Books

The Unity of the Universe

by D. W. Sciama

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In the 1920's, some of the most significant books written to stimulate young people in the new discoveries of physics and astronomy were those of Jeans and Eddington. To name a few, *The Nature of the Physical Universe, The Expanding Universe*, and *Stars and Atoms* were read by boys who later became leading research men. The impact of some of these books was so great that several unexpected segments of the population were heard from. It is said that a famous New York actress once announced that Jeans' book, *The Mysterious Universe*, is what every girl should know.

There is no question that such books have been of tremendous importance in opening the excitement, the mystery, and the coherence of the world at large to the inquiring minds of youth. Often, stimulation at the right moment (usually in the early years of high school) can decide the career of promising minds. Sciama's book on *The Unity of the Universe* is an attempt to provide a modern synthesis of cosmology in the tradition of the 1920's. In the main, Sciama has succeeded. His book is concerned with various aspects of the astronomical universe both from the observational and the theoretical standpoints. It is written for the layman with no mathematical background.

Sciama is a theoretician, closely allied with the steady state school of cosmology. The book has bias toward the steady state theory. To the neutralist, these statements detract from the logical presentation. Fortunately, the bias is not so strong as to prevent discussion of the conflicting theories of evolving cosmology.

The book is divided into two sections, called The Universe in Observation, and The Universe In Theory. The first section contains five chapters dealing with the observational break-through which established that the universe is composed of galaxies at immense distances from the earth which are all moving away from each other at a rapid rate. The presentation is historical, starting from the time of the Greeks and ending with the observations of Hubble. The various chapters discuss the early Grecian geometrical methods of finding distances within the solar system, the history of the quest for the stellar parallax, early speculations of the nature of the Milky Way, a history of the conflict over the nature of the galaxies, and a report of Hubble's discovery of the expansion of the universe.

Deeper waters

The second section takes the reader into deeper waters. Here the beauty of the theories, the power to stimulate young readers, and the bias of the book appear. The chapters treat, in order, Olbers' Paradox, Mach's Principle, The Principle of Equivalence, The Origin of Inertia, The Clock Paradox, several sections on cosmological models, and The Creation of the Elements.

Olbers' paradox concerns the question of why the sky is dark at night. In 1826, Heinrich Olbers reached the conclusion that in an infinite, static universe populated uniformly by radiation sources (stars or galaxies), the radiation density at every point, such as the earth, would be infinite. Consider any spherical shell of radius dr, at a distance r from the observer. Let the average radiation density be U per unit volume. The radiation emitted by the shell is $4\pi r^2 Udr$. The radiation received at the earth from this shell is Udr. Increase the number of shells without limit and the result is infinite.

Cosmology

Because observations are in direct conflict with this result, some of the assumptions must be incorrect. H. Bondi in his book, *Cosmology*, discusses the possibilities and shows that there are at least three circumstances which can modify Olbers' result:

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(1) A certain hierarchical structure to the distribution of sources can give a finite answer.

(2) the sources may have a beginning in time and our observations to very great distances may extend back in time to before the sources began to radiate, or

(3) the universe is expanding.

Hubble's constant

To illustrate the surprising turn which Sciama can and does give to some of his presentations, we see on page 98 the statement ". . . from the observed amount of light in the night sky the actual rate of expansion – that is, Hubble's constant – can be estimated. Thus Olbers could have predicted the expansion of the universe, and could even have made a rough estimate of Hubble's constant, a hundred years ahead of the observer. His failure to do so is one of the greatest missed opportunities in the whole history of science."

And further, on page 172: "Had Einstein remembered, or reproduced, Olbers' argument, he would have seen immediately that his static universe was in disagreement with observation in the most violent way. He would then have been forced to propose an expanding model."

The reader might wish that these two statements were true because the situations w o u l d be a magnificent trick of fate. The statements are examples of Sciama's frequent method of seduction by surprise. But in fact Sciama's claim appears to be false. (1) Most of the light of the night sky comes from the upper atmosphere together with sunlight reflected by interplanetary particles in our solar system. There is in fact no measurement available of the light from the cosmos. (2) Even if Olbers had known what the cosmological light was, he would have to know the radiation density U to calculate the Hubble rate, a quantity he could not possibly have evaluated in 1826.

Clear presentations

The chapters on Mach's Principle, The Principle of Equivalence, The Origin of Inertia, and The Clock Paradox are very clear presentations of the dilemma of Newtonian absolute space, absolute accelerations, the centrifugal and Coriolis inertial forces, and the definition of inertial frames of reference.

Sciama's own theory of the origin of inertia incorporating Mach's principle is explained in simple terms and does much to clarify his published paper in the *Monthly Notices of the Royal Astronomical Society.* He concludes that the inertia of a body is due to the acceleration of all the matter in the universe measured in the rest frame of the body. This acceleration induces a force on the test body which appears as inertia. Sciama derives the gravitational constant as a function of the average density of matter and of the Hubble constant, and concludes that ". . . from observations restricted to our own neighborhood (i. e. the light of the night sky and the laboratory value of the gravitational constant) we can deduce an approximate value for both Hubble's constant and the average density of matter at great distances." This is again a clever statement which suffers from the objections already given.

Cosmological models

The sections of the book on cosmological models treat both the exploding cases and the steady state. The steady state theory as originally proposed rested on the so-called perfect cosmological principle – an *a priori* philosophical dogma. The theory has since been placed on a mathematical basis by Hoyle, who has also given a number of observational tests. Sciama does not discuss these tests but rests his case on a subtheory of the formation of galaxies, on esthetic appeal, and on a belief that the steady state theory contains fewer arbitrary initial conditions than do the conventional models.

It turns out that the most promising of the direct tests concerns the deviation from linearity of the velocity-distance relation of the distant galaxies. Such a deviation was reported in 1956 from observations made with the 200-inch telescope and would disprove the steady s t a t e. However, the results were inconclusive due to certain observational dif-

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ficulties. But in view of these results it is perhaps not correct for Sciama to state on page 174 that ". . . there is no known observation which is in conflict with the idea (of continual creation)" and hence of a steady state. Assuming the observations are true, the statement which perhaps summarizes the present situation is found on page 114. "(This is) the well known device of disappointed theorists (who) claim that (the experiment) had been performed inaccurately."

The final chapter concerns the formation of the chemical elements. Here Gamow's α, β, γ theory is discussed and is contrasted with the hot stellar interior theory of Hoyle, and Hoyle, Fowler, and the Burbidges. The latter theory is now believed to be the more correct of the two, but it does not prove the steady state, as Sciama contends. The element synthesis theory stands apart from any system of cosmology.

Finally, Sciama suggests that the correct theory of the universe must be unique; that is, it must be completely determinate with all initial conditions specified by the theory itself. Because there is only one universe, there must be only one model with no arbitrary constants. Hence any series of models, such as those of evolving cosmologies which differ from each other by different initial conditions, have an arbitrariness about them if all are theoretically possible. On the other hand, Sciama claims that the steady state model is completely determined, with no "accidental" features, and is therefore to be preferred.

This claim seems a bit exaggerated because at least two features of the theory are taken to be "accidental," i.e. not determined by the theory. These are the value of the Hubble constant and the physics of the creation process. It would seem to this reviewer that the validity of the steady state cosmology or the exploding cosmologies must rest on scientific fact rather than on philosophical speculation.

Although I have criticized Sciama's book in some of its details, the book as a whole should teach and generally stimulate young people who are eager to follow complicated arguments described lucidly and who are willing to learn.