younger, more competitive sperm. Smith hypothesizes that the prostaglandins in the semen, known to produce contractions of uterine smooth muscle, may enable the sperm to be conveyed closer to the ovum. In a similar way female orgasm and accompanying uterine contractions may be a way for a woman to differentially aid the sperm of a man she likes, trusts, and feels attracted to. Among prostitutes, Smith finds it significant that call girls, whose customers are better-paying, more considerate, and higher in status, experience orgasm considerably more often than streetwalkers. The chemistry of female secretions may also act selectively on the ejaculates of preferred and less preferred males.

The last, unabashedly speculative, section in Smith's paper picks up the theme of the interplay of male and female strategies. Using fossil and archeological data to speculate about the food resource base of the hominoid lineage, he constructs a series of scenarios from *Australopithecus* to *Homo sapiens sapiens* that portray the changing importance of sperm competition, the changing strategies of males and females, the changes in the mating system that would result, and a timetable for the emergence of traits we see today.

As a whole the book is broad, ambitious, stimulating, and well referenced. I recommend it for young investigators in search of research ideas, as well as for old investigators looking for new directions and fresh perspectives.

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Gaseous Nebulae

Physics of Thermal Gaseous Nebulae. (Physical Processes in Gaseous Nebulae.) LAWRENCE H. ALLER. Reidel, Boston, 1984 (distributor, Kluwer, Hingham, Mass.). x, 350 pp., illus. $49.50. Astrophysics and Space Science Library, vol. 112.

Ionized gaseous nebulae comprise such objects as diffuse nebulae, planetary nebulae, and supernova remnants. They emit a spectrum composed of emission lines and continuum corresponding to an ionized low-density plasma with typical densities in the range of 1 to 10^5 particles per cubic centimeter, densities many orders of magnitude smaller than those attained in terrestrial laboratories.

The study of gaseous nebulae has been of paramount importance for our understanding of the universe. Diffuse nebulae, or HII regions, are conglomerates of gas and dust in which stars are being formed at present. Planetary nebulae are shells of gas ejected from, and expanding about, extremely hot low-mass stars. Supernova remnants are shells of gas violently ejected during supernova explosions by massive stars. In addition to their intrinsic importance, gaseous nebulae give us important clues for the study of the dynamics of the interstellar medium, stellar evolution, galactic chemical evolution, and pregalactic conditions.

The study of gaseous nebulae combines atomic physics with astrophysics through the computation and use of atomic parameters. These parameters permit one to derive such physical conditions in the nebulae as the radiation field, the source of energy input, and the temperature, density, and chemical composition of the ionized gas.

Lawrence H. Aller has been one of the leading astronomers in this field for almost five decades. The book under review is based on lectures he has given over the course of his career.

The first part of the book deals with the study of physical processes in gaseous nebulae. It discusses the early development of the physical concepts, key papers on the subject, and the latest results as of 1983. It presents many tables and the relevant references needed to interpret mainly the optical and ultraviolet spectra of gaseous nebulae. It also presents several exercises at the end of each chapter.

The second part deals with models of photoionized nebulae, like HII regions and planetary nebulae, and models of shock-excited nebulae, like supernova remnants. Special emphasis is given to the effects produced by interstellar dust on the observed spectra, mainly through extinction in the ultraviolet and optical regions and through radiation in the infrared regions, but almost nothing is mentioned of the physics of dust grains.

The third part deals with applications to specific objects like the Orion nebula, which is the most observed HII region due to its apparent size, low reddening, and high surface brightness; the Gum nebula, which is the galactic HII region with the largest apparent size; and 30 Doradus, which is the most important HII region in the Large Magellanic Cloud. The section also includes an account of recent developments concerning the chemical composition of gaseous nebulae and the relationship of gaseous nebulae and stellar evolution, enrichment of the interstellar medium with elements heavier than hydrogen, and chemical evolution of galaxies. The book ends with an appendix by C. Mendoza, which is an excellent compilation, complete up to August 1982, of transition probabilities, electron excitation rate coefficients, and photoionization cross sections.

The book is directed to astronomy graduate students, physicists interested in astrophysics, and astrophysicists interested in the interpretation of the spectra of gaseous nebulae. It could be used in a graduate course on physical processes in gaseous nebulae.

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Cosmology

The Big Bang and Georges Lemaître. A. BERGER, Ed. Reidel, Boston, 1984 (distributor, Kluwer, Hingham, Mass.). xxii, 420 pp., illus. $59. From a symposium, Louvain-la-Neuve, Belgium, Oct. 1983.

This volume is the proceedings of a symposium held in honor of the Belgian-born scientist and priest Georges Lemaître 50 years after his initiation of big-bang cosmology in 1933, the year of his famous paper on the "primeval atom." It is fitting that Lemaître should be considered the father of the big bang. He was not alone in the formulation of a theory of an expanding universe, but he was the first to take the bold leap of considering a universe that began a finite time in the past. The subject is alive and vigorous to this day, as is here attested. The book is divided according to Lemaître's principal scientific interests into sections entitled Cosmology, Celestial Mechanics, and Structure of the Universe and Cosmic Rays. Lemaître was interested in cosmic rays because he thought they were remnants of the primeval atom; today we recognize this to be impossible although we still do not understand the details of the origin of cosmic rays. The true remnant of the primeval atom is the microwave background radiation, an isotrophic blackbody remnant of the hot big bang, which was discovered in 1965, a year before Lemaître's death. A final section, entitled Georges Lemaître: The Man and His Work, contains delightful papers by Deprit and Godart.

Reviews of fundamental cosmology emphasizing Lemaître's contributions are presented in papers by McCrea and Peebles. Lemaître favored a class of models in which the cosmological constant, a cosmic self-repulsion of the vacuum first invented and then rejected by Einstein, plays a major role in the expansion of the universe. Lemaître emphasized the cosmological constant because it could reconcile the geological age of the earth with the much younger age predicted by the expansion rate of the universe as first measured by Hubble. Additionally, a suitably chosen value of the cosmological constant provides an epoch of stagnation, when the universe expands very slowly and fluctuations that would eventually become galaxies can rapidly grow in amplitude. Though no cosmologists today believe in a stagnation phase, most are willing to consider that a cosmological constant may be important. The cosmological constant remains a fundamental outstanding problem of particle physics and cosmology today, and it is a shame that this volume does not contain any contributions addressing modern considerations of the subject.

Modern cosmological theories have progressed to the point of specifying candidate particles to have emerged from the primeval atom and survived to this day as the "dark matter" in the universe. Sciama summarizes the implications of a universe dominated by massive neutrinos or photinos. These candidate particles are suggested for reasons related to theories of particle physics and demonstrate the exciting influx of new ideas generated by detailed consideration of the very early universe, a subject now wholly in the hands of elementary particle physics theorists. The nucleosynthesis of light elements in the first three minutes of the universe is considered the most remarkable success of the hot big-bang models and is here well reviewed by Audouze. A modern view of galaxy formation is provided by Silk, and Oort reviews observational evidence for large-scale clustering of galaxies. Evidence for spatial homogeneity in the universe is very sparse, and therefore it is of interest to consider spatially inhomogeneous cosmological models. Krasinski and Mashoon discuss such models, which are likely to be wrong but are useful nonetheless.

The section of the proceedings concerned with celestial mechanics is connected to the one concerned with cosmology only in being a reflection of Lemaître's scientific focus late in life. Several of the contributions in this section are quite technical. A detailed pedagogical presentation by Deprit of the dynamics of orbiting dust in the presence of radiation pressure is excellent. Broucke discusses modern aspects of the complex problem of motion of a charged particle in the magnetic field of a dipole, a topic that Lemaître labored on for decades because of its connection to the propagation of cosmic rays. Several of these contributions will be of interest only to specialists, but others, such as a review of the three-body problem in astrophysics by Hut, are of more general interest.

The volume is most interesting to me for its historical aspects; it reminds us how the focus of a problem changes over time, and it puts into perspective the progress that has been made in the 50 years since Lemaître's great innovation. However, because of its eclectic subject matter and incomplete coverage, it is not suitable as an introduction or as a testament of current progress in either cosmology or celestial mechanics.

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Stochastic Mechanics

Quantum Fluctuations. EDWARD NELSON. Princeton University Press, Princeton, N.J., 1985. viii, 146 pp. $32; paper, $12.95. Princeton Series in Physics.

Quantum mechanics, from its inception in 1913, posed many questions concerning the mathematical description of physical measurements and the processes of making such measurements. In quantum mechanics one agrees to identify a "state" of a physical system (a beam of photons impinging upon a grating) with a normalized vector ψ in Hilbert space, a physical observable with a self-adjoint operator O in this space, and the measured value of O on the state ψ with the expectation $(\psi, O\psi)$. In 1936, G. Birkhoff and J. von Neumann initiated a derivation of quantum mechanics from a calculus of propositions more suited to the language of measurement, which, at the same time, made clear the special nature of quantum mechanics. This framework was thoroughly reexamined by the Geneva school of J. Jauch in the 1960's. Others have proposed "hidden variable" theories in which quantum mechanical observables are related to deterministic variables that supplant the uncertainty principle on the basis of the inherent lack of simultaneous measureability for complementary observables. Such hidden variables of one type were shown not to exist by S. Kochen and E. P. Specker in 1967. On the other hand, stochastic mechanics as developed by E. Nelson does succeed in basing quantum mechanics on a classical deterministic theory that is not a hidden variable theory. Nelson takes the point of view that quantum fluctuations, which are usually attributed to the uncertainty principle, might be real and caused by direct physical interactions. This is the background field hypothesis. Quantum phenomena are now described in terms of a stochastic process with "diffusion" as the primary construct rather than in terms of only the wave function ψ. The physics, which is purely classical, appears in the equations for the diffusion process, and quantum fluctuations result from the randomness of this process; that is, they are fluctuations in the customary sense of probability theory. Such a relation between the Schrödinger equation of quantum theory and a diffusion was shown by I. Fényes in 1952 and was rederived by Nelson in 1966 from a stochastic analogue of Newton's force equation. A complete account of these derivations with background material is contained in the first two chapters of Nelson's monograph.

To obtain agreement between stochastic mechanics and quantum mechanics, the stochastic diffusion matrix is $\sigma = \hbar m$, where m is the matrix of masses for the classical stochastic dynamics and $\hbar$ is Planck's constant, which determines the scale size for quantum phenomena. This relation between diffusion and mass fixes the size of the fluctuations for the stochastic process in physical terms and is the mathematical manifestation of the background field hypothesis. Dynamics for the underlying process is provided by a variational principle that is a stochastic analogue of Lagrangian variational principles in classical mechanics. The time evolution of the process is related to a Hamilton-Jacobi equation from which results the Schrödinger equation. Given an initial probability density ρ_0, an initial drift vector b_0, and a suitable potential, the stochastic process is a stationary point for the stochastic variational principle when there exists a wave function ψ satisfying Schrödinger's equation and related to the probability density ρ and drift vector b at later times by $\rho = 1\psi1^2$, $b = (\text{Re grad } \psi + \text{Im grad } \psi)/\psi$. In stochastic mechanics, the wave function is a derived quantity, but for all predictions based upon it agreement is obtained with those of quantum mechanics. The point of view, however, is markedly different. The wave function is now described in terms of actual point particle motions that allow the appearance of expressions