JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS
Vol. 23, No. 4, July–August 2000

Book Review

Publishers are invited to send two copies of new books for review to Dr. I. Michael Ross, Code: AA/Ro, Department of Aeronautics and Astronautics, U.S. Naval Postgraduate School, 699 Dyer Road, Monterey, CA 93943.

Solar Sailing: Technology, Dynamics, and Mission Applications

Colin R. McInnes, Springer-Praxis, 1999, $89.95, ISBN 1-85233-102-X

This is an excellent book. It provides a comprehensive treatment of solar sailing that can be used both as an introduction for those new to the concept and as a valuable technical reference for research and design of solar sail applications. The history, theory, technology, and potential mission applications of solar sails are all thoroughly covered. The author of this volume does many things and he does them all well. He is an excellent writer and makes it easy to read. Each of the seven chapters ends with a summary of the important information in that chapter and a reference list for further reading that includes books, journal articles, conference papers, and a few Web sites. There are nearly 200 illustrations, graphs, and tables to aid in visualizing the concepts and understanding the material.

Chapter 1, Introduction to Solar Sailing, provides a thorough foundation for what follows, including historical perspectives, hardware and technology aspects, performance, applications, and potential applications.

Chapter 2, Solar Radiation Pressure, explores the detailed physics of solar radiation pressure, including both the quantum description (packets of energy, photons) and the electromagnetic description (electromagnetic waves). Radiative transfer methods are discussed and mathematical expressions for the sail force are derived and analyzed.

Chapter 3, Solar Sail Design, discusses design parameters, sail films, sail structures and configurations, and recent case studies in solar sail design. Important engineering problems such as sail attitude control and deployment are discussed.

Chapter 4, Solar Sail Orbital Dynamics, derives the equations of motion of a sail in the two-body problem for both sun-centered and planet-centered orbits. Logarithmic spiral trajectories and optimal (minimum-time) trajectories are analyzed in detail. Both sail control laws that maximize the instantaneous rate of increase of the total orbital energy (termed "locally optimal" by the author) and true minimum-time trajectories from optical control theory (termed "globally optimal") are analyzed in detail and their performances compared.

Chapter 5, Non-Keplerian Orbits, describes orbits that are achievable by using a component of the sail force normal to the orbit plane. Examples are displaced sun-centered orbits that lie high above the ecliptic plane and planet-centered orbits that are displaced behind the planet in the antisun direction. Equilibrium solutions and families of these displaced non-Keplerian orbits are analyzed and detailed stability analyses are provided. Solar sail orbits in the circular restricted three-body problem are also discussed in some detail.

Chapter 6, Mission Application Case Studies, covers proposed missions including the Geostorm mission for early warning of geomagnetic storms caused by solar eruptions; a Solar Polar Sail mission for making measurements over the solar poles; a Mercury Orbiter mission; Sample Return missions to Mars and other planets, asteroids, and comets; an Earth Polar Observer mission; Micro-Solar Sail constellations; and missions to the outer solar system using a high-performance sail and a close solar flyby to place the space-craft on an escape orbit from the sun.

Chapter 7, Laser-Driven Light Sails, deals with technology considerations and mission applications, including interstellar flight.

The author describes his reasons for writing the book and his hopes for the future of solar sailing very well in the preface:

> "Although the title is my own, I almost opted for the much more appropriate suggestion by Dr. Jean-Yves Prado, 'Solar Sailing—What Are We Waiting For?'. . . I hope that those who read this book will find the same delight that I have at both the sheer excitement which solar sailing invokes and also the amazing range of mission applications it can enable. While I have no objection to excitement and enthusiasm, I also hope that readers will be hardheaded in their evaluation of solar sailing. I firmly believe that solar sailing can only succeed if we confront the challenges it poses and focus on what solar sails can do, rather than try to advance solar sailing for its own sake. My only other wish is that I may have the opportunity to write a second edition of this book some years from now, detailing the successful use of solar technology for some initial mission applications. As Jean-Yves says: What are we waiting for?"

This book is a valuable learning tool and technical reference for anyone interested in solar sailing. Although not designed as a textbook, it is also highly suitable for an advanced undergraduate or graduate level course in solar sailing.

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