

## LETTERS TO THE EDITORS

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## Composition of the Earth's Outer Core

ATTENTION has lately been given to the following set of four postulates: (a) the Earth, Mars and Venus have a common primitive composition; (b) compressibility is essentially a smoothly varying function of pressure at pressures beyond  $0.4 \times 10^6$  million atmospheres in all three planets; (c) the outer core of the Earth is a high-pressure modification of ultrabasic rock; (d) each planet has an inner core chemically distinct from the matter in the outer core.

With the use of an Earth model referred to as Model B<sup>1</sup>, I showed<sup>2,3</sup> that this set of postulates yielded values of the mean densities of Mars and Venus and of the ellipticity of figure of Mars that were within the standard errors of the observational data available to me at the time. The purpose of the present communication is to direct attention to implications of revisions of the data in question, and to bring up to date a statement in my recently published book<sup>4</sup>.

I am indebted to Dr. G. P. Kuiper for kindly supplying me with the latest information on revisions of the astronomical data. He informs me that the most probable diameter of the solid surface of Mars is now about 3,330 km., as against 3,389 km. computed using postulates (a)-(d); also that estimates of the diameter of Venus are being reduced. In addition, Dr. Kuiper has informed me that it is innate in Woolard's work<sup>5</sup> that, while the observed ellipticity of Mars is not sensibly changed from Struve's value which had been used by me in my previous calculations, the standard error of the determination has been reduced by roughly two-thirds. This has the effect of making the ellipticity calculated on the basis of (a)-(d) different from the observed value by about three times the standard error of the latter.

The effect of these revisions is to demand some reconsideration of postulates (a)-(d), especially (c). A significant feature of the revisions is that they all point the same way. Examination of a diagram of Bullen and Low<sup>6</sup> shows that the influence of postulate (d) is to increase the computed mean diameters of both Venus and Mars above the values which would be yielded if the inner core were composed of iron silicate rather than of purely uncombined iron. The effect of this is to show that, given the masses of Mars and Venus and assuming the postulate (a), then increasing the assumed amount of uncombined iron in their cores diminishes the calculated diameters. Further, with the use of postulates (a)-(c), it had been found<sup>2</sup> that the assumption of (d) led to an estimated ellipticity of Mars of 1/188, as against 1/181 if the inner core contained no uncombined iron. Thus increasing further the assumed quantity of uncombined iron in the core has the effect of bringing the estimated ellipticity of Mars closer to Woolard's value of  $1/191.8 (\pm \frac{1}{2} \text{ per cent})$ .

On the assumption that the terrestrial planets have a common primitive composition, all three of the astronomical revisions indicate that the Earth's outer core is composed of a mixture of uncombined iron and of material the representative atomic number of which is smaller than that of iron. It is interesting that this conclusion finds support in two other independent investigations. In 1952, Birch<sup>7</sup> concluded

that the density in the outer core "is perhaps 10-20 per cent lower than the density of iron or nickel-iron under the same conditions"; Birch suggested alloying with other materials as a possible explanation of the discrepancy. Again, recent work of Knopoff and Uffen, kindly communicated to me in advance of publication, indicates a mean atomic number of 22 for the region E, a value four units less than that for iron, six units less than that for nickel.

The lighter material which seems to be present in the outer core may consist of material such as the rock fayalite. The latter may be in the form of a high-pressure modification as assumed in postulate (c), although Dr. W. M. Elsasser informs me (in a personal communication) that there are serious theoretical difficulties in assuming an accompanying density increase in a ratio as high as 1.6, which is the ratio of the densities on the two sides of the boundary between the core and mantle of the Earth. It is possible that a more detailed calculation which I hope to carry out will throw some light on this question.

An incidental point, of some cosmological importance, is that it still appears possible, by a suitable modification of postulate (c), to reconcile seismic and astronomical data with the hypothesis of a common primitive composition for the Earth, Mars and Venus, although further calculation is needed to confirm this. Such a result is important in that earlier work<sup>8</sup> appeared to have excluded this hypothesis. Moreover, there is little difficulty in adapting any model to bring the Moon into the same picture. Mercury remains an apparent exception; but I have earlier suggested<sup>9</sup> that observations of the present-day Mercury may be inapplicable to the primitive Mercury.

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<sup>1</sup> Bullen, K. E., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **6**, 50 (1950).

<sup>2</sup> Bullen, K. E., *Mon. Not. Roy. Astro. Soc.*, **109**, 688 (1949).

<sup>3</sup> Bullen, K. E., *Mon. Not. Roy. Astro. Soc.*, **110**, 256 (1950).

<sup>4</sup> Bullen, K. E., "Seismology" (Methuen, 1953).

<sup>5</sup> Woolard, E. W., *Astron. J.*, **51**, 33 (1944).

<sup>6</sup> Bullen, K. E., and Low, A. M., *Mon. Not. Roy. Astro. Soc.*, **112**, 637 (1952).

<sup>7</sup> Birch, F., *J. Geophys. Res.*, **57**, 227 (1952).

<sup>8</sup> Jeffreys, H., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **4**, 62 (1937).

<sup>9</sup> Bullen, K. E., *Nature*, **170**, 363 (1952).

## Proposal for a New Aether Drift Experiment

It is interesting to learn from L. Essen's communication<sup>1</sup> that the accuracy of measurement of frequencies in the 9,000 Mc./s. region attained at the National Physical Laboratory with existing equipment is high enough for the new aether drift experiment to be carried out. I understand that preparations have been made for the same purpose at the Zeeman Laboratory of the University of Amsterdam by F. Bruin, to whom I suggested the experiment last summer.

May I point out that the experiment proposed by me<sup>2</sup> is not a repetition of the Michelson-Morley experiment, in which interference between progressive waves is observed. It is an experiment with standing waves, and resonance frequencies are measured for different orientations of the axis of the resonator.

A fixed distance ('axis') between two parallel mirrors, moving with uniform velocity through the