Reflective Telescopes:
Principles and Geometric Optics

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Preface

The goal of a scientist, as such, is to discover, understand and explain the world we live in and that so often and so deeply wonder us.

The importance of Science is widely recognized in modern societies as well as the importance of a sound widespread science education and scientific literacy.

Schools from early ages and basic to secondary and vocational schools have a major role in improving scientific literacy and in training the future scientists. A huge and major task our science teachers commit themselves to undertake daily is overcoming a wide range of barriers and constraints. Sharing experiences discussing and exploring teaching strategies in different contexts is very important to the teacher. As well, knowing about new teaching approaches, not simply theories but specially examples, both positive and well succeeded or failed, of in classroom practices and new support materials can be extremely useful for the teacher and to the success of the school in having their students learning [about] science.

To observe, seeing critically, is a first and fundamental step in this process. Always in an active and committed way, the student must, like scientists do, to define predict and construct new scenarios raising doubts and problems, critically analyzing the situations and proposing explanations and solutions to the questions and problems identified. Students must to able to observe, establish hypothesis, express discuss and criticize their own conclusions and establish/decide, themselves, what to do in order to establish and acquire new knowledge. Understanding the world, we are living in, improving students' knowledge on science and learning science in an effective way, requires active committed and volunteer work as well as responsibility and method (the scientific method) by the students themselves. Exposure to knowledge or access to its sources is not a sufficient condition for learning to occur! Science teachers and educators should lead the students to question themselves to wonder, feel, discover and define the problems, the situations to explain..., by observing, criticizing and building their own knowledge… "doing" SCIENCE…

The Hands-on Science Network, established two decades ago by a wide group of scientists researchers teachers and educators from all around Europe, and now from all around the World, aims to promote the improvement and generalization of science education and literacy. With a broad open understanding of the meaning and importance of Science to the development of our societies, each individual and of the humankind, the main goal of the Hands-on Science Network is the development improvement and generalization of science education and scientific literacy by an extended use of investigative hands-on experiments based active learning of Science and its applications, while fostering cooperation and mutual support understanding and respect among teachers, researchers, educators, students and all involved and committed to science education at all levels and contexts.

The book herein is a remarkable example of an innovative, scientifically sound rigorous and very carefully elaborated tool that will effectively help teachers to improve the quality of the teaching of optics, a major field of physics, and particularly geometric optics and its application to reflective telescopes at secondary schools.

In a wide range of optics' topics the concept of image and image formation is key. When we use a magnifier a microscope or a telescope, or even when a mirage is formed, light travels from a point of an "object" to a point in an "image" by passing through different materials or optical components or materials, for instance lenses and or mirrors, in a certain way. How the image relates to the object, even when the students have a fairly good theoretical understanding of the optical instrument used is not easily comprehended.

This book presents an innovative approach and view on the study of reflective telescopes. Making an extended use of very interesting experiments, with which the students will have the effective, and most pleasant, opportunity to observe what in fact happens when light travels from an object, a star for instance, through a telescope into a projection screen or camera, the author provides teachers and educators, as well as students, with a rather detailed complete and comprehensive book tool that may replace many textbooks that propose ineffective or even misleading experiments and lack a comprehensive conceptual framework. It will allow a better sound correct and effective teaching of geometric optics and refractive telescopes in particular.

Telescopes, including refractive telescopes, and compound microscopes are commonly covered in most geometric optics textbooks. However, many students struggle to grasp their principles, which are, in fact, quite straightforward. This indicates that textbooks often fall short in conveying the captivating and engrossing knowledge of geometric optics, not to mention the principles of reflective telescopes.

Geometric optics is a well-established science, yet it continues to play a pivotal role in cutting-edge technologies, such as the production of advanced computer chips through state-of-the-art lithography machines. Despite its maturity, there is always room for improvement in the field of optics education.

This book seeks to bridge the gap by providing a restructured conceptual framework and a set of innovatively designed experiments. These resources work in tandem to enable students to intuitively and profoundly comprehend these principles.

Reflecting telescopes, including astronomical telescopes like the Hubble Space Telescope and the Webb Space Telescope, may initially appear complex compared to refractive telescopes. They feature a primary concave mirror, along with a secondary mirror and supporting poles positioned in front of the main mirror. These elements might seem to hinder their functionality by blocking light partially. Some large reflective telescopes, such as the Webb Telescope, employ multiple smaller mirrors to form the main mirror. Understanding how these smaller mirrors can function as a concave mirror and why reflective telescopes operate efficiently despite the obstacles in front of their main concave mirrors can be perplexing.

To address these challenges, this book introduces an improved concept map and various teaching aids. The concept map highlights four pivotal issues: (1) Objects in geometric optics are composed of numerous point sources of light that our eyes perceive; (2) The remarkable functions of concave mirrors; (3) A real image is equivalent to a real object in geometric optics, both composed of point sources of light. The real image can be directly observed projected onto a screen and magnified using a magnifier; (4) Reflective telescopes produce high-quality real images that can be recorded by electronic devices. These images can be treated as if they were real objects reconstructed at their location and magnified using an eyepiece.

By guiding learners convincingly to understand and accept these four key issues, they can intuitively and deeply grasp the principles of reflective telescopes. The aim is for learners to master these principles and even innovatively design reflective telescopes, enabling them to easily comprehend and explain their observations while conducting experiments related to reflective telescopes. Furthermore, this book also explores intriguing and seemingly unbelievable optical experiments in a more easily comprehensible manner, according to the well-organized knowledges and related experiments in this book.

Consequently, the quality of teaching the principles of reflective telescopes can be significantly enhanced. Moreover, the content of this book benefits geometric optics education in schools, providing valuable insights and tools for both educators and learners.

University of Minho, Braga, Portugal, November 18, 2023

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(President of the Hands-on Science Network)

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