Phys. **19,** 247; 1974) experiments using beams of Zn and Ge ions, the latter being accelerated by a tandem arrangement of two cyclotrons. Looking for spontaneous fission activity with an experimental arrangement which permitted high sensitivity, the teams were unable to find any evidence for the production of superheavies. It seems that further work will require even more sensitive experiments and higher intensity beams of energetic heavy ions.

Solar gravitational deflection of radio waves

from J. M. Riley

SINCE the publication of Einstein's general theory of relativity in 1916, there have been many attempts to test the prediction of this theory that electromagnetic radiation is deflected in the gravitational field of the Sun. The experimental test of the prediction involves measuring the change in the apparent position of a star when it is close to the Sun. The effect is extremely small as the predicted deflection amounts to a maximum of 1.75 arc s, for a ray path from a star which grazes the limb of the Sun, and decreases inversely with distance from the centre of the Sun. A very accurate measurement of this deflection is required as it is clearly of fundamental importance to find out how closely general relativity agrees with observation and to test its predictions against those of other theories of gravitation. Among the alternative theories which have received serious consideration is the Brans–Dicke scalar–tensor theory which, in its latest form, predicts that the deflection is 0.94 times that predicted by general relativity.

Until ten years ago the only tests had been carried out optically during total solar eclipses and, owing to great technical difficulties, had provided only semi-quantitative support for general relativity with accuracies of about 25%. Recently however it has become possible to perform the experiment at radio wavelengths using the technique of interferometry, in which the position of a radio source may be found by measuring the difference between the time of arrival of signals from the source at two radio antennae some distance apart on the Earth's surface; this method involves knowing with great precision the time at which the signals are recorded at each antenna. An experiment of this type has been performed several times since 1969 using the QSO 3C279 which passes behind the Sun in October every year; it may be observed for several days before and after this when it is very close to the Sun. The change in its apparent position is measured relative to that of another source, 3C273, which is close to it in the sky but sufficiently far from the Sun during the experiment to be unaffected by the gravitational deflection.

The first tests of this kind were made using antennae separated by relatively short distances (from 1 to 5 km) operating at frequencies between 2,700 and 8,000 MHz; it was therefore possible to have direct electrical connection between the antennae and consequently it was relatively easy to standardise the time of the observations at the two antennae. The most accurate experiment of this type gave a result 0.96 ± 0.05 times the value predicted by general relativity.

It is also possible to carry out the experiment using antennae several hundreds of kilometres apart. In such an experiment the difference between the time of arrival of signals at the two antennae is proportionately greater than in the shorter baseline experiments and in principle therefore the experiment should be much more accurate. But in a long baseline experiment, direct electrical connection between the antennae is impossible so that independent clocks must be used at the two sites; due to instabilities in these clocks there is then a problem standardising the time of the observations at the two antennae. Furthermore, as the two sites are so far apart there are likely to be very significant differences in the path lengths through the atmosphere of the radiation arriving at the two antennae.

In a recent paper in *Physical Review Letters* (**33,** 1621; 1974) Counselman *et al.* describe the first results of such an experiment performed in October 1972 using a baseline of 845 km and a frequency of 8,000 MHz. In this experiment the problem of the differences between the independent standards used at the two sites was overcome by using a pair of antennae at each site, one directed at 3C279 and the other at 3C273. A single clock governed the recording of the signals received by both antennae at a given site; the difference between the time of arrival of the signals from 3C279 at the two sites could then be measured with reference to that between the time of arrival of the signals from 3C273 at the sites, thereby eliminating the effects of any clock instabilities at either place. This method also reduces the effects of any differences in the atmosphere and ionosphere above the two sites. In analysing the data it was necessary to assume models for the atmosphere, ionosphere and the solar corona, and uncertainties in these models, particularly in that for the corona, contribute about half the error in the final result. The remaining error is attributed to experimental difficulties, in particular those introduced by fluctuations in the solar corona. The observed deflection was 0.99 ± 0.03 times the value predicted by general relativity. This measurement is probably the most accurate yet made of the gravitational deflection of radiation and the result is in close agreement with general relativity; it is slightly more than one standard deviation from the value predicted by the Brans–Dicke Theory.

The prospects for improving the accuracy of this test of general relativity using the method of very long baseline interferometry are good, as it is possible to eliminate several of the problems encountered in the experiment mentioned above by making simultaneous observations at two frequencies. It is likely that accuracies better than 1% may be achieved in the very near future.

A hundred years ago

WHITE'S "SELBORNE"

White's Natural History of Selborne. Edited by J. E. Harting, F.L.S. Illustrated by Bewick. (London: Bickers and Co., 1875.)

ALTHOUGH we have no evidence that, within the last century, there has been any considerable change in the average standard of human mental power amongst civilised nations, the surroundings of every-day life have so greatly altered, both in their quality and in the rapidity of their occurrence, that the standard of ordinary existence has undergone a corresponding modification. The introduction of steam locomotion, the electric telegraph, and the penny post have developed such a condition of unrest in humanity at large that the unalloyed repose of a continuous rural life is rarely sought for, and as infrequently obtainable. We can hardly conceive it possible that anyone, such as a life-fellow of a college, as was Gilbert White, of Oriel, Oxford, should at the present day settle down in any out-of-the-way part of the country, satisfied with nothing more than an opportunity of observing and recording the surrounding phenomena of nature. More would be expected of him, and he would be continually led to feel that he was but one of the instances of the vegetating influence of an antiquated system, whose advantages were being daily disproved by his individual existence.

from *Nature,* **11,** 423; April 1, 1875