Notes <u>106(3)</u>: <u>Orbits</u> of <u>Binary</u> <u>Pulsars</u>

The first binary pulsar was found in 1974 by Hulse and Taylor. In 2004 a second one was found at Jodrell Bank. The HT pulsar consists of a pulsar (a neutron star) with a pulsation period of 59 milliseconds and a second neutron star in an elongated orbit of period 7.75 hours. Each neutron star is 1.4 million times the mass of the sun. The orbit is gradually shrinking by about 3.1 mm per orbit. In 300 million years the two stars will collide. The orbital precession is 4.2° a year. In ECE <u>theory</u> a <u>constant</u> orbital precession is given by a constant T/R:

$$-\frac{T}{R} = \frac{2MG}{c^2} := r_s \quad -(1)$$

However, the orbit of the binary pulsar is a spiral inwards towards each other, so $-T/R$ is not constant. <u>It</u> is time dependent. This means that the energy:

$$V(r) = \frac{mc^2}{2}\left(-\frac{r_s}{r} + \frac{a^2}{r^2} - \frac{r_s a^2}{r^3}\right) \quad -(2)$$

<u>is</u> <u>getting</u> smaller <u>with</u> <u>time</u>.

Here:

$$\frac{mc^2}{2} a^2 = \frac{L^2}{2m}, \quad -(3)$$

$$\frac{mc^2}{2} a^2 r_s = \frac{GML^2}{c^2 m} \quad -(4)$$

2) In the standard model this loss of potential energy is postulated to be gravitational radiation. For several reasons this postulate is incorrect. Therefore we replace it by a modelling of T/R, which is given more fully in papers 105 and notes 106(1) and 106(2).

In ECE theory the advance of the perihelia is given by:

$$\delta\phi = -\frac{3\pi}{A(1-e^2)}\left(\frac{T}{R}\right) \quad -(5)$$

which is calculated from an angular frequency:

$$\omega_r^2 = \frac{1}{m}\left(\frac{d^2V}{dr^2}\right)_{r = r_{outer}}$$

$$\boxed{\omega_r^2 = \omega_\phi^2\left(1 - \frac{3r_s^2}{a^2}\right)^{1/2}} \quad -(6)$$

with r_s given by eq. (1).

Computer Graphics

1) From eq. (6) graph ω_r^2 against t with R/T modelled as a function of time. As the two stars spiral inwards, ω_r^2 will increase. Fit to the experimental data of -3.1 mm per orbit.

3)

2) The equation of motion of a mass m orbiting a mass M is:

$$V = \frac{1}{2} m \left(\frac{dr}{d\tau}\right)^2 = \left(\frac{E^2}{2mc^2} - \frac{1}{2}mc^2\right) + \frac{GMm}{r} - \frac{L^2}{2mr^2} - 2\left(\frac{T}{R}\right)\frac{L^2}{mr^3} \quad (7)$$

Graph V as a function of time dependent T / R.

A time dependent V/R arises from a time dependence of the spin connection, in the simplest case

$$\boxed{\omega_r = \frac{T}{R} = -\frac{1}{r}} \quad (8)$$

For universal gravitation this is constant, however in the case it is time dependent, i.e. Newton's laws are slowly changing with evolution (Pioneer anomaly).