matters arising

Has the Sun a companion star?

HARRISON[1] suggests that the Sun is accelerating at $\sim 10^{-6}$ cm s^{-2} in the general direction of the galactic centre, and attributes this acceleration to a companion star with

$$M/R^2 \approx 1.7\times 10^{-6} \qquad (1)$$

where M is the mass in solar units and R is the distance in AU. Analysis of planetary perturbations[2] gives a limit on the tidal acceleration equivalent to

$$M/R^3 < 2.7\times 10^{-11} \qquad (2)$$

Combining equations (1) and (2) gives

$$R > 6\times 10^4 \text{ AU} \approx 0.3 \text{ pc} \qquad (3)$$

and

$$M > 6\times 10^3 \qquad (4)$$

The orbital period is $> 1.8\times 10^5$ yr and the velocity is > 9 km s^{-1}.

If we accept a supermassive black hole as the solar companion, it will have observable consequences. The gravitational deflection of the light from a star 1 arc min from the black hole is > 3 arc s. The black hole moves < 6 arc s in six months due to parallax and < 7 arc s yr^{-1} due to orbital motion. This motion will modulate the gravitational deflection, leading to a detectable pattern of proper motions and parallaxes in the background stars.

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HARRISON REPLIES—I am not competent to judge the analysis by Rawlins and Hammerton of Neptune's residuals. I notice that these authors exclude the possibility of a perturbing object at distances greater than 300 AU, and assign a probable longitude of 319°±24° to a hypothetical tenth planet that is roughly 55° from the suggested companion star. My impression is that it is not easy to determine with precision the residuals of an orbit that has been observed continuously for a time less than one period (in this case 165 yr) when the disturbing force has a very much longer period ($\sim 10^4$ yr). Also, if the companion is temporary only, and is a neutron star moving at the high velocity typical of such objects, it would pass by the Solar System in a time of 50–100 yr. Neptune's residuals in this case, if determinable, might then be small, and even smaller, if the neutron star is moving toward the Solar System.

It has been suggested[1,2] that condensations in the early stages of the Galaxy may have resulted in the formation of numerous supermassive black holes of masses 10^3-$10^6 M_\odot$. Wright's comment on the possibility of a supermassive black hole at a distance of one light year is therefore interesting. Such an object in Saggitarius, or thereabouts, should be identifiable from radiation emitted by the infalling interstellar medium.

The hypothesis of a companion star has the virtue of being falsifiable (using Popper's terminology), and in my opinion the easiest way at present to falsify the hypothesis is to find a pulsar of an anomalous period-derivative in the opposite hemisphere of the sky.

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Absolute radiocarbon dating by low-altitude European tree-ring calibration

PEARSON *et al.*[1] recently reported the results of 58 precision radiocarbon measurements of samples from a floating tree-ring chronology 1,140 rings long, essentially covering the third millenium BC. Unfortunately, the authors chose to approximate their results by a straight line, obscuring the most interesting part of their results, the so called 'wiggles' in the functional relationship between radiocarbon years and calendar years. There seems to be a psychological preference for a smooth linear relationship, although such a relationship cannot be considered *a priori* more probable than an irregular one[2]. Pearson *et al.* conclude that the fact that a linear relationship exists, which approximates within limits of errors their experimental data 'rules out over the period investigated, the use of wiggle matching as a dating technique.' This dating technique has been used successfully not only by the La Jolla Laboratory[3] but also by the laboratories in Groningen[4], in Bern[5], and possibly elsewhere. Its applications included the period under consideration. Also, Pearson *et al.* do not seem to be aware of the fact that hundreds of measurements have shown that within experimental errors the wiggles in the calibration curve are identical in the California bristlecone pine and in oak trees from central Europe[6,7].

The most deplorable fact concerning 'smoothed calibrations' as derived by a number of authors[8,9] is that they give the erroneous impression that irregularities are essentially caused by experimental errors. Such a misconception, however, leads to a gross underestimate of the intrinsic errors necessarily incurred in calibration. The article by Pearson *et al.* tends to support this misconception and the purpose of this note is to correct it.

I have presented elsewhere the numerical results of some 700 ^{14}C measurements of tree ring dated wood carried out so far in La Jolla[10]. A statistical analysis and discussion of these results will be published later. Sixty-two of them came from the period under consideration. The measured samples were bristlecone pine wood that had been tree-ring dated by C. W. Ferguson of the University of Arizona. Also included were the results of 55 samples from the same period of time which consisted of wood samples from a floating 1,250-ring chronology, the Becker Bronze age chronology of European oak[11].

The agreement in the features obtained in the three series is indeed remarkable. Certainly Pearson *et al.* have shown that by applying the necessary care and precautions, their scintillation counting technique for radiocarbon measurements can compete successfully with any gas counting system presently in operation. The authors, however, seem to have underestimated the accuracy of their own results or else they would have noticed that an irregular curve of the type of my calibration curve of 1969 would better approximate their results then the straight line that they propose. This can be seen from the way in which the data points cluster alternatingly on one side of the regression line and then on the other (Fig. 1 in ref. 1).