# PERIHELION SHIFT - A COUPLE OF EXAMPLES

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Reference: Moore, Thomas A., *A General Relativity Workbook*, University Science Books (2013) - Chapter 11; Problems 11.02-03.

The precession of an object's closest approach in its orbit around a central mass can be applied to other situations as well. For example, if we have a satellite orbiting Earth we can use the values:

$$GM = 4.44\times10^{-6}\text{ km} \tag{1}$$

$$r_c = 6500\text{ km} \tag{2}$$

$$T = 90\text{ min} = 1.711\times10^{-4}\text{ years} \tag{3}$$

We get

$$\Delta\phi = \frac{6\pi GM}{r_c}\left(\frac{180}{\pi}\text{deg rad}^{-1}\right)\left(3600\text{ arcsec deg}^{-1}\right)\left(\frac{100}{1.711\times10^{-4}}\text{orbits century}^{-1}\right) \tag{4}$$

$$= 1552\text{ arcsec century}^{-1} \tag{5}$$

As a more extreme example, suppose we're orbiting a neutron star with $GM = 2.0$ km at a distance of $r_c = 400$ km. This time we'll just find the periastron shift in one orbit. This is

$$\Delta\phi = \frac{6\pi GM}{r_c} = 0.0942\text{ radians} = 5.4^\circ \tag{6}$$

To find the shift per unit time as viewed by an observer at infinity, we need to find the period as seen by this observer. This can be found from the angular speed

$$\Omega = \sqrt{\frac{GM}{r_c^3}} \tag{7}$$

$$= 1.768\times10^{-4}\text{ km}^{-1} \tag{8}$$

$$= \left(1.768\times10^{-4}\right)\left(2.99\times10^{5}\right) = 52.86\text{ sec}^{-1} \tag{9}$$

The period is then

$$T_{\infty}=\frac{2\pi}{\Omega}=0.1189\text{ sec} \tag{10}$$

The periastron shift is then

$$\Delta\phi_{\infty}=\frac{0.0942}{0.1189}=0.792\text{ rad sec}^{-1} \tag{11}$$

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