THE

OBSERVATORY

A REVIEW OF ASTRONOMY

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Vol. 139 No. 1270

2019 JUNE

We are currently in a gender-scary epoch, so I end with one seeming political incorrectness from a discussion of the early development of relativistic cosmology: "Willem de Sitter (a Dutchman with a pointy beard), Alexander Friedmann (a Russian with a caterpillar moustache), Georges Lemaître (a clean-shaven Belgian Catholic priest), Bob Robertson (an American with the tiniest moustache you've ever seen), and Arthur Walker (an Englishman with no beard) ... . The most important point is that it demonstrates that no matter your choice of facial hair arrangement, you too can be a theoretical physicist." I find I have very little choice in that matter. — VIRGINIA TRIMBLE.

Limiting Outer Space: Astroculture after Apollo, edited by Alexander C. T. Geppert (Palgrave Macmillan), 2018. Pp. 367, 24 × 16·5 cm. Price £88 (hardbound; ISBN 978 1 137 36915 4).

This surprising book is the second in a series by a group of scholars associated with a German research group called The Future in the Stars which is described as dealing with Astroculture — a term introduced in their first volume, *Imagining Outer Space*. This second book is an excellent collection of essays which encompasses a wide sweep of the impact of space research and space dreams on the cultural landscape of society as a whole, beyond the limiting technological confines within which the enterprise is usually examined. Why is the book surprising? Firstly as a physical object it is surprisingly well made; the cover design subtly sets the agenda with a monochrome foreground image of the Moon and in the background a barely bluish Earth on a cool black material that is soft and tactile. The pages are clear and bright and the font is well sized and legible. The second surprise is the title: what can it mean to talk about limiting something so obviously limitless as outer space? Finally the content, in which space research is described as being limited by a sort of self-imposed lack of ambition, is surprising. To be confronted with information from one's working life but viewed not from a technological, functional stand point but from the different, but equally valid, perspective of the effect on human society is enlightening and rather unsettling.

The main discussion of the book is about the effect of space research on society at large and the effect of society's interests and aims on the pursuit of space science, especially during the years following the Apollo Moon landings but before the beginnings of the recent low-Earth-orbit industrialized space programmes of the present day. The contributors are addressing what they see to be a massive de-scope in the aims of space research from the original ambitions of the 1950s in which the message of "our future lies in the stars" was changed to the more mundane pragmatic view of the 1980s in which space becomes simply a platform for commercial interest and the quest for abstract knowledge is replaced by a relentless search for profit. This topic is discussed in a series of brilliantly researched essays referencing movies, novels, architecture, international treaties, and even LEGO figures, and with the possible exception of those egalitarian smiling toy characters, every human endeavour involves politicians making deals somewhere in the background.

The time-scale of the cultural arc from star-based fantasy to factory-floor reality is nicely bracketed by movies which illustrate those two concepts — from the Utopian evolution of humanity to become children of the stars in the film *2001 A Space Odyssey*, released in 1968, to the bleakly despairing *Alien*, released in 1979, in which the action takes place on a squalid industrialized factory

spaceship. There is nothing new in observing that art references technology. But it is a mistake to see art only as a mirror. By reflecting the interests of, but also giving voice to the feelings of society at large, art also helps to set the context and agenda in which science operates — and can limit its more high-flown ambitions.

According to the editor, as far as society is concerned the two greatest achievements of the Apollo programme are not the kilos of Moon rock brought back for detailed study, or Neil Armstrong's footprints in the dust of the Sea of Tranquillity, but two photographs. Earthrise, taken by the astronauts on *Apollo 8* as it came out from behind the shadow of the Moon to witness the Earth rising above the lunar landscape in its viewports just before Christmas 1968, and the 'Blue Marble' — a view of the entire Earth seen by the last people to set foot on the Moon in 1972. The authors contend that those two images taken by humans with hand-held cameras on rolls of film encapsulate an essential human element not present in images from robotic spacecraft and their electronic eyes; and that that human vision was instrumental in progressing the nascent environmental movement — it now had powerful visual symbols of what it means to live on a fragile planet in the dark isolation of space. The authors argue that the very term 'globalization' could be seen to be a direct consequence of the view of the Earth provided by Apollo and that that new view at least contributed to the subsequent change in direction and overarching message of space research. So the bleak decade following Apollo involved a reigning in of space ambition and a greater focus on problems associated with living on a planet with decreasing resources and increasing human population. It could also be argued that without the global perspective provided by those images of the Earth in space, and the obvious lack of visible country borders on the surface of the globe, there would be no world wide web.

What did novelists think? Generally writing after they had time to digest the significance of both the reaching-for-the-stars type of space hype and the navel-gazing pondering of the whole-Earth images, at least as far as the Anglophone novels were concerned it was generally felt that "the process by which a mere visual image is charged with much more significance than it would appear to merit is less than wholesome". And that the novel is a much better medium for understanding humanity than any amount of space-image-inspired navel-gazing. But then they are wordsmiths and do not deal in emotive visuals.

In 1968 we could watch the film *2001* and believe that far enough into the future the events described would be at least technically plausible, and a few years later the follow-up novel *2010* occupied the same credibility space. Yet here in 2019 space travel is carried out in pretty much the same way as in the 1970s — often with the same technology: chemical rockets still 'Guy Fawkes' astronauts to the space station — which is not an elegant rotating wheel creating its own gravity but a kludged together mishmash of what looks like the contents of a second-hand space-hardware store. This clash between the 1970s dreams and 1980s and 90s realities is the core of this book. The shiny streamlined dreams of the 1950s were confronted with the realities of space travel in the Apollo era and the "mind's eye was now constrained by what the physical eye was seeing" and reality was found wanting — people looked elsewhere for excitement and visions of the future.

The early dreams of space were not just American or Soviet. An early chapter discusses in detail the UK's entry into space science and technology, dealing with the development of the UK launcher and the influence of the British

Interplanetary Society. It was under those influences that many space scientists and engineers were inspired to chart a course to space-based careers. The excitement was maintained with the daring activities of *Sputnik*, Gagarin, and the Mercury and Gemini programmes; but after Apollo the dreams faded — perhaps best illustrated in the popular context by the decline of the comic-strip hero Dan Dare.

In the last chapter, 'Final Frontiers?', we are given a necessary uplifting view of the future as the author reviews and places in context the previous 11 chapters, if not with the early technology-led visions and fantasies of the 1950s Astroculture, at least with a more hopeful stance. The entire book is a thoroughly worthwhile thought-provoking read. — BARRY KENT.

Low Frequency Radio Astronomy and the LOFAR Observatory: Lectures from the Third LOFAR Data Processing School, edited by George Heald, John McKean & Roberto Pizzo (Springer), 2018. Pp. 251, 24 × 16 cm. Price £96·50/$139 (hardbound; ISBN 978 3 319 23433 5).

LOFAR is the *LOw Frequency ARray* radio interferometer centred in the northern part of The Netherlands. As with any many-antennaed interferometer, its use is computationally intensive, and this volume is the proceedings of a 2014 November school for future users. The editors explain, in a 2018 March preface, that the system is rapidly changing and that they have tried hard to update the material in the lecture chapters from the school year to their present. They encourage readers to consult the *LOFAR* web pages for current information, and urge the use of proceedings from a 1998 June Summer School in Socorro, New Mexico, as a source of complementary and more stable information.

Chapter 1 is a very brief history of radio astronomy and of the low-frequency sky; Chapter 14 addresses high-time-resolution data from *LOFAR* — mentioning the PulP Standard Pulsar Pipeline is irresistible, though the process has been folded into the MoM/Scheduler. The other chapters are portions of an instructional manual rather than results from its use. Is something of the sort necessary? Undoubtedly! Should it be a £100 hardcover? Probably not. Loose-leaf with replaceable pages or even a downloadable 'App' might suit the purpose better.

Still, there are tidbits worth retaining: (*i*) a.u. is not always astronomical units, but sometimes (I think) arbitrary amplitude units (Fig. 9.2); (*ii*) sometimes the Crab Nebula is a noise source that has to be "demixed" even when it is outside the field of view (ditto for the A's of Cas, Cyg, Vir, Hyd, and Her (erroneously Hera in Fig. 4.3), though poor old Sgr A isn't even a dot on their map); (*iii*) there are two types of antennas, leaving 100 MHz undetectable in between because FM radio is also a noise source; (*iv*) Reber's 1960s array in Tasmania was the first radio *Square Kilometer Array*; and (*v*) extensive air showers due to very-high-energy cosmic rays are low-frequency radio sources, and this has been known since 1965–66. Not synchrotron or Bremstrahlung, but electrons and positrons accelerated into an electric current by the Earth's magnetic field and a build-up of negative charge excess in the shower front, made of electrons knocked out from atmospheric molecules. The data can be used to reconstruct the depth into Earth's atmosphere where the shower has its maximum development, and so is complementary to studies from the *Auger* CR array — not for the same showers, though, since *Auger* is in South America and, based on times of sunrise on December and June 21st, northern Netherlands must be quite far north. — VIRGINIA TRIMBLE.