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Jacob W.M. Baars • Hans J. Kärcher

Radio Telescope Reflectors

Historical Development of Design
and Construction



Springer

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*To our numerous international colleagues
and friends in the Astronomical Community
and Industrial Companies.
Their contribution and dedication to our joint
tasks led to the realisation of many radio
telescopes.
It enabled us to write this book about their
achievements.*

Preface

This book deals with the conception, design and construction of large reflector antennas functioning as radio telescopes. Communication and deep space ground station antennas employ essentially the same technology. Both authors have devoted the major part of their professional life to this subject, be it from a rather different educational background or in a diverse professional activity.

Jacob (Jaap) W. M. Baars has been educated as an applied-physicist and has for 50 years been connected with the creation and execution of radio telescope projects while on the staff of the originating radio observatories. Thus, his main task has been to translate the science case of a project into the requirement specifications for the telescope and to manage the communication with and oversight of contractors and of in-house activities up to final acceptance, testing and astronomical commissioning.

Hans J. Kärcher is by education a structural engineer, a “bridge builder”. He spent his professional life as a system engineer for large telescopes on the contractor side of the projects. This involved the full design of the telescope and the control over the contractual and financial aspects of the manufacturing, verification of its functionality and performance through testing and commissioning, in order to deliver a functioning telescope to the final users.

Physicists and engineers differ in the approach to their subject. The aim of physics is to describe the material world, including the Universe, by a limited number of theoretical assumptions and mathematical equations and test the resulting predictions by experiment in the laboratory or by observation through the telescope. The goal of engineering is to create material devices that fulfil the tasks required of them by the customers—in our case telescopes for astronomers. The engineer has a service function with respect to the astronomer. The astronomer is the originator of the project, defining the requirements to be fulfilled by the engineering effort of creating the telescope. Also, the astronomer has to convince the funding agencies, which often ultimately means the citizen taxpayer, to provide the funds. It is of interest to point out that science projects requiring advances in engineering capabilities often are looked at favourably by funding agencies because

the development of new technologies by industry may create wider commercial application.

The basic requirement of a telescope is to point to an astronomical source in a given direction, to follow the object along its path on the sky and to concentrate the received radiation effectively to the detector in the focal point of the reflector. The realisation of such an instrument involves aspects of structural and mechanical engineering, control systems, electronics and the theory of elasticity and electromagnetic waves. Our individual background and experience (HK in mechanics and control, JB in electromagnetism and radio astronomy) complement each other well, so that a comprehensive treatment of telescope design could be envisaged. The intention of our joint authorship is to convey a fuller picture of the overall subject to the reader than a single author would be able to do.

This book presents a narrative of the historical development of reflector telescopes and antennas up to the latest state-of-the-art projects. We highlight the progress in design methods and the resulting larger and more accurate reflectors by describing in some detail telescopes with significantly new and original design features and technical solutions. We emphasise the importance of a balance between the astronomical requirements and the technical feasibility of realising those under the prevailing financial and technical limitations. The interplay between structural imperfections and electromagnetic performance forms an essential aspect of any advance in the state of the art. Next to the general description of the technical advances by example of radio telescopes, we summarise the basic background of the mechanical, structural, electromagnetic and thermal aspects of telescope design. The mathematics is minimised in favour of physical explanation with the aid of graphical material. The description of some more specialised aspects has been separated from the main text in Addenda to the particular chapters.

An essential and increasingly difficult feature of highly advanced antennas and radio telescopes is the experimental confirmation of the structural and electromagnetic specifications. A fruitful approach has been the direct involvement of the future users, mostly radio astronomers, in the development and execution of the necessary test methods and accompanying equipment. Based on our joint experience in several projects, we add some remarks on the management and realisation of our projects.

We address a readership with interest in the progress of engineering solutions and/or the general development of ever larger and more accurate radio telescopes. As such it should be of interest to observational radio astronomers, structural, mechanical and control engineers, operational staff of radio telescopes and satellite ground stations as well as students in these areas. Also, our goal is to present the rather wide area covered here in a comprehensible and informative way to the non-expert while still providing sufficient detail to interest the expert in a particular field.

As the subtitle states, the emphasis of our book is on the history of design and construction of reflector telescopes. We do not present a history of radio telescopes or the science of radio astronomy.

A considerable amount of work made by industrial contractors, especially in the area of structural mechanics and control systems, has not been published in a readily available form, if at all. Wherever possible we refer to original publications and reports to enable the reader to dive deeper into the subject of his interest. Several figures are not of a quality that one would desire. These are mostly copies of old, original drawings, made well before computer drawing became available and easy. Because of their historical flavour we decided to use them and we hope the reader will accept the lack of clarity.

We owe our career-long association with the design and construction of telescopes to our employers. In the case of JB, these were radio observatories embracing projects that advanced the state of the art, while HK joined a company that created and maintained a strong foothold in the telescope business over more than 50 years. We have been fortunate to collaborate with many highly capable colleagues without whom the enormous progress in this field would not have materialised. They are too numerous to name. We express our gratitude and thanks for our joint experiences. In the preparation of this book, we have been helped by colleagues and librarian staff of several institutes for material too old to be in our private library. We extend a special thanks to Dennis Downes and Dave Morris (both colleagues of yore and now retired from IRAM) for their comments, corrections and suggestions on the style and contents of the book. JB thanks Mark Gordon of NRAO for presenting him with a copy of Strunk and White's *The Elements of Style*. The booklet is a gem! It turned the original text in what we hope is now reasonably proper English. Obviously, we are responsible for any remaining error and "Dutchism" or "Germanism".

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June 2017

Jacob W.M. Baars
Hans J. Kärcher

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