other planets is 43“ per 100 years, that's 0.012°/415 revolutions = 0.000029° deviation of the Mercury orbital axis per revolution.

We are surching for a force that had caused the deviation of Mercury's axis in the range of 0.000029°, according to astronomic observations.
And we find a force that can explain a deviation of up to 0.002°, that's 69 times more than required.

Thus the kinetic energy of Caloris Basin asteroid was much greater than necessary to cause the deviation of Mercury. Even if most of the energy was absorbed by tectonic destruction there was more than enough power to cause the perihelion shift of Mercury.

Or from another point of view: A heavy right-angled asteroid impact will cause tectonic destruction as well as deviation of Mercury's track. If the degree of destruction requires a certain amount of an asteroid's kinetic energy, another part of its energy will cause the deviation. Therefore, to explain both effects, destruction as well as deviation, the asteroid had some more size than necessary to explain tectonic destruction alone.

Because of the conservation of the angular momentum a continuing shift is resulting.

EXPERIMENTAL CONFIRMATION BY PENDULUM EXPERIMENTS.

Imagine a simple pendulum experiment. Or you may carry it out yourself. Hanging up an object of metal or stone by a string, free-moving at the ceiling, setting the object swinging and then causing an impact from the side, you will get a deviation of the long axis of the pendulum's track, directly proportional to the energy of the impact. And you will see the swinging object performing a continuing shift or precession as long as the pendulum keeps swinging.

Like the perihelion shift of Mercury.

We recognize that the permanent shift of an orbiting object in vacuum is another movement of inertia, like Newton's rectilinear inertia, or the orbiting inertia of the stars orbiting the galactic centre or of the planets orbiting the Sun, or like the rotational inertia of any celestial body.

400 years ago it would already have been possible to carry out these simple pendulum experiments.

DISCUSSION.

The stars of our Milky Way are orbiting the galactic centre on almost perfect circuits.

In contrast to this, the planets of our Solar System are orbiting on elliptic tracks, as J. Kepler showed [1]. The eccentricity of the Earth is small (0.017), that of Mars is greater (0.093), that of Mercury is greatest (0.206). The inclination of the planets to the ecliptic is also different. We find the biggest difference at Mercury (7°).

It is reasonable to suppose that the eccentricity of the elliptic tracks as well as the inclination of the planets to the plane of the Solar System is due to heavy collisions in the early Solar System age.

And there are good reasons why both eccentricity and inclination are biggest at Mercury. We know that Mercury is the smallest and the lightest planet, that's diminishing its kinetic energy. On the other hand every asteroid will get increasing kinetic energy near Mercury. The nearer it comes to the Sun the more its velocity will increase according to Kepler's laws, and Mercury is the planet closest to the Sun. So if any asteroid hits Mercury, its effect on behalf of deviation will be greater due to increased kinetic energy of the asteroid versus diminished kinetic energy of Mercury.

Therefore it is unsurprising that because of asteroid impacts the perihelion shift of Mercury is also maximum of all planets.

And we know there was indeed an extraordinary heavy impact showed by the Caloris Basin.

It is remarkable that the result of the vector analysis above is fitting the observations of the perihelion shift, confirming physical causality between impact and precession.

Based on theoretic consideration as well as on the obvious results of appropriate pendulum experiments, there are convincing reasons to suppose that an asteroid impact will cause continuing precession, not only a one-time deviation.

On the other hand it is not necessary to prove the effect of exactly 43“. For we don't know the angle of the impacting asteroid nor its exact mass and velocity. We don't know whether Mercury had lower or higher speed than average at the moment of the impact. And we don't know the subdivision of the effects of the impact like tectonic destruction or deviation on behalf of eccentricity, inclination and precession. And of course there may be additional effects by other impacts, visible by other huge craters like Tolstoj Basin, Beethoven Basin and so on.

Perhaps the gravitational force of the Sun is stabilising the perihelion shift, as the 3 : 2 spin-orbit resonance is synchronized by the Sun. Thus the perihelion shift of Mercury, once started by impact, may also be gravitationally locked.

The calculations above show that a heavy asteroid has got enough energy to change the track of Mercury by transmission of kinetic energy to Mercury, according to the scale of observations.

It should be mentioned that in 1915 A. Einstein presented in Berlin a way to calculate exactly the gap of the unexplained perihelion shift of 45“ [2]. At that time the gap was supposed to be 45“, whereas today the most exact amount is 43“. Since that time many people say that Einstein explained and “predicted“ the perihelion shift. (And some are even convinced that he surely would have “predicted“ the correct amount of 43“, if he had known it.)
However these calculations were not based on physical causality.

If at this time, about 100 years ago, there had been more information and knowledge about asteroid impacts and about the surface of Mercury, one surely had taken into account that asteroid impacts are able to cause Mercury's perihelion shift.

REFERENCES.

[1] Kepler J 1609: Astronomia nova

[2] Einstein A 1915 in SBII (p. 831-839): Erklärung der Perihelbewegung des Merkur aus der allgemeinen Relativitätstheorie