TOCK (1975) gelang, ist es möglich geworden, diese Frage zu prüfen. Da für Vela XR-1 Radialgeschwindigkeitskurven sowohl für den optischen Hauptstern wie für die Röntgenquelle vorliegen, ist das Massenverhältnis direkt bestimmbar. Einem Übersichtsreferat von Vidal (1975) kann man entnehmen, daß $q \approx 0.085$ ist; die Helligkeitsamplituden sind $\Delta m_1 \approx 0\overset{m}{.}10$ und $\Delta m_2 \approx 0\overset{m}{.}07$, die Bahnneigung i liegt zwischen 80° und 90°. Die theoretischen Lichtkurven mit diesen Parametern ergeben $\Delta m_1 = 0\overset{m}{.}098$ und $\Delta m_2 = 0\overset{m}{.}073$. Diese Übereinstimmung rechtfertigt die Bestimmung des Massenverhältnisses in Röntgendoppelsternen aus den optischen Lichtkurven.

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G. Börner, J. Ehlers, E. Rudolph, München: Relativistic effects in the binary pulsar PSR 1913 + 16

In the system of PSR 1913 + 16 the first order Doppler effect and the periastron advance, if due to relativity only, give 3 relations for the 4 unknown parameters M_1, M_2 (the masses of the pulsar and its companion), a_1 (the semimajor axis of the pulsar orbit), and i (the angle between the orbit normal and the line of sight). A fourth relation, which would permit the determination of all the parameters, may be provided by the second-order Doppler effect. As shown by e. g. BLANDFORD & TEUKOLSKY (1975) such a measurement would require 5 to 10 years of regular observations.

Another possibility for a fourth relation – or even for a test of general relativity – may be the prediction of general relativity that the spin axis of a star in a binary system precesses around the normal of the orbital plane. This effect which has not yet been observed otherwise is quite large in the case of the binary pulsar. The precession angle is approximately 1° per year. In the calculation of the spin precession of the binary pulsar it has to be taken into account that the components of this system have masses M_1 and M_2 of comparable size. The spin precession formula for a general binary system has been calculated by B. M. BAKER, R. F. O'CONNELL (1975) using quantum field theoretical methods and by N. D. HARI DASS and C. F. CHO (1975) using Schwinger source theory. Here we present the results of a derivation from General Relativity theory (BÖRNER, EHLERS, RUDOLPH, 1975). The formula for the case $M_1 \ll M_2$ can be found in text books (MTW 1973, WEINBERG, 1972).

In the case of a general binary system the relativistic spin precession rate of, say, the first body consists of three contributions associated with: *

a) the "magnetic type" component of the instantaneous Schwarzschild field of the second body relative to the rest frame of the moving first body (de Sitter-Fokker precession)

b) the spin – spin interaction between the two bodies and

c) the dragging of the inertial frame at the first body due to the translational motion of the second body

c) does not contribute in the case of $M_1 \ll M_2$. The corresponding spin precession formula therefore cannot be naively generalized to the case $M_1 \approx M_2$.

In the post-Newtonian approximation we obtain for the spin precession of body 1 in a general binary system (contribution b) can be neglected for our purpose):

$$\frac{d\vec{S}}{dt} = \vec{\Omega} \times \vec{S} \tag{1}$$

$$\vec{\Omega} = 3/2\, \vec{u}_1 \times (\nabla_1 U_2) + + 2\nabla_1 \times \vec{V}_2 \tag{2}$$

where u_1 is the c.m. velocity of the pulsar and

$$U_2 = \frac{G}{C^2} \frac{M_2}{|\vec{x}_1 - \vec{x}_2|} \tag{3}$$

$$\vec{V}_2 = \vec{u}_2\, U_2$$

We now use the familiar Newtonian notation for a binary system

$$\vec{R} = \vec{x}_1 - \vec{x}_2, \quad \vec{V} = \dot{\vec{R}}, \; |\vec{R}| = R$$

$$\mu = \frac{M_1 M_2}{(M_1 + M_2)} \tag{4}$$

If $\vec{R}$ describes an ellipse with semimajor axis a and numerical excentricity e we obtain:

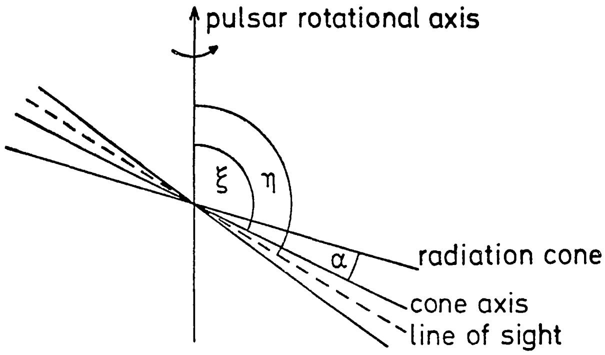
$$\langle\vec{\Omega}\rangle = \frac{G^{3/2}}{c^2} \mu \left(1 + 3/2 \frac{M_2}{M_1}\right) \frac{(M_1 + M_2)^{1/2}}{a^{5/2}(1-e^2)} \vec{n} \tag{5}$$

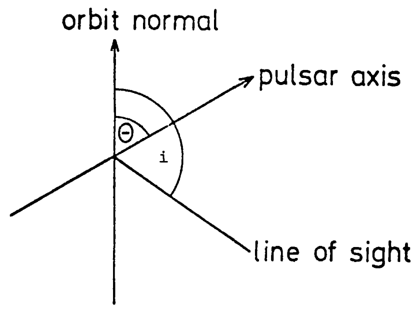
where $\vec{n}$ is the normal to the orbital plane. In Börner, Ehlers, Rudolph (1975) these calculations have been performed within the PPN formalism.

The spin precession of the binary pulsar must show up in a change of the observed pulse shape. For a calculation of this effect we use the oblique rotator model (Gold, 1968, Ruderman, Sutherland, 1974). For the notations see fig. 1 and fig. 2.

We assume that the observed radiation is linearly polarized with the electric vector parallel to the plane containing the line of sight and the cone axis.

* Remark: The Newtonian torque on the pulsar due to the tidal field of the second star is negligible by at least five orders of magnitude due to the high degree of sphericity of the pulsar.





We obtain for the pulse width (HARI DASS, RADHAKRISHNAN, 1975)

$$\cos\psi = \frac{\cos\alpha - \cos\eta\,\cos\xi}{\sin\xi\,\sin\eta} \tag{6}$$

$$\psi = 1/2\,(\omega\,\Delta\,\tau)$$

and the polarization sweep (the change of the polarization vector through the pulse)

$$\cos\Gamma = \frac{1}{\sin^2\alpha}\,[-\,2\sin^2\psi\,\sin^2\xi + \sin^2\alpha] \tag{7}$$

where ω is the rotational frequency of the pulsar and $\Delta\tau$ the pulse length. η, the angle between the rotational axis of the pulsar and the line of sight, is time-dependent because of the spin precession:

$$\cos\eta\,(t) = \sin\Theta\,\sin i\,\cos\Sigma + \cos\Theta\,\cos i \tag{8}$$

with:

$$\Sigma = |\Omega|\,t$$

Formulas (6) and (7) yield complete information about the change of the pulse shape due to the spin precession.

Details concerning the assumptions underlying the calculations, the results of which have been given in this paper, will be published elsewhere.

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