visual observations; reflectors replaced refractors. The new physics of atomic spectra replaced the gravitational physics of binary stars, planets and the solar system. *Eye on the Sky* emphasizes the early years, with only 40 pages for the last 40 years. It covers the building of the 120-inch reflector and the introduction of electro-optical sensors. Application of the "new physics," in any epoch, requires that the "new astronomy" renew itself as it deals with a continuously varying subject matter.

The two books overlap considerably; the Keeler biography gives more detailed source material and brief sketches of the astronomical establishment of that period. Important figures then included Samuel Langley, Simon Newcomb, Edward Pickering, Henry Rowland and the rising star, George Ellery Hale at Chicago, a strong supporter of Keeler. (Hale and Keeler were cofounders of the *Astrophysical Journal* in 1895.) A group of San Francisco businessmen and politicians persuaded James E. Lick (1796–1876) to give $700 000 to build a telescope "superior to and more powerful than any telescope yet made." Lick, with little education, a carpenter turned piano maker, had made himself into a real-estate tycoon in San Francisco. He had a strong layman's interest in the planets and stars, and no close family. Joseph Henry and Louis Agassiz called on him. He created a board of trustees (which took excellent advice) to build the 36-inch refractor, the largest in the world. It was sited not at the university, but on 4200-foot Mount Hamilton, making it the first mountain observatory above the temperature inversion. With the sea fog kept below, there was stable air, that is, good "seeing," above the telescope much of the year. Only later did the growth of city lighting impede observation of faint objects. In 1888 the Lick trustees, led by the Civil War veteran Captain Richard Floyd, transferred the finished telescope and buildings to the regents of the University of California. There was a negligible endowment. The 36-inch remained the largest telescope in the world for only ten years, but its excellent location and devoted, if small, staff kept it at the frontier until Hale built 60- and 100-inch reflectors on Mount Wilson (1918), with similar climatic advantages. But with the installation of its 120-inch reflector in 1959, the Lick returned to the competition.

Competitive "big science" in the US began with the Lick, and some problems of big science were evident from the start. The University of California was stingy with its support. The first—traditionally all-powerful—director, Holden, who served from 1888 to 1897, proved disastrous, and the experiment of having staff dwell together on that isolated mountain did not always make life easy. Both books contain more details of internal strife within the "family" of scientists than we may wish to know. Yet problems posed by the emergence of scientific novelties were successfully encountered at Lick. Photographic spectroscopy with the large refractor gave orbital velocities in binary stars, supplementing masses from visual binaries. Because the staff had enough observing time, major long-duration programs were carried out successfully. A 36-inch reflector, bought for essentially nothing, permitted second director Keeler (who had studied with Rowland) to obtain beautiful photographs of nebulae having either emission-line or absorption spectra—the former from gas clouds in the Milky Way, the latter from stars in "extragalactic" nebulae or galaxies. (The distinction only became obvious after Edwin Hubble established that the Andromeda spiral "nebula" and others like it lay outside the Galaxy.) Among Keeler's discoveries were the exact wavelengths of the "nebulium" lines in gaseous nebulae, different from any then known in the laboratory, and later shown to be "forbidden" atomic transitions. [See the article by Leo Goldberg on page 38.] Osterbrock's biography of Keeler reflects how difficult a research career was a century ago, and how important a few individuals could be in building institutions that survived on private funds.

Students were supported by small Lick Fellowships, and had austere living accommodations. Twenty percent of the PhDs before 1931 were women. Such history seems particularly relevant now that science, at the end of a happy epoch of dependence on a gush of Federal money, worries about the shaky foundation of university-scale projects, about continued postdoctoral education, about how young scientists can test new ideas. Can energetic leaders again find equivalents of a James Lick? Observational astronomy became one of the most cost-effective "big sciences" in the US while remaining largely dependent on the private and state-university sector. Among Ludwig Boltzmann's autobiographical papers is an idiomatic and amusing account of a 1905 trip to California. He delights in his meetings with the philanthropic widows of Leland Stanford and George R. Hearst. On his visit to the Lick Observatory, he looked at Mars through the 36-inch refractor and remarked, "Glücklich das Land wo Millionäre ideal denken und Idealisten Millionäre werden [Happy the country where millionaires are idealists, and idealists become rich]." Would that he were right.

I recommend both books, *Eye on the Sky* for its scientific and cultural information about a great institution, and *Keeler* for those more interested in the difficult life of the scientific pioneer.

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BOOK NOTE

First Light: The Search for the Edge of the Universe

Richard Preston
Atlantic Monthly P., New York, 1987. 263 pp. $18.95 hc ISBN 0-87113-200-1

In Darkness Born: The Story of Star Formation

Martin Cohen
Cambridge U. P., New York, 1988. 196 pp. $19.95 hc ISBN 0-521-26270-4

Thursday's Universe: A Report from the Frontier on the Origin, Nature and Destiny of the Universe

Marcia Bartusiak
Times Books (Random House), New York, 1986. 306 pp. $19.95 hc ISBN 0-8129-1202-0

The flood of books on astrophysics for lay readers continues with this trio, which demonstrate different approaches to science popularization.

In *First Light*, journalist Richard Preston, a nonscientist, provides graphically detailed portraits of a few observational astrophysicists, particularly of Maarten Schmidt and James Gunn observing at Palomar. He uses reconstructed dialogue from oral interviews and novelistic detail to give a human dimension to scientific research. Its subtitle, "The Search for the Edge of the Universe," is identical to that of Timothy Ferris's *The Red Limit* (second edition, Quill, New York, 1983). With its close focus on practical observing—often with recalcitrant gadgets—Preston's book conveys well the spirit of comments

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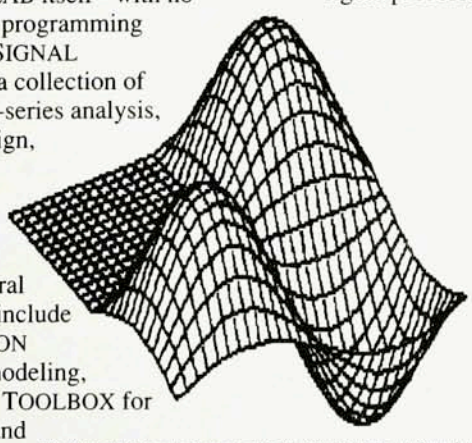

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by Caltech astrophysicist Jesse Greenstein, quoted in *The Red Limit*: "When you're in the observer's cage of the 200-inch, the telescope turning and the stars going by, it's romantic, beautiful, marvelous, but on the other hand it's uncomfortable, tedious, bone-cramping and you get sleepy." Unlike *The Red Limit*, Preston's book has no index, no bibliography and no illustrations. Still, this is a book that a teenager, perhaps a potential scientist, might particularly enjoy reading.

In Darkness Born is by Martin Cohen, a professional astrophysicist writing about his own specialty. The focus is very much on detailed scientific findings, with the human element obscured. Those who are already regularly reading articles on astrophysics in, say, *Scientific American*, *Sky and Telescope* or PHYSICS TODAY will probably enjoy reading this book about star formation.

Thursday's Universe presents an assessment of both observational and theoretical cosmology. Of the three books it takes the most ambitious—and potentially the most hazardous—approach in attempting to describe the rapidly expanding research frontier in cosmology. Yet nearly two years after its publication the book remains both timely and comprehensive. The author, Marcia Bartusiak, is a journalist with physics training. Clearly Bartusiak has talked to numerous people and distilled the information well. The book has a good balance between carefully written science and quick sketches of those who are mapping the cosmic landscape. This is a convenient book for the lay reader or nonspecialist to read for background on the hot topics cosmologists are discussing among themselves at their technical meetings.

—PER H. ANDERSEN

NEW BOOKS

Astrophysics

Astrophotography. Proc. IAU Wksp., Jena, GDR, April 1987. S. Marx, ed. Springer-Verlag, New York, 1988. 241 pp. $45.00 *hc* ISBN 0-387-18498-8

Astrophysical and Laboratory Spectroscopy. *Scottish Universities Summer School in Physics 33.* Proc. Sch., St. Andrews, UK, September 1987. R. Brown, J. Lang, eds. SUSSP, Edinburgh, UK, 1988. 415 pp. £24 *hc* ISBN 0-905945-16-6

The Harlow-Shapley Symposium on Globular Cluster Systems in Galaxies. *International Astronomical Union Symposium 126.* Proc. Symp., Cambridge, Mass.,