Systematic survey of the spheres

Physics of the Solar System: Dynamics and Evolution, Space Physics, and Spacetime Structure
by Bruno Bertotti, Paolo Farrinella & David Vokrouhlický
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Progress in our understanding of the Solar System has been extremely rapid over the past decade. It has been fuelled by the discoveries of extrasolar planets, the Kuiper Belt and myriad distant planetary satellites, by spacecraft fly-bys of asteroids and comets, by the *in situ* exploration of Mars, and by the advent of fast computers and efficient numerical algorithms. To the great benefit of students and practitioners alike, the appearance of advanced textbooks has been almost equally rapid. The most recent offering is *Physics of the Solar System*, a well-written and comprehensive overview of the diverse bodies that surround the Sun and of the intricate interplay between them.

Physics of the Solar System is much broader in scope than two other recent advanced textbooks, *Solar System Dynamics* by Carl Murray and Stanley Dermott (Cambridge University Press, 2000) and Alessandro Morbidelli's *Modern Celestial Mechanics* (Taylor & Francis, 2002). These titles focused primarily on orbital dynamics, a topic that accounts for only about half of *Physics of the Solar System*, which manages to cover it clearly and succinctly by outlining many derivations rather than providing full details.

Preceding the orbital dynamics is an opening section that emphasizes the physical states of planetary bodies, including their rotation, gravitational fields, tidal distortions and heat budgets, and another that focuses on magnetospheres and atmospheres. The volume concludes with several chapters devoted to issues relevant for artificial satellites. The book is more focused and deeper than *Planetary Sciences* (Cambridge University Press, 2001) by Imke de Pater and Jack Lissauer, but is less broad, containing no chemistry and only a limited discussion of geological topics.

Physics of the Solar System is tightly written, fun to read and should appeal to experts in the field and new graduate students alike. Within its covers abound a wealth of interesting and little-known nuggets of planetary lore that, although available in the scientific literature, have not appeared in an accessible text before. For instance, it is well known that planets move along elliptical paths around the Sun and that these orbits precess (or rotate) slowly in space under the influence of weak gravitational perturbations from the other planets. What is less widely known is that these elliptical orbits do not always precess independently; those of Jupiter and Uranus, for example, oscillate about one another, while precessing at a common rate.

The book has a nice introduction to planetary atmospheres that starts from the concept of hydrostatic equilibrium. The authors show that an atmosphere of constant temperature continually loses gas molecules to space, and they make an analogy to the solar wind. Magnetic fields are treated in greater depth than is usual for a planetary textbook, but without the overwhelming detail of a text on plasma physics. The authors keep their focus on the Solar System by pointing out, for instance, that the energy source that powers the Earth's magnetic dynamo is thought to arise from heat released as the Earth's core solidifies. The lack of ongoing core solidification in Venus, rather than the slow rotation of our sister planet, is the preferred explanation for its lack of an active dynamo.

The authors provide a clear and insightful discussion of planetary gravitational fields. They describe how the dipole terms of an expansion of a gravitational field vanish with the choice of the centre of mass as the origin, and show that two of the five quadrupole terms disappear when the z-axis is chosen to point along the spin axis. They show that although geostationary satellites drift slightly relative to a fixed point on Earth's equator, there are two stable longitudes where this drift vanishes, thanks to a 1:1 resonance with the geopotential. These longitudes are defined by the minimum equatorial diameter of the Earth, which pierces our planet near the Maldives and the Galapagos — true islands of stability in Earth's chaotic seas.

There is also a beautiful presentation of orbital-perturbation theory. It begins with a derivation of the perturbation equations of celestial mechanics based on changes to energy and angular momentum. Subsequent discussion applies the equations to the examples of atmospheric drag and the Earth's quadrupole field. I follow the same scheme when teaching my undergraduate orbital-dynamics class.

Each chapter comes with a generous set of useful and challenging problems, making the text appropriate for a graduate-level course on the Solar System. One minor quibble is that the chapter on the space-time structure of the Solar System, which is a brief introduction to the general theory of relativity, is less well linked to the book's other topics than one expects from the book's subtitle. Even so, I strongly recommend making space on your shelf and time in your schedule for this lively, interesting and authoritative volume. ■

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