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Book Review

Laboratory Astrophysics and Space Research
edited by P. Ehrenfreud, C. Krafft, H. Kochan, V. Pironello.

Ever since the detection of the first carbon-bearing radicals CH, CH^+ and CN in the interstellar medium almost 60 years ago, physical and chemical processes leading to the formation of molecules under the harsh, cosmic radiation field has been a stunning target of extensive scientific research. The book '*Laboratory Astrophysics and Space Research*' has chosen an elegant formula to bring this truly interdisciplinary topic to a broad readership of astronomers, astrophysicists, astrochemists, and space mission specialists. Rather than dwelling on details, the editors mastered an outstanding responsibility and understood it very well to provide a superb overview of cutting-edge topics in modern laboratory astrophysics and future space missions.

The book is divided into 26 carefully selected chapters, which can be grouped into three main divisions. The first sections summarize current astronomical observations on the chemistry, composition, and physical processes in extraterrestrial environments. A general introduction provides an overview of the way in which gas and dust is cycled through interstellar matter and stars in our galaxy. The reader gets acquainted precisely with interstellar environment and the basic physical conditions in which molecule formation takes place. The role of diffuse clouds, dark molecular clouds, circumstellar shells as well as young stellar objects and hot molecular cores in the synthesis of complex molecular species are presented, and the connection to dust particles including condensed ices is skillfully exposed. The elementary processes on interstellar grains — high energy processing by photons and cosmic rays and potential catalytic surface-surface reactions on the grain surfaces — and the gas phase like ion — molecule reactions are reviewed wisely. Unfortunately, the crucial role of neutral — neutral reactions to form complex molecules in the gas phase is missing though sophisticated laboratory experiments together with chemical modeling exist at least for the last 10 years. Based on this sweeping introduction to the interstellar medium and distinct environments, the next chapters provide a comprehensive overview on the chemical and mineralogical composition of the solar system bodies such as planets, comets, and interstellar ices. The compilations are remarkably compressed and precise. The chemical composition of planetary atmospheres and solar system bodies including recently discovered centauers and trans-neptunian objects as well as solar system ices, interstellar/interplanetary grains and the ices in the interstellar medium are grouped together very systematically including the most recent ISO observations. This structure combined with listed references gives even novices a unique opportunity to get an overview of these branches of astrophysics within an acceptable time frame. A compilation of the nature of carbon-containing gaseous molecules as well as solids concludes this section.

This skilful compilation of the observations of gaseous matter and the solid state phase together with the physical conditions in these environments serve as 'input data' for laboratory experiments simulating the chemical and physical processes in the interstellar medium and in our solar system — ultimately to understand and predict the formation of molecules. Saturn's moon Titan is employed as a typical example to the investigation of planetary atmospheres via laboratory simulation experiments. The authors understand it to present the broad scope of previous simulation studies very intelligently to a broad readership and combine it with an overview of the actual atmosphere of Titan to compare the laboratory versus observational data. Further chapters discuss the high energy particle processing of solid ices extensively subdivided into UV irradiation and keV/MeV particle processing of ices to simulate the interaction of the cosmic ray particle component, ions in the magnetospheres of solar system bodies such as Jupiter and Saturn, and the solar cosmic rays bombarding comets, with ices. The change of the chemical composition of the ices is presented very-well, ranging from the formation of the most simplest molecule hydrogen via intermediate sized carbon-bearing molecules up to complex polycyclic aromatic hydrocarbons (PAHs) as found in ion irradiated methane ices. Last but not least, the up-to-date knowledge of comets as derived from large-scale comet simulation laboratory experiments together with the

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GIOTTO mission to P/Halley and rather exotic studies on the resistance of life forms toward ionizing radiation at low temperatures are presented extremely concisely to the reader giving an excellent review to go deeper into this field.

The third and final part of this book is devoted to ongoing and future space missions and the technology involved in these missions ranging from mass spectrometers, laboratory dust analyses via laser desorption mass spectrometry, optical components, and space robotics. The Cassini–Huygens project to the Saturnian system and especially Titan as well as the international Rosetta mission to rendez-vous with comet 46 P/Wirtanen serve as typical milestones in the still ongoing understanding of chemical and physical processes in extraterrestrial environments.

Whereas the astrophysical concepts are presented exceptionally clear in this book, chemical processes in various interstellar and solar system environments are less emphasized. The basic chemical processes involved in the formation and processing of molecules and matter in the gas phase as well as solid state are scratched only on the surface. Two chapters discussing the mechanisms leading to the formation of new molecules in the gaseous interstellar medium and planetary atmospheres (ion — molecule reaction versus neutral — neutral reactions) and in solid matter on interstellar grains and in solar system ices (cosmic particle versus UV photon induced synthesis and non-equilibrium chemistry versus thermal, diffusion limited reactions) could have complemented an otherwise remarkably well-written book to bridge the still existing gap between chemists and astrophysicists.

Summarized, the underlying topics in laboratory astrophysics and space research are compiled extraordinarily concise. To make this complex framework more accessible especially for newcomers, numerous original references to originally published literature are skillfully presented. Graduate students and researchers will find this book as a gold mine of useful references to dive deeper into a great variety of topics ranging from physical and chemical processes in the interstellar medium, gas phase processes and composition of the interstellar medium and planetary atmospheres, systematic classification and composition of interstellar grains as well as icy bodies in our solar system, the connection between the solid state and gas phase of extraterrestrial environments, and last but not least ongoing and future space missions to investigate these processes. This balanced representation and outstanding editorship make this book a must for the interdisciplinary scientific community in laboratory astrophysics.

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