as we expand the cube and let $n \to \infty$. The first two terms cancel identically. One can prove the correctness of the relation,

$$\sum_{c=1}^{\infty} \frac{4}{c} J_c(c) J'_c(c) \qquad (7)$$

from the generating equation of the Bessel function.

This work was sponsored by the Air Force Cambridge Research Laboratories, Office of Aerospace Research.

DONALD H. MENZEL

Harvard College Observatory,
Smithsonian Astrophysical Observatory,
Cambridge, Massachusetts.

Received May 3, 1968.

General Relativistic Influence on Observed Pulsar Frequencies if Pulsars are Orbiting Objects

RECENTLY[1], I pointed out that pulsars might be a means of making a new test of the general theory of relativity by providing a stable extra-terrestrial frequency standard against which the differential general relativistic effect on terrestrial clock rates at perihelion and aphelion could be measured.

The purpose of this communication is to point out what could be an important analogous effect should the pulsars prove to be orbiting bodies.

Suppose the pulsars were orbiting bodies, and for simplicity consider the case of a pulsar the orbit of which is in a plane perpendicular to the line of sight. The contribution of its motion to the first order Doppler effect will then be essentially zero, and one might be tempted to assume that once the contribution of the Earth's orbital motion had been subtracted, any residual variation in the observed frequency of recurrence of the pulses would arise from a variation in the basic pulse rhythm of the source itself. As was previously pointed out[1], however, there would be a small general relativistic effect of about 1 part in 2×10^9 arising from the ellipticity of the terrestrial orbit. In addition to this, as will be shown, there could be a non-annual residual variation in the observed frequency that did not arise from a variation in the intrinsic pulse rhythm of the source itself, provided the orbit of the source was significantly different from a circle.

Let the maximum and minimum orbital distances of the source from its star be R_a and R_p, respectively, let the mass of the star be M, and let the intervals between pulses measured in Schwarzschild co-ordinate time at maximum and minimum orbital distances from the central star be dt_a and dt_p.

Then[2],

$$dt_p/dt_a - 1 = 3MG(R_a - R_p)/2c^2 R_a R_p$$

where G is the Newtonian gravitational constant and c is the speed of light. For the Earth this comes to $4{\cdot}9 \times 10^{-10}$.

It could be smaller or larger for an orbiting pulsar source depending on the values of R_a, R_p and M. Because the Schwarzschild coordinates used in deriving this formula are static, the effect will be transmitted faithfully to the Earth and will appear as a residual variation in the rhythm of the received pulses. Because the effect does not depend on the orientation of the plane of the pulsar orbit relative to the line of sight, it will yield information involving the eccentricity of the orbit, the mass of the central star and the period of the orbital motion, even though the orbit is here assumed to be in a plane perpendicular to the line of sight.

Should pulsars prove to be orbiting objects, there could be a problem concerning their intrinsic periodicities if the above effect, which could be relatively large for some of them, were not taken into account in analysing the data. Moreover, if the problem were removed by taking account of this effect we would have yet another confirmation of general relativity.

BANESH HOFFMANN

Queens College of the City University of New York,
Flushing,
New York.

Received April 5, 1968.

[1] Hoffmann, B., *Nature*, **218**, 667 (1968).
[2] Hoffmann, B., and Sproull, W. T., *Amer. J. Phys.*, **29**, 640 (1961).

Discrimination of Temporally Overlapping Seismic Events

ROUTINE digital processing of seismic events recorded on analogue magnetic tape at the Yellowknife seismic array, Canada, is being carried out in Ottawa with the aid of a computer. The array is of the UKAEA pattern and has been described by Manchee and Somers[1]. Processing methods have been described by Weichert *et al.*[2]. Although no attempt is being made to process every event that is received, a large enough sample is selected from each month's recording to enable a library of third zone events to be accumulated on digital tape. Sometimes, as in the present instance, a particular event is of more than passing interest.

The present routine processing of the analogue or digital tapes proceeds at twice real-time speed, the output consisting of certain diagnostic traces plus a time track, displayed on an eight trace hot wire recorder. Recently, these traces have consisted of (1) the output of the cross-over point seismometer; (2) the sumall phased toward the epicentre; (3) the correlogram corresponding to the sumall; (4) a trace showing the variations between sample, in the maximum value of the computed correlograms (169 beams are formed in each sampling interval); (5) a trace showing the total slowness (ms/km) as derived from the data of traces (7) and (8); (6) a trace showing the variations between samples in the computed value of the azimuth; (7) and (8) traces giving the two components of slowness in the N.–S. and E.–W. directions as determined from parabolic interpolations around the slowness values giving the maximum correlation. Time marks (1 s) are provided on the two edge-tracks. When an event arrives, each of traces (5) to (8) should settle to a reasonably stable value within a few seconds and stay there, unless new energy from a different azimuth or distance arrives. At present this new event must also carry more energy, that is, produce a larger correlogram, than the first event in order to take over control of traces (5) to (8), but steps are now being taken to ensure that any coherent new energy will be recognized. While our experience with these traces is still limited, we hope that late phases (pP, PP, PcP) will be more easily identified with their aid. There is also the possibility that some sort of "source signature" will become apparent from the study of a large number of them.

An event which was processed recently produced outputs on traces (5) to (8) which settled alternately on two sets of values. One set indicated that the event originated in the North Atlantic and the other indicated an origin in north-west China. In order to clarify the situation, a new output was programmed as shown in Fig. 1. Here the traces are described as follows: (1) the output of a single seismometer near the centre of the array; (2) the sumall phased toward the north-east China event; (3) the sumall phased toward the North Atlantic event; (4) the correlogram for the north-east China event; (5) the correlogram for the North Atlantic event; (6) the apparent velocity for the dominant correlogram at any given moment; (7) the azimuth for the dominant correlogram at any given moment with a compressed scale. The slow-