crystalline humor was bombarded with forms from all points of the object, and confusion seemed inevitable. Alhazen made an apparently ad hoc escape by according a privileged position to rays that fell perpendicularly on the surface of the crystalline humor and were thus, according to his view of ocular structure, directed toward the center of the eye. These determined how the object was to be grasped. But even this was not the end of the story, for Alhazen later allowed an important role to rays that fell obliquely on the eye and were refracted by its outer parts. He rather proudly said that none of the older writers had used refraction in this way, but if Lindberg's interpretation of the difficult passage expounding the matter is right he was falling into a fairly elementary error. I am not yet convinced that Lindberg has given the whole picture, but if Alhazen could be made more consistent he may also appear far less "modern."

In the West, Lindberg establishes for Roger Bacon a position of central scientific importance as the first person to assimilate the work of Alhazen with any thoroughness, although Bacon still managed to add to Alhazen's scheme a visual power emitted from the eye. Grosseteste, who was ignorant of Alhazen's work, is accorded less importance than in many accounts. Lindberg makes a good case for Bacon's influence on John Pecham, and a rather more tenuous one for his influence on Witelo. Printed editions of Pecham's short textbook and Witelo's long one had considerable influence in the 16th century, and it was against Witelo that Kepler reacted in his major optical work. The later Middle Ages saw less positive work in the tradition of geometrical optics. We may best see this as resulting from a paradoxical combination of skeptical tendencies and a more rigid adherence to Aristotelian texts. Lindberg discusses a variety of Renaissance writers, but manages to show their limited role in preparing the way for the Keplerian achievement.

The central feature of that achievement was the treatment of the crystalline humor as a lens which focused the incoming rays to form a picture on the retina, although Kepler was able to give no more than a qualitative account. The essential one-one correspondence was now between points of the object and points of the retina, and many difficulties in Alhazen's model were averted. There is the obvious analogy of the camera obscura, to the theory of which Kepler had made some important contributions, but Lindberg is at pains to minimize its significance. A difficulty which Kepler strongly felt was that the retinal image was inverted and reversed, and this contributed to his demand for a strict separation between the "optical" and "physical" aspects of vision: the former ended at the retina. Lindberg is much concerned to maintain Kepler's continuity with preceding work. "I am arguing that Kepler was the culminating figure in the perspectivist tradition, and I must strenuously object to Crombie's and Straker's attempt to view him as a revolutionary figure who transformed visual theory by 'mechanizing' it" (p. 207). Lindberg's approach brings out many important aspects of Kepler's thought that might otherwise be lost, but, I think, gives less than full weight to the significance of Kepler's pushing a *single* optical theory as far as it would go, rather than letting the geometrical propagation of light and color slowly merge into something else inside the eye. Crombie's striking image of the eye in Kepler's treatment as a dead eye can still direct our attention to what may be greater elements of novelty than Lindberg would allow.

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The Sun's Atmosphere

The Solar Chromosphere and Corona. Quiet Sun. R. GRANT ATHAY. Reidel, Boston, 1976. xii, 506 pp., illus. $59. Astrophysics and Space Science Library, vol. 53.

The outer atmosphere of the sun is a wonderfully complex tangle of magnetic field, streaming gas, wave motions, and nonthermal particles. A generation of solar physicists have struggled to understand it, and despite their heroic efforts, aided during the last decade by detailed measurements from space experiments, the sun preserves most of its mysteries intact.

According to current ideas, the two-million-degree solar corona is heated by the dissipation of mechanical energy propagated from the top of the convection zone. Heat flows back to the surface by conduction, there to be radiated into black space. Heat flows outward as well and, where the magnetic field lines open to interplanetary space, drives the solar wind. R. Grant Athay's new book surveys the physical processes that underlie this broad conception and the empirical evidence that supports (and contradicts) it.

The monograph is intended for a wide audience. Comprehensive and current, the book is remarkably self-contained and clearly written. Second-year graduate students with a background in stellar atmosphere theory, as well as solar or stellar specialists, can profit from reading it. In the first half of the book, Athay reviews recent observations of structure, motions, magnetic fields, and spectral characteristics. Two excellent chapters summarize the essential elements of non–local-thermodynamic-equilibrium line formation and the inference of chromospheric structure. In chapter 9, Athay assesses the energy and momentum balance of the solar atmosphere. The final chapter reviews, rather hastily, some elements of wave generation and heating.

Considering its great scope, I found the book well balanced between theory and observation. Athay has contributed heavily to the field he summarizes (particularly in the analysis of line spectra), and his authoritative, physical approach to the subject sustains the reader throughout. Many blunt, provocative statements appear—the field is by no means a closed subject, and the specialist will find many points with which to argue. But this, after all, is the mark of a good monograph.

The book is strongest when Athay is discussing chromospheric observations and their interpretation. I found his discussion of chromospheric and coronal heating in the last chapter too short and too isolated from the rest of the book to be satisfactory. In fact, the book's main fault is that it lacks a sustained, coherent point of view. Each chapter is complete and well written, but the book does not have a dominant theme, despite the author's intention, expressed in the preface, to treat the atmosphere from the viewpoint of energy transformations in a magnetized gas. Moreover, too little distinction is made between the energy flow in open as opposed to closed magnetic regions in the corona.

Athay's review of the literature stops at about 1974; the pace of research has overtaken him at several points. The index is hopelessly inadequate—for example, not a single reference to the coronal temperature distribution is included.

Despite these minor faults, this monograph will serve solar and stellar astronomers as a guide and challenge for many years to come. Athay has reviewed a vast, untidy, and fascinating subject with authority and insight.

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