"deep sea intuition" into quantitative models.

In summary, this volume makes for timely and interesting reading and firmly establishes studies of the deep sea bed in the mainstream of oceanographic research. It does, however, suffer somewhat from the lack of a synthetic chapter; the editors provide little overview of the meeting's goals and conclusions. Nonetheless, it should prove informative to a broad range of ocean scientists and at least provide stimulating browsing for those seeking a glimpse of processes in the most remote, but perhaps not so exotic, ecosystems on the earth's solid surface.

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Orrery of Orreries

The Milky Way as a Galaxy. GERALD GILMORE, IVAN R. KING, and PIETER C. VAN DER KRUIT. Roland Buser and Ivan R. King, Eds. University Science Books, Mill Valley, CA, 1990. xiv, 392pp., illus. $42.50. Saas-Fee Advanced Course no. 19 (Leysin, Switzerland, March 1989).

Ancient Greeks thought that a jet of milk squirting from Hera's breast across the sky had created the Milky Way. More than two millennia later, 17th-century telescopes resolved the faint glow into myriads of stars. Yet it took photography, an emerging understanding of spiral galaxies, and the discovery of the obscuring influence of Galactic smog to help 20th-century astronomers develop our modern view of the Milky Way: a rotating disk of stars and gas some 150,000 light-years in diameter, in which our sun orbits approximately halfway between the center and the edge and which is surrounded by a vast but tenuous halo of stars and globular clusters.

The position of the sun near the midplane of this disk, and thus deep in the layer of absorbing dust and gas, has bedeviled Milky Way studies from the beginning. How do you study a fogged-in forest from nearby trees? Fortunately, new technologies emerging from two wars have opened new windows at more transparent wavelengths: radio astronomers now study monatomic hydrogen and nearly 100 species of molecules throughout the Galaxy, and infrared cameras pierce the smog to yield our first detailed views of the Galactic center. Yet many classical problems of Milky Way research remain dependent on optical work and suffer from the vast extrapolation necessary to deduce large-scale structure from solar-neighborhood observations. For example, we still do not know to within 25 percent how spherical or flattened the Galactic halo of stars is. And after many decades, astronomers still struggle to disentangle the spatial decline of the number density of stars from that of chemical abundances and possibly ages, both of which affect a star's luminosity and inferred distance.

Through this Galactic labyrinth, the authors offer the reader a helpful guided tour. From the volume's jacket, which juxtaposes splendid photographs of the Milky Way and a related galaxy, to its index, they present a comprehensive account of the nature of our home galaxy and its neighbors. They exploit the fact that studies of the Milky Way and external galaxies are complementary: most global properties of galaxies such as shapes, diameters, and rotation patterns are now more easily determined for external galaxies, whereas many detailed investigations of stellar populations—of their chemical compositions, ages, and kinematics—are still possible only within the Milky Way.

A central topic is the gravitational force field generated by 100 billion stars and by dark matter of unknown composition. This field can be deduced from measured motions of stars and gas and yields, in turn, the Galactic mass distribution. The many methods invented during the present century to analyze stellar motions and build mass models are critically reviewed. Despite an enormous amount of astronomers' thought and labor, many fundamental questions remain unanswered. Does a census of all visible matter in the solar neighborhood yield enough mass density to explain the observed stellar motions perpendicular to the Galactic plane, as some astronomers now conclude? Or does the census fall short by a factor of two, thus requiring dark matter in the disk, as Jan Oort pointed out six decades ago and many astronomers still believe? In several lucid chapters on stellar dynamics, the authors lay the groundwork for a future generation of astronomers to grapple with such difficult issues.

The volume originates from 28 lectures given by its three authors. The editors have aptly consolidated these lectures into 16 chapters, for each of which the principal author is identified. A great strength of this outstanding account of our present knowledge of Galactic structure is that it emphasizes historical perspective; it traces the development of ideas, portrays false starts as well as successes, encourages the novice to consult classic books such as the proceedings of the 1957 Vatican Conference (*Stellar Populations*, North-Holland, 1958), and spells out the motivation for ongoing and future investigations in unusual detail. Many of the historical anecdotes will interest first-year graduate students as well as experienced researchers.

There are also other nuggets to keep the reader's attention, even through technical chapters. How many astronomers would know that the Galactic center currently seen at $-29°$ declination south of the celestial equator and a main stimulus for building major observatories in Chile, will in 13,000 years' time appear north of the equator at $+18°$ declination owing to precession of the earth's axis? And did you know that the sun's present position deep in the Galactic smog layer is sheer bad luck? Roughly 90 percent of all disk stars of comparable age reside outside this layer, and even our upward-moving sun will nearly emerge from the smog at about 280 light-years above the midplane—17 million years from now—only to be forced back into the muck by the disk's gravitational attraction. Yet, for some million years earthlings will enjoy a relatively clear view of the Galactic center and bulge.

After reading this volume I no longer see the Milky Way as a labyrinth whose study is daunting but as a grandiose orrery of orreries. From the hustle-bustle of stars in the central cauldron, through the epicyclic ballet of disk stars dancing up and down, to the lone orbits of halo RR Lyrae stars blinking like fireflies in the night, there is a hierarchy of motions too complex to fully comprehend yet beautiful to behold.

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