RADIAL OSCILLATIONS OF A STAR AND THE FORMATION OF THE PLANETARY SYSTEM

BY

H. K. SEN

(*Mathematics Department, Allahabad University*)

THE solar system, as we know, is isolated in space, and possesses certain regular features.[1] The first theory relating to the origin of the solar system was that of Laplace-Kant[2] according to which, the solar system was originally a huge sun which broke up as a result of its rotation. The Laplace theory, while explaining most of the regular features of the solar system, failed to explain an equally conspicuous feature, *viz.*, that almost the whole of the angular momentum of the system is contributed by the four major planets, which have less than one-seven hundredth of the total mass of the system. In the words of Spencer Jones,[3] "the origin of the solar system is not to be explained by the gradual cumulative action of internal forces: an explanation must be sought in the swift catastrophic action of forces from outside."

The catastrophic action was supposed to have been brought about by a very close passage of another star to the sun; this assumption has been made in the planetesimal theory of Chamberlin[4] and Moulton[5] and the tidal theory of Jeans[6] and Jeffreys.[7] The planetary ribbon was supposed to be formed between the sun and the passing star, out of which the planets condensed. But the passing star could give, as Russell[8] pointed out, only one-tenth of the average angular momentum per unit mass possessed by the planets. On Russell's suggestion Lyttleton[9] advanced the "enticement theory"[*] of the solar system. The sun was pictured as a binary star. The visiting star had a large mass and velocity so as to provide enough energy for the shearing of planetary material. The sun was supposed to have been just so far off as to escape capture by the visiting star but nevertheless to gain chunks of the planetary ribbon. The validity of this assumption has been questioned by Luyten.[10] Bhatnagar[11] has shown that even under the most favourable conditions there would be a catastrophic collision between the three bodies. From astrophysical considerations Spitzer[12] has drawn the conclusion that the planetary ribbon, if formed, would dissipate into space in a period of the order of an hour at the most at stellar temperatures.

In a recent and interesting paper, A. C. Banerji[13] has opened up an entirely different line of approach to the problem. The sun is supposed to be originally part of a Cepheid Variable of about nine times the sun's mass, oscillating with small amplitude. The nearby passage of a star of about the mass of the Cepheid increases the amplitude of the Cepheid's oscillations. The passage of the second star need not be grazing or very close, but only sufficiently near to produce appreciable tidal protuberances in the Cepheid. Banerji has shown that under these conditions dynamical instability is caused in the Cepheid's oscillations resulting in ejection of matter of the sun's mass from it. The planets are supposed to be formed out of the part of the ribbon attached to the sun's mass. The visiting star has sufficient angular momentum to impart the necessary momentum to the planets. It has also been shown that the solar system will have to take about two-fifths of the energy of the parent Cepheid to escape from the latter. A specially remarkable feature of the theory is that it makes a less number of assumptions than any other existing theory. The parent Cepheid will also have a planetary system of its own and the probability of there being other planetary systems than our own is definitely increased.

Observation has not so far disclosed any other planetary system similar to the solar system. Russell[14] is of the opinion that, even if there be planetary systems in some of the distant stars, they will not be visible even through the most powerful telescope that we can construct. But theory may well open fresh avenues for observation, and we are hardly entitled to pass verdict against a theory of the origin of the solar system merely because it points to the possibility of a plurality of such systems. In most of the theories "so many special assumptions are involved that it has been remarked that the solar system had a very narrow escape from never coming into existence."[15] Banerji's theory is unique in that it makes the birth of the solar system definitely more probable.

---

* Knox-Shaw.

1 Jeffreys, *The Earth*, 1929, p. 16.

2 Jeans, J. H., *The Problems of Cosmogony and Stellar Dynamics*, 1919, p. 1.

3 Jones, H. S., *Life on Other Worlds*, 1940, p. 219.

4 Chamberlin, *Ap. J.* 1901, **14**, 17.

5 Moulton, *ibid.*, 1905, **22**, 165.

6 Jeans, J. H., *The Problems of Cosmogony and Stellar Dynamics*, 1919, p. 275.

7 Jeffreys, *The Earth*, 1929, p. 16.

8 Russell, H. N., *The Solar System and its Origin*, 1935, p. 113.

9 Lyttleton, R. A., *M.N.*, 1938, **98**, 536.

10 Luyten, *ibid.*, 1939, **99**, 692.

11 Bhatnagar, P. L., *Ind. J. Phys.*, 1940, **14**, 253.

12 Spitzer, L., *Ap. J.*, 1939, **90**, 675.

13 Banerji, A. C., *Instability of Radial Oscillations and the Origin of the Solar System.* (To be published.)

14 Russell, H. N., *The Solar System and its Origin*, 1935, p. 113.

15 Jones, H. S., *Life on Other Worlds*, 1940, p. 234.