406(2): Find Version of Nolle 406(1)

From Marion and Thornton, 3rd edition, the observed precession of the Earth is:

$$\Delta\phi(\text{obs}) = (5.0 \pm 1.2)'' \text{ per earth century} \quad -(1)$$

(Table 7.2 third edition). The semi-major axis is:

$$a = 1.495 \times 10^{11} \text{ m} \quad -(2)$$

and the eccentricity is:

$$\epsilon = 0.0167 \quad -(3)$$

(Table 7.1). Use:

$$1'' = 4.84814 \times 10^{-6} \text{ radians} \quad -(4)$$

and the observed precession is:

$$\Delta\phi(\text{obs}) = 0.05'' \text{ per earth year} \quad -(5)$$

$$= 2.424 \times 10^{-7} \text{ radians per year} \checkmark$$

(double checked).

The result of EGR is given in Eq. (7.84c):

$$\Delta\phi_E = \frac{6\pi mG}{ac^2(1-\epsilon^2)} \quad -(6)$$

where the standard model's Schwarzschild radius of the sun is

$$r_s = \frac{2mG}{c^2} = 2.95 \times 10^3 \text{ m.} \quad -(7)$$

Fm eq. (3) $\epsilon^2 = 2.79 \times 10^{-4}$ $-(8)$

so to an excellent approximation:

$$\Delta\phi_E = \frac{3\pi \times 2.95 \times 10^3}{1.495 \times 10^{11}} \quad -(9)$$

$$= 1.86 \times 10^{-7} \text{ radians per earth year}$$

This is a bit less than the observed result, and EGR does not give precise agreement.

2) Table: Comparison of Observed and EGR Precessions for Mercury and Earth (radians per Earth year)

planet	$\Delta\phi$ (obs)	$\Delta\phi$ (Einstein GR)
Mercury	2.09×10^{-6}	2.08×10^{-6}
Earth	2.42×10^{-7}	1.86×10^{-7}
Venus	4.07×10^{-7}	4.19×10^{-7}

It is seen that there is no "precise agreement". Furthermore, EGR neglects to take into account the geodetic and Lense-Thirring precessions, so is completely wrong. Table 7.1 in Maria and Thornton is useful for further calculations. Table 2

planet	a in astronomical units*	ϵ	T (earth years)
Mercury	0.3871	0.2056	0.2408
Venus	0.7233	0.0068	0.6152
Earth	1.00	0.0167	1.000
Mars	1.5237	0.0934	1.8809
Jupiter	5.2028	0.0484	4.6035
Saturn	9.5388	0.0557	29.458
Uranus	19.182	0.0472	84.013
Neptune	30.058	0.0086	164.794
Pluto	39.518	0.2486	248.430

*One astronomical unit = 1.495×10^{11} m

3) The precession of any planet can be calculated from the orbit precession using:

$$\Delta\phi_p = \left(\frac{1}{a_p T}\right)\Delta\phi_E \quad -(10)$$

where T and a_p are in the astronomical units of Table 2, and

$$\Delta\phi_E = 1.86\times10^{-7} \text{ radians per earth year} \quad -(11)$$

So for Mercury

$$\Delta\phi = \frac{1.86\times10^{-7}}{0.387\times0.241} = 1.99\times10^{-6} \quad -(12)$$

radians per earth year

and for Venus:

$$\Delta\phi = \frac{1.86}{0.7233\times0.615}\times10^{-7} = 4.18\times10^{-7}$$

radian per earth year

Note that here is quite a large difference for the precession of Mercury from Tables 7.1 and 7.2 of Moira and Thomas, this is because eq (10) was $\epsilon \sim 0$.

Proceeding in this way, the planetary precessions from EGR are as follows, in radians per earth year.

Planet	$\Delta\phi$(EGR)	$\Delta\phi$(observed)[1]	Total $\Delta\phi$(obs)*
Mercury	2.08×10^{-6}	2.09×10^{-6}	2.79×10^{-5}
Venus	4.19×10^{-7}	4.07×10^{-7}	1.38×10^{-5}
Earth	1.86×10^{-8}	2.42×10^{-7}	5.55×10^{-5}
Mars	6.49×10^{-9}		7.89×10^{-5}
Jupiter	7.77×10^{-10}		3.18×10^{-5}
Saturn	6.61×10^{-10}		9.45×10^{-5}
Uranus	1.15×10^{-10}		1.62×10^{-5}
Neptune	3.76×10^{-11}		1.76×10^{-5}
Pluto	1.89×10^{-11}		

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1) Attributed to EGR after extracting the planetary planets &c.