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BOOK REVIEW

Astronautics

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Astronautics: the Physics of Space Flight by Ulrich Walter, Wiley-VCH, Weinheim, 2012, pp. xxviii + 568. Scope: text book. ISBN 978 3 527 41065 1 (Hardcover), 978 3 527 41035 4 (Softcover). Level: space industry professionals, postgraduates, senior undergraduates.

Space flight provides beautiful examples of the Newtonian dynamics that teachers of physics have always wanted to demonstrate for their students – the consequences of Newton's Laws and gravitation writ large, and with the effect of dissipation also coming in at the launch of the spacecraft and (especially) during its re-entry to the Earth's atmosphere. For physicists, the basic principles of space flight are self-evident, but how best to apply them is far less obvious. Ulrich Walter's book not only presents the theory, but also shows how it gets turned into practice.

The author knows personally about space flight from all angles, being himself a physicist, with a PhD in solid state physics, who subsequently became an astronaut and flew on the Space Shuttle Columbia, and who now heads the Institute of Astronautics at the Technical University of Munich. His book is in its second edition, substantially enlarged and updated compared to the original version.

He opens with a review of rocket fundamentals pointing out that, prior to space flight, there was widespread ignorance about the reality of Newton's Third Law. Remarkably, the august and normally reliable *New York Times* ridiculed the pioneer rocket designer Goddard for suggesting that a rocket could "push on nothing" and thus work in the vacuum of space. But this, as every physicist knows, is exactly what rockets do. One hopes that the developments in space flight of the last half-century have corrected the image of dynamics in the minds of non-scientists.

After deriving the rocket equation (and the relativistic rocket equation) the author goes on to consider the principles of rocket flight quite generally, including in free space, in a gravitational field, impulsive manœuvres, propulsion, performance and payload. There follow chapters on specialised topics like rocket staging, engines (both thermal and electric), and ascent flight. Chapter on orbits and transfer between them lead on to a discussion of interplanetary flight. The chapter on re-entry explains the daunting problem to be solved: that the kinetic/potential energy of $\sim$33 MJ/kg acquired during ascent must somehow be lost in a controlled way, quite fast, but without melting the spacecraft or incinerating its occupants or cargo. Several solutions are discussed in detail, including the selection of trajectories, heat flux, material properties, reflection and skip re-entry, and re-entry with lift (as in the erstwhile Shuttle).

It is a big book, and the items mentioned above are just example. The author also covers diverse but relevant physics such as the three-body problem, orbit perturbations, orbital resonances, chaos, rigid body dynamics, and much else. There are numerous examples and problems at the ends of chapters, a select bibliography (mostly books), and two appendices. Although the text is translated from the original German, the style is pleasant and easy to read. Everything a physicist could possibly want to know about the reality of space flight is here.

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