Book Reviews

O-Type Stars

Mass Loss and Evolution of O-Type Stars. Papers from a symposium, Vancouver Island, Canada, June 1978. P. S. CONTI and C. W. H. DE LOORE, Eds. Reidel, Boston, 1979. xx, 502 pp., illus. Cloth, $63; paper, $31.50. International Astronomical Union Symposium 83.

The O-type stars are the hottest, most massive, and most luminous of all the classes of stars. They delineate the spiral structure of our own and other galaxies, serve as powerful probes of the interstellar medium, and are the site of nucleosynthesis, via supernova explosions, of most of the elements heavier than helium. Recent rocket and satellite studies of far ultraviolet spectra of O-type stars show that all are losing mass at rates that typically fall in the range 10^{-5} to 10^{-6} solar masses per year.

The symposium proceedings presented in this volume focus first on the mass loss itself, including both observational characterizations and theoretical modeling of its properties. There is general agreement among the contributors that the winds of the O-type stars are accelerated to the observed velocities of 2000 to 3000 kilometers per second, or about three times the escape velocity, by radiation pressure, but there is controversy about whether radiation pressure alone can initiate the flow. In any case, the discovery of anomalously high stages of ionization of particular elements (for example, O-VI) demonstrates that the winds cannot be in radiative equilibrium with the stellar photospheres, which typically have temperatures in the 30,000 to 50,000 K range. A particularly promising model for the wind postulates that mechanical energy is deposited in a narrow (10 percent of the stellar radius) coronal ($T \sim 5 \times 10^6$ K) region at the base of the flow. The anomalous ionization is then caused by x-rays from the corona, while the remainder of the wind has the temperature appropriate to a gas in radiative equilibrium. Since the symposium, astronomers at the Einstein X-ray Observatory have discovered that O-type stars are indeed weak x-ray sources and that the intensity of the x-rays is approximately in accord with the coronal model.

During main sequence evolution an O-type star may lose half or more of its original mass, and the second half of the book discusses the impact of stellar winds on the evolution of both single and double stars. Extensive mass loss lengthens the main sequence lifetime and produces a star that is overluminous for its mass, relative to a star evolving without mass loss. If the hydrogen-rich envelope is stripped away nuclear-processed material, enriched in helium, nitrogen, or carbon, may be observed at the stellar surface. An understanding of these effects is critical in analyses of binaries that emit x-rays owing to accretion of material from a stellar wind by a neutron star or black hole, in calculations of the impact of pre-supernova mass loss on nucleosynthetic yields, and in determining the origin of the Wolf-Rayet stars, extraordinary objects that have mass loss rates two orders of magnitude higher than other luminous stars as well as anomalous abundances of helium, carbon, and nitrogen.

The study of mass loss in O-type stars has become possible only through the availability of new facilities for far-ultraviolet, infrared, radio, and x-ray astronomy. Because so many results have been obtained in the past five years, a symposium on this subject was particularly timely. The six review papers provide an excellent overview of both current research and outstanding problems, and the level of the contributed papers is unusually high. The volume is indispensable for anyone who wishes to understand or be actively involved in the study of the mass loss and evolution of O-type stars.

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Antecedents in Meteorology

The Thermal Theory of Cyclones. A History of Meteorological Thought in the Nineteenth Century. GISELA KUTZBACH. American Meteorological Society, Boston, 1979. xiv, 256 pp., illus. $30. Historical Monograph Series.

Modern meteorology owes much to Norway. Between 1918 and 1924 a group of Norwegian and Swedish scientists working in Bergen under the leadership of Vilhelm Bjerknes transformed theoretical and practical meteorology. Their various achievements included a new model of the extratropical cyclone, that is, the type of low-pressure system common in the mid-latitudes. Recognizing that these atmospheric disturbances are composed of three-dimensional surfaces of discontinuity—fronts—they began conceiving the cyclone as a wave that develops and grows along preexisting polar fronts that separate polar and subtropical air masses. In shifting from regarding cyclones as undifferentiated entities to regarding them as composed of fronts, they were able to provide the first clear physical explanation of cyclone evolution. The Bergen school's models and forecasting techniques marked a turn to a dynamical-physical comprehension of the atmosphere, in contrast to the statistical-climatological approach that had dominated meteorology since the late 19th century. Not surprisingly, the Bergen meteorology promoted an unprecedented interaction between theory and practice that proved critical for the rapid growth of meteorology as a professional scientific discipline during the 1920's and 1930's.

Like other scientific breakthroughs, the Bergen meteorology incorporated aspects of earlier thought. Also like other major changes in science, it generated jealousy and even hostility. In her book Gisela Kutzbach takes up and elaborates upon a view of the developments argued during the 1920's by German and Austrian meteorologists. According to this view, the Bergen meteorology, far from being novel, essentially repeats what was known earlier and where innovative ought be understood as the capstone of a 19th-century school of thought. To prove the case Kutzbach presents what she calls the thermal theory of cyclones and traces its development leading to the Bergen school's work.

The theories Kutzbach's classification subsumes are ones according to which the kinetic energy of a cyclone derives wholly or partly from thermal energy released during condensation. Such theories, using the first law of thermodynamics as a basis, proliferated during the second half of the 19th century. Kutzbach ably presents many of them. Readers not acquainted with meteorological thought during this period will find a competent overview of some prevailing ideas and controversies. Much of this material will be new to present-day readers.

Unfortunately, as historical analysis the book fails. Ignoring the wealth of European and American archive materials, Kutzbach has relied solely on published scientific papers and on rather dubious historical accounts. Instead of documenting how meteorologists established their theories and why they reacted to criticism as they did, she infers thought processes and imputes motives. Not surprisingly, many of the resulting accounts are misleading; indeed, some are erroneous. Kutzbach does not allow for a multiplicity of problem interests on the part of the meteorologists in question or for any significant role of forecasting concerns and practices in the evolution of meteorological thought. All meteorologists are made to appear, falsely, to have had an overriding concern with the thermal theory of cyclones. These weaknesses preclude an understanding of the Bergen school's achievements and their relationship to past accomplishments.

Bergen meteorologists, such as Bjerknes and his son, Jacob, Solberg, and Bergeron, did not arrive at their new models through contemplation in the peace of a university milieu. Rather, they brought about their transformation of meteorological thought while constructing a weather service intended to aid Norway in time of economic and social crisis. Kutzbach's assumption that theory begets theory misses the point, as does her characterization of the Bergen meteorology solely as theory. Bergen meteorologists constructed their models over a period of time partly as a consequence of changes in forecasting methods and partly in conjunction with their efforts to forge new forecasting techniques to meet challenges arising from agriculture, aviation, and fishery. Physical reasoning and theoretical deliberation were involved in this process, but not in the way Kutzbach assumes. Her discussion of alleged precursors and supposed unacknowledged influences, such as Dove, Helmholtz, Margules, and Shaw, reveals a lack of appreciation for the nature and historical significance of those scientists' work as well as of the Bergen school's.

Much of the confusion originates from uncritical reading of the historical statements written by meteorologists, both opponents and adherents of the Bergen school. The historical literature on which Kutzbach builds her argument stems from a struggle for power and authority within the meteorological discipline. When international scientific cooperation resumed after World War I, German and Austrian meteorologists, who had been at the center of the discipline, found themselves at the periphery. Moreover, Bjerknes, who had left Leipzig University during the war, was now attempting to establish a new international capital for meteorology in Bergen. Understandably, some embittered German and Austrian meteorologists refused to concede any novelty in the Bergen school's work. Turning to the past, these scientists conjured a multitude of examples that allegedly showed the unoriginality of the new meteorology. The Bergen investigators also sought assistance from the past. In their efforts to make their ideas and methods more appealing to the discipline, they tended to link their work with the thoughts of great scientists who had preceded them. Interestingly, the names invoked generally changed with the audience being addressed and with the severity of the priority debate. Behind the attempts at finding historical continuities lay a recognition that a significant discontinuity had occurred. When von Ficker, one of the leading Austrian meteorologists, explained to Bjerknes his hostility, he succinctly noted, "The Norwegian school . . . has broken the Austrian school's hegemony in meteorology" (quoted by Bjerknes in a letter to C. W. Oseen, Oseen Papers, Kungliga Vetenskaps Akademien, Stockholm, 16 July 1929). The accomplishments of the Bergen group do not diminish the significance of 19th-century meteorology. To appreciate the work of pre-Bergen meteorologists, however, it should be analyzed in the context of their own time and not in the light of later events.

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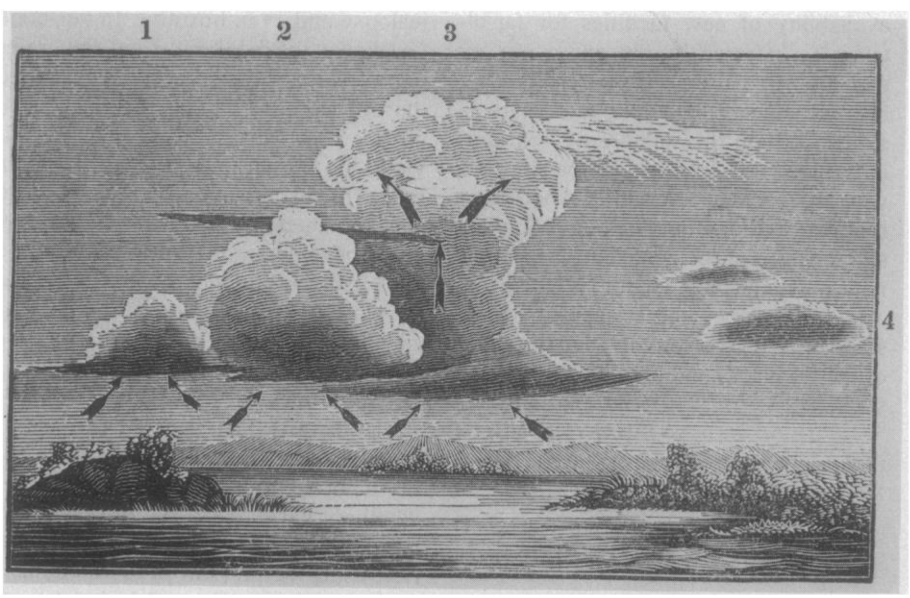

Formation of cumulus clouds by convection, from James Pollard Espy's *The Philosophy of Storms* (Boston, 1841). On the basis of measurements of the amount of water vapor in saturated air (made with the nepheloscope, an instrument he devised) and the data then available on specific heats and latent heat, Espy reached the conclusion that when a cloud is of great height above its base its top must be much warmer and consequently much lighter than the atmosphere at that height. "Condensation of water vapor thus enhanced the rising of air, i.e., thermal convection and therefore cloud growth. . . . This explanation of Espy's stood in outright contradiction with traditional teaching. Customarily it had been assumed that 'when a portion of atmospheric vapor is condensed into cloud, the air in the cloud becomes specifically heavier than it was before,' because the density of water vapor is less than that of air. Accordingly, condensation of water vapor appeared to inhibit convection of air. . . . Scientists . . . quickly realized that Espy's explanation of condensation and rain was superior to the prevalent mixing theory of rain by the Scottish geologist James Hutton." [From *The Thermal Theory of Cyclones*]

A Plant Family

The Biology and Taxonomy of the Solanaceae. Papers from a symposium, Birmingham, England, July 1976. J. G. HAWKES, R. N. LESTER, and A. D. SKELDING, Eds. Published for the Linnean Society of London by Academic Press, New York, 1979. xviii, 738 pp., illus. + plates. $93.25. Linnean Society Symposium Series, No. 7.

This is another contribution to a series of volumes that has been published in recent years dealing with the biology and chemistry of large flowering-plant families. Its predecessors covered the Cruciferae, Leguminosae, and Compositae. In the preface, the editors point out that of the "really large" families of flowering plants the Solanaceae, or nightshade family, is perhaps one of the least well