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