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Plasmas in the Universe

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Plasmas in the Universe

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Plasmas in the Universe, the book of Proceedings of the International School of Physics Enrico Fermi (Varenna on Lake Como, Villa Monastero, 6–16 July 1999), Course CXLII edited by B.Coppi and A.Ferrari was published by the Italian Physical Society in 2000 (IOS Press, Amsterdam, Oxford, Tokyo, Washington DC). This book contains a collection of the lectures given at the School the main purpose of which was to present a detailed picture of the state of art and recent achievements in the field of interdisciplinary studies called Plasma Astrophysics. It is not necessary to prove the importance of this field for physics in general and for astrophysics in particular. It is sufficient to note that most processes occurring in the Universe cannot be understood regardless of their plasma nature. This concerns star formation and stellar activity, non-thermal radiation and high-energy particle generation, electromagnetic radiation sources in various frequency ranges (from X-ray to radiofrequencies), magnetic structures generated by plasma instabilities etc. All these and many other topics are discussed in the lectures presented in the Proceedings.

General overview of the properties of astrophysical plasma was given in the lecture by A.Ferrari. The most important features of such a plasma as well as its typical parameters were discussed. This lecture gives an example of a brief but highly informative introduction to plasma astrophysics.

The problem of an anomalous transport of angular momentum in the course of accretion of matter was discussed in the lecture by B.Coppi. In order to understand the nature of this phenomena, the model of the accretion disk was proposed and applied to explain the laboratory experiments with rotating high-temperature magnetically confined plasma. The basic modes of the model were studied and the conclusions about the sequence of specific accretion stages were made. A brief threelecture course on scattering and acceleration of particles in astrophysical plasma is presented by O.B.Melrose. Various particle scattering and acceleration mechanisms are discussed. Special attention is paid to the acceleration at shock fronts and to the generation of the cosmic rays.

The concept of dynamical reconnections associated with resistive instabilities in astrophysical plasmas and its relation to recent experiments are discussed by E.Einaudi. The lecture by R.M.Kulsrud is devoted to the origin of a galactic magnetic field. The dynamics of perturbation in astrophysical shear flows is discussed by D.G.Lominadze. A detailed discussion of the collective emission mechanisms which could be realized in both astrophysical and laboratory plasmas (in particular, emission produced by scattering from strong Langmuir turbulence and Compton scattering from solitons) is done by G.Benford.

Much attention is paid to the variety of problems of solar physics. These are nonlinear dynamics (in particular magnetic field reconnection) in solar corona (G.Einaidi), solar wind generation and processes in the heliosphere (E.J.Smith), properties and structure of coronal plasma (G.Noci), microscopic plasma structures in the solar wind (B.T.Tsurutani, G.S.Lakhina) and solar phenomena causing geomagnetic activities at Earth (magnetic storms and substorms due to magnetic reconnection and interconnection between interplanetary and planetary fields) (B.T.Tsurutani).

The possibility and conditions of magnetic reconnection in collisionless astrophysical plasmas is discussed by J.Buchner. The magnetic nature of stars and the problems related to the origin of stellar magnetic fields are the main points of the lecture by R.Rosner. The detailed information about the G-ray and X-ray bursts is presented by D.Q.Lamb. The model of gravitational plasma (point objects interacting by means of gravitational potential) and its application to the description of the structure and evolution of galaxies is presented by G.Bertin. The problems of magnetic reconnection and radiation activity of galactic nuclei are the matter of the lecture by B.Lesch. The physical processes which cause the activity of the nuclei of galaxies, in particular, that associated with the accretion of the matter and high-energy jet generation are discussed in two lectures by A.Ferrari. The results of experimental observation of X-ray sources obtained with the Roentgen satellite (ROSAT) and Rossi X-ray Timing Explorer (RXTE) satelite are presented by J.Trimper and H.Bradt, respectively.

Summarizing, the conclusion can be drawn that the book of Proceedings "Plasma in the Universe" gives a deep insight on the recent state of astrophysical science especially on that part related to plasma physics. The theory and experiments are presented in a reasonable proportion. No doubts, this book will be of great interest for both plasma physicists and astrophysicists dealing with space and solar physics, dynamics of stars and galaxies, high-energy astrophysics etc. The only remark, which could be regarded as a critical one, concerns the absence of any information about dusty plasmas which plays a more and more important role in astrophysical studies. Discussion of this important issue could give a more complete picture of plasma phenomena in astrophysical objects.

A.Zagorodny