craters he cites studies of lunar craters, and also gives some interesting data on the pits formed during tests of nuclear devices in the earth's atmosphere and on the ground. Describing evidence of wind erosion on Mars, the author reproduces a curious aerial photograph of a terrestrial desert, and then shows some very striking pictures of Martian dunes.

One can gauge the progress in mapping the planet by comparing several numbers. Observations from the earth provide a Martian surface resolution of 150 km. On the first flyby of the planet, in July 1965, the Mariner 4 probe took pictures of 3-km resolution. Mariner 9 (1971-1972) and the Soviet orbiter Mars 5 (1974) photographed the planet at 100-m resolution, and finally the Viking spacecraft transmitted frames showing the Martian surface at resolutions as sharp as 10 meters! Today we have a good impression not only of the surface but of atmospheric phenomena on Mars: dust storms, clouds, cyclones. Many of the Martian surface structures resemble formations on the moon and Mercury. For instance, the relation between the diameter and the depth of impact craters is much the same on Mars as on the moon, except that Martian craters do not reach such great depths, due to the stronger gravity on Mars. Sometimes, however, Martian craters show a very distinctive morphology: they often are accompanied by extensive ejecta deposits surrounding the crater wall, of a character found only on Mars.

One particularly interesting chapter deals with the statistics of craters and with estimates of their age. For example, crater destruction by Martian surface erosion can be studied by comparing the observed number of craters per unit area against that calculated from inspection of atmosphere-free planets (Mercury, the moon). In this fashion one finds that asteroid-impact craters of given diameter ought to have been formed twice as often on Mars as on the moon or Mercury, while comet-produced cratering should be only half as common on Mars as on the moon, and 1/16 as common as on Mercury (mainly because of the differing impact velocities). Overall the Martian cratering rate should be about the same as on Mercury and twice that for the moon. Martian craters range widely in age (the geological age of the surface): from 4 billion yr for the most heavily cratered terrain to 300 million yr in the central Tharsis region.

Two chapters on Martian volcanism thoroughly examine the history of tectonic processes on the planet. Analogies are drawn with terrestrial phenomena: the Martian volcanoes in the Tharsis, Elysium, and Hellas regions compare with the largest ones on the earth, those in Hawaii. The author discusses the possible occurrence of global convection of planetary mantle material, with a mechanism like that responsible for continental drift on the earth. Of great interest is his inquiry into the nature of the Martian "channels" – not what Giovanni Schiaparelli though were canals, but long, winding gullies reminiscent of river beds. Their origin is a matter of much debate.

The automated spacecraft missions to Mars have largely laid to rest the idea that the planet may harbor life. Nonetheless, each new space expedition makes Mars seem all the more "lively" and dynamic to us, opening our eyes to a world similar to our own in many respects, yet quite distinctive in its own right, arousing more and more interest. Carr's book will satisfy the inquisitive reader and stimulate the imagination of the serious researcher.

The book has been accessioned by the Shternberg Astronomical Institute library.

Translated by R. B. Rodman

Edwin Hubble

The Realm of the Nebulae*

Reviewed by V. G. Surdin

(Submitted May 27, 1983)

Astron. Zh. **61**, 201 (January–February 1984)

This reissue of Edwin P. Hubble's famous book is a direct copy of the first edition, published in 1936. In a new five-page Foreword, James E. Gunn sets Hubble's work against the background of the 1920s, the heroic epoch that culminated in the development of modern microphysics and relativistic cosmology. "Before the early 1920s," he writes, "no one knew for sure that this realm [of extragalactic nebulae] existed, that there were other galaxies like our own Milky Way System." In fact, by 1923 Adriaan van Maanen's astrometric studies had seemed to demonstrate that the spiral nebulae are situated inside our Galaxy. But it was in this same year that Hubble confidently established that the Andromeda Nebula contains Cepheids. A period–luminosity relation had been derived for these stars in the previous decade, chiefly through the efforts of Henrietta Leavitt, Ejnar Hertzsprung, and Harlow Shapley. At the December 1924 meeting of the American Astronomical Society Hubble dramatically announced that the Andromeda Nebula is about one million light years away. Forthwith extragalactic astronomy was born. It is interesting to recall that Alexander A. Friedmann's papers, which laid the foundation for modern cosmology, had meanwhile come out in 1922 and 1924, providing the theoretical groundwork for another discovery Hubble made shortly afterward, in 1929: that the world of "island universes" is expanding!

Although Hubble's cosmological discovery by good fortune was mated with the devising of an appropriate theory, his ideas in cosmogony simply marked the starting gun of a prolonged attack (more than 50 years now) on the problem of the origin and evolution of galaxies. Hubble's celebrated tuning-fork diagram is still the subject of analysis and debate. Studies of galaxy evolution have broadened enormously; the problem is now being approached by diversified methods from the standpoint of various theo-

*Yale University Press, New Haven. 1982 reprint of 1936 edition. xx + 207 pp. Clothbound; paperbound No. Y-428.

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ries, but everyone who involves himself in whatever fashion in the world of galaxies comes faces to face with Hubble's tuning fork – so pervasive is the influence of this morphological scheme which had once been thought successfully established.

To a large extent Hubble's success derived from his years of activity in observing variable stars in our neighbor galaxies. His research brought fame to Cepheids as intergalactic distance indicators. In our electronics age, systematic photography of nearby galaxies with big telescopes is no longer a popular task. Yet Cepheids have lost none of their amazing properties; on the contrary, they can serve as reliable indicators not only of distance but of the age of stellar aggregates, and also as tools for studying the late phases of stellar evolution, as Yu. N. Efremov explains in the book, Stars and Stellar Systems (Nauka, Moscow, 1981). Perhaps Hubble's account of the pioneer surveys of extragalactic variables will inspire some of today's astronomers to turn once again to these remarkable stars. Hubble's book may prove valuable as well to beginning researchers, for many of the questions posed by the early students of galaxies still await an answer.

As Hubble himself points out, in working on the Realm of the Nebulae he was assisted by Milton Humason, Walter Baade, Richard Tolman and Fritz Zwicky, today renowned as classical figures in astronomy and cosmology. But perhaps Hubble's chief helpmates in this endeavor were the 60- and 100-inch Mount Wilson reflectors, then the greatest in the world.

Well illustrated, the book contains about 30 astronomical photographs (the author's earnest approach to the subject is highlighted by the fact that every picture has a caption giving the instrument used, the date of exposure, and the orientation and scale of the print). Eight tables and 16 graphs and diagrams provide what in those days was a wealth of information on extragalactic astronomy. Hubble had prepared the book to reflect the series of lectures that he gave during the fall 1935 term at Yale University. Thus it is hardly surprising that the writing retains a certain academic flavor and a lucid style, without, however, losing touch with true creative activity, thereby lending the text the same charm that one would encounter in talking with an intelligent and enthusiastic scholar. Hubble's book offers us a rare chance to hold a really lively dialogue with one of the giants of science, and by standing on his shoulders we can see just that much farther.

The Shternberg Astronomical Institute library has acquired the book.

Translated by R. B. Rodman

C. Goudis

The Orion complex*

Reviewed by N. G. Bochkarëv

(Submitted July 4, 1983)
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Here is a book representing a comparatively rare genre of scientific literature, for it offers an exhaustive compilation of all the data acquired on a single topic. The Orion Nebula is the brightest gaseous nebula in the sky: astronomers have been observing it with telescopes ever since the 17th century. An enormous amount of information has now been gathered. Often the Orion has been used as a touchstone for new research techniques. As has long been recognized, the nebula is associated with a fairly intensive star formation site, the one closest to us, and is the centerpiece of an intricate conglomerate of stars, gas, and dust that has come to be called the Orion Complex. This complex surely is the best studied example of a star formation region, playing just as important a role in the analysis of stellar birth processes as does the sun for stellar physics, or the Crab Nebula for manifold problems in astrophysics.

Goudis has collected into his monograph all the published information on the dust and gaseous matter found in this complex. For the most part the data are gathered into a great many carefully compiled tables, arranged for convenient use, and are displayed in numerous figures. Of the 240 pp. in the main part of the book, only 37 pp. are occupied by text: the illustrations take up 95 pp., and the tables 108 pp. This part, consisting of five chapters, is followed by four comprehensive Appendices dealing with methods of investigating gaseous nebulae. In the Appendices are many handy equations, various tables and graphs, and some more useful illustrations. Concluding the book are a bibliography of 713 references covering the literature through about 1979, and a subject index.

The first chapter concerns the large-scale structure of the Orion region. The morphology of Barnard's Loop is described. Recent wide-angle photographs of the Orion–Eridanus field in individual emission lines show a system of filaments stretching nearly 40° across the sky to galactic latitude −50°; in 1979 R. J. Reynolds and P. M. Ogden interpreted these structures as cavities blown out by stellar wind from the Orion I association, which is bounded by faintly glowing filamentary nebulae. This whole region represents an extended x-ray source. Assembled in the same chapter are data on the magnetic field distribution in this region, a description of the dark nebulae, and a general account of the subassociations into which the OB

*A Case Study of Interstellar Matter. Astrophysics and Space Science Library, Vol. 90. Reidel, Dordrecht, 1982. xiv + 311 pp.

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