TYCHO BRAHE: A PASSION FOR OBSERVATIONAL ACCURACY

The Lord of Uraniborg: A Biography of Tycho Brahe

Victor E. Thoren
Cambridge U. P., New York, 1991. 523 pp. $59.50 hc
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Reviewed by Curtis Wilson

For a quarter century Victor Thoren, a professor of the history and philosophy of science at Indiana University, devoted his scholarship to the scientific achievements, societal context, personal character and vicissitudes of the Danish nobleman Tycho Brahe. The present biography, which combines a narrative of the ascertainable facts of Tycho's life with a careful assessment and interpretation of them, became generally available only after Thoren's death last March at the age of 55. The book is at once a scientific biography and a very readable account of people, places and times.

It was Tycho, as all the world should know, who accumulated the data that enabled Johannes Kepler to arrive at the laws of planetary motion, which in turn became essential grist for Isaac Newton's mill. In addition Tycho's refinement of the Ptolemaic and Copernican account of the lunar motions—his discovery of the variation, or speeding up, of the moon through the syzygies, of the oscillation in the inclination and the nodes, and of the annual equation—supplied impressive corroboration for Newton's theory of gravitation. (Newton derives qualitatively the first two of these discoveries in Proposition 66 of Book I of the *Principia*, and the third figures prominently in Book III.) All these Tychonic results were basically *empirical* (though, as Thoren shows, Tycho's discovery of the nodal oscillation was an artifact of his theoretical explanation of the wobble in the orbital plane, and his grasp of the annual equation was muddled by the attempt to explain it as a special lunar equation of time). Without Tycho's passion for observational accuracy—unprecedented among astronomers from antiquity to his own day—the discovery of these facts would have been delayed for perhaps a century. Without them, the deity's "Let Newton be" might have yielded but a dim and flickering light.

Yet it is one thing to recognize retrospectively Tycho's role in the scientific revolution and another to understand how, within the context of his own time, Tycho came to achieve what he achieved. Thoren's earlier published articles dealt primarily with Tycho's astronomical work and provided a fundamental reinterpretation of Tycho's achievement. Thoren was the first to make systematic use of Tycho's observational logs, thereby clarifying the history of Tycho's observational instruments and justifying Tycho's extensive experimentation as a systematic search for the means of obtaining an accuracy of one arc-minute, rather than, as it might at first appear, merely an ostentatious development of fancy instrumentation. The new biography incorporates the results of these earlier studies. But it is devoted in even greater measure to an account of Tycho the man and his context—the world of the Danish warrior-class nobility in the late 16th century and the later years of the Northern European Renaissance and Reformation.

Tycho was scarcely a charmer. As Thoren shows, the man was overbearing and imperious, a veritable Rumpelstiltskin for fits of rage and unfair to others in matters of money, honor and scientific achievement. But with the picture Thoren gives us of court life and politics around the Danish throne in the late 16th century, one comes to question whether Tycho's scientific work could have begun had he not been of a deviant and rebellious cast of mind. Danish nobles of his day had their tasks laid out for them: to climb a political and military ladder and to maintain an elevated social caste. Intellectual work was left to the scions of commoners. Some quirk of nature or fortune led Tycho to flout the customs of his class, even to the extent of taking a commoner as a common-law wife and planning to emigrate from Denmark to pursue his quest for knowledge. This quest extended beyond astronomy to Paracelsan medicine, cosmology and Lutheran theology.

With the nova of 1572 and Tycho's scientific coup in proving its supralunar location (contrary to generally accepted Aristotelian tenets) came fame and royal funding. So emerged the possibility of building Uraniborg, the first modern scientific research institute, on the island of Hven in the Danish Sound. Now Tycho came to see his special vocation as that of renovating astronomy from the ground up. And to this vocation he brought all the imperious and autocratic habits of his social caste. Had his nature or second nature been less demanding, one wonders if Tycho would have achieved his star catalog, his extensive series of planetary observations or his lunar theory—indeed anything of scientific importance.

With the ascent of Christian IV to the Danish throne in 1596, Tycho was called to account for abuses of privilege, and the royal funding of his enterprise was curtailed. Whether he could have held on and continued his work is moot; angry and confused, he decided on emigration and eventually found a post as imperial mathematician to the Holy Roman Emperor Rudolf II in Prague. But as Thoren argues, Tycho's observational work was essentially at an end.

Curtis Wilson has written extensively on the history of 17th- and 18th-century astronomy. He is joint editor with Rene Taton of Volume 2 of *The General History of Astronomy: Planetary Astronomy from the Renaissance to the Rise of Astrophysics* (Cambridge U. P., New York).

After his immigration, first to Germany and then to Bohemia, Tycho's preoccupations—aside from the difficulties of suitably relocating himself and his family—were to publish the works that would guarantee his fame and to defend his priority in what he seems to have regarded as his chief claim to fame: the Tychonic system, a transformation of the Copernican system that kept the Earth at rest in the center while the Sun revolved around it carrying the accompanying planets. Similar schemes had occurred to more than one thinker of the time, but Tycho regarded one of them, Nicolai Reymers Ursus, as an out-and-out plagiarist and pursued him with lawsuit and counter-publication until his prey escaped by death. Ironically, Tycho's chief reason for acquiring Kepler as an assistant was to have him prepare an *Apologia contra Ursum*. Once more, Tycho's egoistic striving had consequences that went far beyond what he had envisaged, blinkered as he was by the limitations of time, place and social context.

Thoren's biography is likely to remain the definitive work on Tycho for a long time to come. And it makes a very good read.

Introduction to the Theory of Neural Computation

John Hertz, Anders Krogh and Richard G. Palmer
Addison-Wesley, New York, 1991. 327 pp. $44.25 hc
ISBN 0-201-50395-6

The growing interest in neural computing is based on the hope that computational architectures resembling in some sense the structure of our brain can perform tasks that are difficult for conventional computers and algorithms but that appear easy for the brain. Among those tasks are the abilities to deal with information that is fuzzy, noisy and inconsistent, to learn from examples and to operate independently of a specific program. These hopes are almost certainly bound to be disappointed unless one understands at least some of the brain's basic functions.

Introduction to the Theory of Neural Computation can be viewed as a first guided tour through many of the concepts, ideas and models that have evolved in this field over the last one or two decades. It starts with the pet of theoretical physicists, the Hopfield model—a fault-tolerant associative memory—and some of its various extensions. The book continues with single- and multi-layer feed-forward networks, the type most widely used in technical applications, including supervised learning. The book's next topic deals with various aspects of unsupervised learning in a variety of network architectures. The last chapter, reflecting the background of the authors, shows how methods of statistical physics can be applied to studying models of neural networks.

The title of the book is somewhat misleading because there is nothing like *the* theory of neural computation. Some of the topics covered have a quite elaborate theoretical background; others do not. Those theories that exist are described as simply as possible but are not oversimplified. This is one of the strong points of the book. The book's other virtue is its quite complete coverage of the various attempts to understand the computational capabilities of different types of networks. Even those readers who do not have much background in mathematics can understand almost any chapter. Thus, the book is a pleasure to read. Although parts of some of the chapters have the character of a warehouse catalog, they provide a good and complete reference to the literature.

Because the aim is to provide those interested in artificial networks with some basic knowledge of the field, the book contains only a few basic facts about the biological aspects of neural networks. Nevertheless those who are primarily interested in biological networks also may find useful information and thoughts.

This first guided tour through a rapidly evolving and fascinating field has been accomplished successfully. I recommend this book highly to those who want to do more in this field beyond playing around on a personal computer.

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Electroweak Interactions: An Introduction to the Physics of Quarks and Leptons

Peter Renton
Cambridge U. P., New York, 1990. 596 pp. $110.00 hc
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ISBN 0-521-36692-5

The great success of the "standard model" as a compact intellectual foundation for understanding elementary particle interactions has encouraged the writing of a number of expository textbooks during the past decade. Peter Renton's book is a recent addition to a collection of graduate-level texts that includes Lev B. Okun's *Leptons and Quarks*, Ian J. R. Aitchison's *An Informal Introduction to Gauge Field Theories*, Kerson Huang's *Quarks, Leptons and Gauge Fields*, Chris Quigg's *Gauge Theories of the Strong, Weak, and Electromagnetic Interactions*, and *Quarks and Leptons* by Francis Halzen and Alan D. Martin. *Electroweak Interactions*, the longest and most comprehensive of these books, is somewhat mistitled because it also includes a fairly extensive discussion of quantum chromodynamics, the physics of strong interactions.

Renton's book is based on a course of lectures given to first-year postgraduate students at Oxford, most of whom were experimentalists in high-energy physics. His text is, however, written entirely from a theoretical perspective, albeit starting from a very basic level. The first 145 pages are devoted to a general overview of particle interactions and symmetries and to a summary of nonrelativistic quantum mechanics, special relativity, angular momentum, group theory and the basic concepts of the field theory of elementary particles of spin 0, $\frac{1}{2}$ and 1. The introduction includes a derivation of propagators in configuration and momentum space, while fundamental issues in perturbative field theory, such as higher-order calculations and renormalization, are addressed in a later section.

The central part of the book consists of a very comprehensive and systematic discussion of many scattering and decay processes involving electromagnetic, weak and strong interactions. A list of topics includes electron–proton scattering, Compton scattering, muon decay, electron–positron annihilation, photon and hadron structure functions, neutrino–nucleus scattering, Cabibbo theory, tau–lepton decays, W and Z boson decays, mixing phenomena and many others. For most processes, the author presents the appropriate Feynman diagrams, first-order matrix elements and the resulting cross sections or decay rates. Derivations are not exhaustive but they do show several intermediate steps sufficient for reconstructing the final result; Renton provides a number of technical appendixes that assist the reader in this task. A very nice feature of the book is that the spin and polarization dependence is derived explicitly for many of the interactions listed above.

The last section of *Electroweak Interactions* discusses some of the open or unanswered questions in the