Letters to the Editor

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New Planetary Systems

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OBSERVATION has at last succeeded in giving us a verdict on the vexed problem which had been engaging the attention of the theorists for some time—whether our solar system is the only one of its kind in this vast universe. From the study of parallax observations Dr. K. Aa. Strand[1] has recently been able to prove the existence of a planetary body companion to the 61 Cygni system. The system shows a periodic deviation from the Keplerian orbit, and this can only be explained on the supposition that a third body (61 Cygni *C*) of small mass, about sixteen times that of Jupiter, revolves around one of the stars of the binary system. The luminosity of 61 Cygni *C* is found to be very low, and it can very well be classified as a planet.

A parallel discovery to 61 Cygni *C* has also been almost concurrently made. Reuyl and Holmberg[2] have discovered a similar planetary body of even smaller mass in the binary star system, 70 Ophiuchi. It is worthy of note that neither of the stars 61 Cygni and 70 Ophiuchi exceeds a distance of 10 parsecs from the sun.

We have, at last, evidence of the discovery of two planetary systems other than our own, and, what is more, these happen to be very near our own system. The suggestion naturally comes to mind that we may by similar means be able to find many more planetary systems in our galactic system, and the number of planetary systems in this universe may be quite large. It will be interesting in this connection to review briefly what theory has to say on this question.

On the tidal theories of Jeans[3] and Jeffreys,[4] planetary systems should indeed be rare. Taking the generally accepted age of the universe as of the order of 10^9 to 10^{10} years, and Jeans' estimate (1929) of the frequency of planetary systems on his theory—about one per 5000 million years—we have at the most two planetary systems in our galactic system. On Lyttleton's[5] binary star collision theory, the probability of the formation of planetary systems is almost nil.

The probability is much greater on Banerji's[6] Cepheid theory (1942) in which a passing star is supposed to break up an oscillating Cepheid. Encounter at only a moderate distance is necessary in this theory—it need not be grazing or close. Banerji has stated his conclusion in the following words, "One conclusion seems to be irresistible. If the theory be correct in its essentials, there may be more planetary systems than at present supposed." The observations thus definitely favor Banerji's conclusion.

It may be remarked that the presence of planetary systems in binary stars is very plausible on the Cepheid theory of the origin of binary stars recently advanced by the author.[7] A Cepheid is supposed to break up into a binary star system on account of increase of angular velocity due to radiation of energy. The filament connecting the two stars affords a chance for planets to be formed by condensation.

[1] K. Aa. Strand, Pub. Astronom. Soc. Pac. **55**, 29 (1943).
[2] Reuyl and Holmberg, Astrophys. J. **97**, 41 (1943).
[3] J. H. Jeans, *The Problems of Cosmogony and Stellar Dynamics* (1919), p. 275; *Astronomy and Cosmogony* (1929), pp. 7, 22, 409.
[4] H. Jeffreys, *The Earth* (1929), p. 16.
[5] R. A. Lyttleton, M.N.R.A.S. **98**, 536 (1938).
[6] A. C. Banerji, Proc. Nat. Inst. Sci. Ind. **8**, 173–197 (1942).
[7] H. K. Sen, Sci. and Cult. **7**, 582 (1941–1942).

Quantized Probability

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THIS communication proposes for development the theory that there exists a finite unit of probability, representing the lower limit of possibility. (A suggested designation for this unit is the "chance-quantum," abbreviated cq.) Thus, if the probability of an event is equal to or greater than one cq., it may ultimately occur. If its probability is less than one cq., it will never occur. The latter statement constitutes a break with classic probability theory.

Probability-quantization theory results from consideration of hypothetical experiments wherein, for example, a sufficiently great multiplicity of monkeys operating at random an adequately large number of typewriters will ultimately reproduce master-works of literature. Inherent aversion to this conclusion has led some to hold that the assumed result would necessarily be interpreted as fraudulently achieved. This mode of escape from the assumed conclusion can perhaps be avoided by postulating that the probability of thus reproducing great literature is so small as to fall below one cq. Accordingly the assumed result becomes flatly impossible.

If probability-quantization is an existent condition in nature, certain interesting theoretical consequences appear to follow. These include:

1. If an event has a calculated probability of less than one cq., it will not occur.

2. Assuming the validity of Bayes' theorem, events can occur only if both their existence probability and their likelihood equal or exceed one cq., and if their product exceeds one cq.

3. Events may differ in probability only by an integral number of cq.

4. The occurrence of events having a probability of one or relatively few cq. will be not only extremely infrequent but may have an unusual form of random distribution.

5. For an event having an appreciable probability (equivalent to many cq.), a change in surrounding conditions leading to a computed change in probability of less than one cq. will in fact cause no change in the probability of the event.

6. The interrelations between the cq. and the energy quantum (as well as the elsewhere proposed time quantum) may be close and significant.

An absolute proof of the existence of the cq. faces the usual difficulties of proving a universal negative. At best, the establishment of a high probability for the existence of the cq. is attainable. A possible experimental method might be based on the following thoughts. Suppose that there exist n possible but very improbable events of a similar and identifiable type. If the selected one of these events not only does not occur in n trials, but also does not occur in mn trials (where m is a large number), there is a likelihood that it will not occur at all and that its probability lies below the assumed unit cq.

Such an experiment might be attempted using, as a basis, mechanical, electrical, or electronic coincidences. Illustratively, there may be used a set of coaxially rotating disks, propelled pneumatically along their peripheries, mounted in low friction bearings, and mechanically isolated from each other. Each disk bears a circular perforation of the same radius, and at the same distance from the disk center. A collimated light beam, parallel to the rotational axis, can pass through the perforations when lined up, and thereafter be registered by conventional photoelectric means. Control of perforation size, perforation distance from the axis, and number of disks, will enable selection of desired probability parameters. If a coincidence of extremely small probability did not occur in a time which was a large multiple of the time of its probable occurrence, the hypothesis of probability-quantization would be strengthened. Great care might be necessary to avoid confusing quantum effects in the physical system with quantization of probability.

If the cq. theory is found valid, interesting consequences may follow. Philosophically, the universe will be a system subject to prediction (determinism) for events of probability less than one cq. and to non-prediction ("free will" or normal chance) for events of probability above one cq. Probability theory for ordinarily likely events will be little affected. But the probability of small-scale and extremely unlikely effects may be largely controlled by the new theory—a matter of considerable interest in certain modern microphysical realms. And the comparison between continuous probability and quantized mechanics, on the one hand, and quantized probability and continuous mechanics, on the other hand, may well merit study.

It is hoped that others will see fit to develop probability-quantization theory and its implications. The author particularly wishes to express his deep appreciation of the searching and constructive comments on this theory which, in the course of correspondence, he has received from Professor F. Bernstein, Dr. Thornton D. Fry, and Professors Harold Hotelling and Richard von Mises, as well as other interested men of science.