Imperfect lunar voyage

P. Kenneth Seidelmann

The Motion of the Moon. By Alan Cook. *Adam Hilger: 1988. Pp. 222. £35.*

IN THIS book, the author provides a literary introduction to the history and basic concepts behind calculating the motion of the Moon. The methods are developed historically with verbal descriptions and a minimum number of equations; this approach has its advantages but also serious shortcomings.

The reader must recognize the book for what it is, and for its limitations. First, it is rather dated — other than citations of papers by the author, the most recent reference is 1983, and the general level of currency is about 1980. There are also general omissions and inconsistencies. Although there is a chapter on the applications of computers, the work of Babbage and Comrie is not mentioned. The relationship between the motion of the Moon and determinations of time, such as ephemeris time and the irregular rotation of the Earth, is omitted. As for the inconsistencies, the quoted accuracy of lunar laser ranging is between one-half metre and ten millimetres; and on page 120 the planets are said to present no problems in determining the orbit of the Moon, while on page 161 their direct and indirect effects remain the most difficult part of the lunar theory. Those without a background in celestial mechanics or mechanics will be frustrated, I expect, by the name dropping which goes unaccompanied by explanations. Thus, the bases for classical equations are mentioned by name, but without any further discussion.

It is in Chapter 9, "The Applications of Computers", that the book's lack of currency is most apparent. Here, great emphasis is put on the use of computers for developing analytical theories. Numerical integrations are dismissed as being for short time periods, yet reference is made to a numerical integration covering 44 centuries. What we are not told is that the numerical integrations have been fitted to observations and that they are the source of the accurate ephemeris of today. The current analytical theories have been fitted to the numerical integrations; they have not been fitted to the observations.

The real shortcomings of analytical theories are that they do not converge predictably, and that to achieve the accuracies needed today requires more terms than can reasonably be determined and evaluated by current methods. The discussion of lunar librations does not mention the requirement that lunar librations must be integrated along with the lunar orbit because of the interrelationship between the two.

In the last two chapters, the author makes an attempt to bring things up to date. Unfortunately, he is not successful. Constants are quoted at random, without an explanation of the sources. The requirement to know where the Earth station is, along with the lunar station, when performing lunar laser ranging, is forgotten. And although Cook says that no calculation of the lunar orbit that incorporates relativity has been carried out, he himself cites a paper by Newhall *et al.* that does just that. The requirements of relativity for time, light-bending and equations of motion are not mentioned anywhere in the volume.

If supplemented by material on analytical developments and on recent work, *The Motion of the Moon* will serve as an introductory textbook for courses on lunar theory. But it is not an accurate or up-to-date account of the subject. □

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New in Britain

- *The Stone-Age Health Programme: Diet and Exercise as Nature Intended.* by S. Boyd-Eaton, M. Shostak and M. Konner. (Angus & Robertson, £4.95). For review see *Nature* **336**, 282; (1988).

Arm waving

Edwin W. Taylor

Cell Movement. Edited by Fred D. Warner *et al. Alan R. Liss: 1989. Vol. 1 Pp.356; Vol. 2 Pp.494; Vol. 1 $88, £78.50; Vol. 2 $98, £87.50.*

CILIA and flagella are extremely complex structures compared with muscle myofibrils, possibly because the propagation of a bending wave is more difficult to achieve than the longitudinal sliding of muscle filaments that ultimately produces force. In 1965, Gibbons and Rowe showed that the arms of the nine 'outer-doublet' microtubules in cilia (see figure) consist of a high-molecular-mass ATPase which they named dynein. By analogy with muscle contraction, the authors suggested that doublet microtubules and dynein form a type of motile system in which the dynein arms are equivalent to myosin crossbridges.

Slow but steady progress was made over the next 15 years by the handful of investigators who were willing to grapple with this difficult system. Was the postulated complex structure really necessary for a microtubule-based motile system? Could cytoplasmic microtubules and dynein produce linear movement rather than bending waves, and could such a system be responsible for particle movements within cells, such as chromosome movement during mitosis? Although dynein-like proteins were discovered in the cytoplasm, it was argued that they could be precursors of cilia or soluble proteins which became bound to the mitotic apparatus during its isolation.

New methods developed during the past six years have revived interest in old questions. The refinement of light-microscope techniques, in particular by R.D. Allen, allowed single microtubules to be observed. *In vitro* assays for motile systems developed by Spudich and Sheetz for actomyosin were applied to microtubule systems. But it turned out to be vesicle transport in neurons which provided the key to the problem. Particles had been observed moving along axons in both directions at velocities of the order of 1 μm per second. These velocities are comparable to filament-sliding velocities in muscles. In 1985, a previously unknown translocator protein, kinesin, was purified from squid axoplasm — this protein could account for anterograde transport, as vesicles are moved by kinesin towards the 'plus', or growing, end of microtubules. A similar protein was obtained from sea urchin eggs and subsequently from various cells and tissues. Another protein in axoplasm moves particles in the retrograde direction *in vitro*. This protein, then known as microtubule-associated protein-