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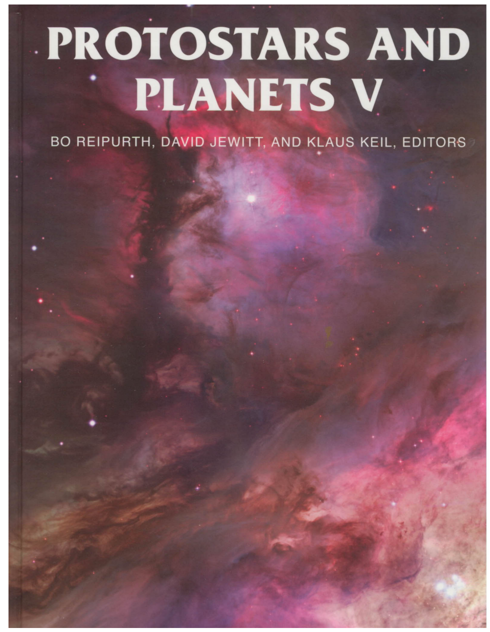
Book Review

Protostars and planets V, edited by Reipurth B, Jewitt D., and Keil K. Tucson, Arizona: The University of Arizona Press, 2007, 1024 p., cloth (ISBN 978-0-8165-2654-3).



Some thirty years ago, planetary science and the study of star formation were different scientific fields with different practitioners who rarely interacted with one another. Planetary scientists, mostly geochemists and geophysicists, resided in geology departments whereas star formation was the domain of astronomers. All this has changed starting with Tom Gehrels who organized the first Protostars and Planets conference in January 1978 in Tucson. In the book that followed this conference, which was edited by Gehrels, he expressed the hope "to develop the interface between studies of star formation and those of the origin of the solar system." This hope has been fulfilled beyond expectations. The first volume has been followed by four more in intervals of about seven years. Each book was preceded by a conference. The Protostars and Planets V Conference took place at the Hilton Waikoloa Village on the Big Island of Hawaiʻi on October 24–28, 2005. The subsequent book appeared early this year. As its forerunners, it is part of the University of Arizona Space Science Series, which is devoted to different aspects of solar system science.

The rapid growth of this new interdisciplinary field between astronomy and planetary science is demonstrated by several facts. Whereas the first conference was attended by 183 scientists, the last one attracted 805 participants. The first volume contained 39 chapters written by 51 authors, *Protostars and planets V* contains 58 chapters produced by 249 authors. Interestingly, the average number of authors per chapter has also steadily increased, from 1.3 to 4.3. I do not want to speculate whether this increase reflects the ever escalating amount of information or the dearth of true experts.

The chapters of the book correspond to review talks given at the conference. Each of the five *Protostars and planets* volumes has a different set of editors, and the editors of the present book have done an excellent job in selecting topics for chapters and their authors. The book's content is divided into nine parts: 1) molecular clouds, 2) star formation, 3) outflows, 4) young stars and clusters, 5) young binaries-brown dwarfs, 6) circumstellar disks, 7) planet formation and extrasolar planets, 8) dust, meteorites, and the early solar system, and 9) life. About three quarters of the authors did not contribute to *Protostars and planets IV* and thus bring new perspectives to this expanding field.

The arrangement of the chapters roughly follows the inferred prehistory of our own solar system. In the dense core of a molecular cloud, gravity overcomes thermal and magnetic pressures, leading to the formation of a star, in most case actually of a binary star system. A central single star is surrounded by a disk of gas and dust from which planets form. This whole sequence constitutes a series of extremely complex processes, and we are still far from understanding most of the details. Beyond being a compendium for scientists active in the areas covered in this volume, *Protostars and planets V* presents useful material for a graduate course and, as I know, has already been used for this purpose. It should be valuable for meteoriticists who want to attain a wider understanding of the astronomical environment in which our solar system formed. The part presenting the closest connection to meteoritics is chapter 8, "Dust, meteorites, and the early solar system", which contains 10 chapters ranging from the protoplanetary disk to transneptunian (Kuiper Belt) objects. The editors point out that that this subject has been kept short on purpose because of the recent publication of *Meteorites and the early solar system*, edited by Dante Lauretta and Hap McSween, in the Arizona Space Science Series. I also want to point to *Chondrites and the protoplanetary disk*, edited by Alex Krot, Ed Scott, and Bo Reipurth, and published in 2005 by the Astronomical Society of the Pacific. Both of these books contain a wealth of complementary information, and we are blessed to have such excellent surveys of this complex field available at this time.

Most of the information presented in this book is obtained not only by astronomical observations, but also involves computational simulation and even laboratory studies of meteorites and interplanetary dust. Astronomical observations are made with ground-based and satellite telescopes covering a huge spectrum of wavelengths from radio waves to X-rays. Almost every chapter emphasizes the progress made since *Protostars and planets IV.* Most of this progress is based on improvements in the sensitivity and spatial resolution of millimeter, submillimeter, and infrared (IR) detectors, such as recently available large-format IR array cameras, which make the study of molecular clouds in other galaxies possible. Other areas of progress are numerical simulations of star and planet formation and the evolution of stellar disks based on new algorithms implemented on large-scale parallel supercomputers. One field that saw especially rapid growth is the detection and study of extrasolar planets. In *Protostars and planets IV*, five years after the discovery of the first exoplanet around a main-sequence star, 17 such planet are reported. In the present volume the number reported has increased to at least 200. The mass of planets has been lowered from about half a Jupiter mass to the mass of Neptune (about a 20th of Jupiter's mass). In addition, 18 stars have been found to host dual or multiplanet system, one of them having four planets. While the radial-velocity technique has been essential for the detection of exoplanets, several have been detected photometrically during transit surveys and confirmed by radial velocities. Other rapidly developing areas are the study of binaries and the investigation of brown dwarf stars. In *Protostars and planets III*, brown dwarfs were not mentioned at all; now their study is actively pursued by many scientists and three chapters are devoted to them.

Not surprising for such a developing field, several important new findings were reported just after the publication of *Protostars and planets V.* One is the discovery of Gliese 581c. This planet with a mass of five times that of the Earth, is one of three planets found to orbit a red dwarf star. What makes this discovery so exciting is that the orbit of Gliese 581c is within the habitable zone, i.e., temperatures on the planet's surface are such that water could exist. This finding directly connects to the last two chapters of this book, which are concerned with the search for and the possibility of life outside the solar system, and thus has far-reaching implications. Another recent result stems from the laboratory analysis of cometary samples returned by the Stardust mission. The presence of high-temperature phases with the characteristics of CAIs in a comet, believed to originate from the Kuiper Belt, provides clear evidence for radial mixing of solids in the early solar system. Many further advances are expected to result from new future instruments. Among them are the Herschel Space Observatory and the ground-based James Clerk Maxwell Telescope, both of which will host submillimeter and far IR instruments, and new interferometers such as the Atacama Large Millimeter Array (ALMA) and the Combined Array for Research in Millimeter-Wave Astronomy (CARMA), the first in the Southern and the second in the Northern Hemisphere. There will be plenty of new information for *Protostars and planets VI*. The James Webb Space Telescope, whose launch is planned for 2013, offers the possibility of direct detection of exoplanets as does the Planet Finder instrument on the Very Large Telescope. The expected results will be too late for *Protostars and planets VI*, but hopefully not for a *Protostars and planets VII*.

No book is perfect, and some nitpicking remains to be done. These comments refer almost entirely to questions of general editorship even though I realize that with a volume of this size and scope, the editors were faced with an almost impossible task. I was somewhat turned off by the preponderance of acronyms in some chapters. While this may not be a problem for experts, it makes it difficult for a general reader to keep track of dozens of acronyms. A glossary of acronyms would have helped. Acronym usage is not even consistent. In one chapter GMC stands for galactic molecular cloud, in other chapters it stands for giant molecular cloud. MC can mean molecular cloud but also molecular core.

One thing I missed is the glossary of previous *Protostars and planets* volumes. Readers who have some of the old books might consult them, but even in *Protostars and planets IV* the glossary was already quite reduced. I would have wished for an expanded glossary where readers could browse and be motivated to look at various chapters. In *Protostars and planets I*, Gehrels actually recommends that one starts reading the book by looking through the glossary. This is not possible here.

The index is hardly adequate and not very complete. Terms such as IRAS (the infrared astronomical satellite) or the future Herschel Space Observatory are not listed, whereas other telescopes and satellites are. Some items such as GLIMPSE (Galactic Legacy Infrared Mid-Plane Survey Extraordinaire) and ROSAT (Roentgen Satellite) are listed as acronyms, whereas others such as Infrared Array Camera (IRAC) of mean-motion resonances (MMRs) are listed under their full names. Only one occurrence is given for the Hubble Space Telescope (HTS), although it is mentioned many times. Likewise, only one entry is found for solar system, although Part VIII and several chapters have solar system in their titles. The usefulness of an index is diminished if no effort is made to make it complete.

In spite of these misgivings, *Protostars and planets V* offers a tremendous amount of information, and I highly recommend it to anyone who has more than a fleeting interest in the solar system and its origin.

Ernst Zinner
Laboratory for Space Sciences
Washington University
Saint Louis, MO 63130, USA