Preface

This book contains review articles of most of the topics addressed at the conference on *Simulations of Magnetohydrodynamic turbulence in astrophysics: recent achievements and perspectives* which took place from July 2 to 6, 2001 at the Institut Henri Poincaré in Paris. We made the choice to publish these lectures in a tutorial form so that they can be read by a broad audience. As a result, this book does not give an exhaustive view of all the subjects addressed during the conference.

The main objective of this workshop which gathered about 90 scientists from different fields, was to present and confront recent results on the topic of turbulence in magnetized astrophysical environments. A second objective was to discuss the latest generation of numerical codes, such as those using adaptive mesh refinement (AMR) techniques.

During a plenary discussion at the end of the workshop discussions were held on several topics, often at the heart of vivid controversies. Topics included the timescale for the dissipation of magneto-hydrodynamical (MHD) turbulence, the role of boundary conditions, the characteristics of imbalanced turbulence, the validity of the polytropic approach to Alfvén waves support within interstellar clouds, the source of turbulence inside clouds devoid of stellar activity, the timescale for star formation, the Alfvén Mach number of interstellar gas motions, the formation process for helical fields in the interstellar medium. The impact of small upon large scales was also discussed. Does an incorrect treatment of small scales (e.g. neglect of the Hall effect) affect large scales? What is the impact on reconnection? Is there a relation between the coherent structures of magnetic fields (sheets, tubes ...) and the plasma parameter β at the scale considered? What is the effect of magnetic helicity ejection on the dynamo mechanism? The articles presented in this book address many of these issues, and illustrate the fact that many of them remain open questions.

The book has been divided into four chapters. In the first chapter, general topics in incompressible and compressible MHD turbulence are discussed. These topics include scaling laws, intermittency, energy decay, reduced MHD (with a discussion on coronal heating models), a new regime of turbulence at very large Prandtl number and weak turbulence. In particular, the issue of anisotropy and its relation with the Goldreich-Sridhar and the Iroshnikov-Kraichnan theory is fully discussed. The second chapter contains a general discussion of numerical issues in astrophysical MHD turbulence and a presentation of the NIRVANA

code. The third chapter is devoted to the physics of the interstellar medium and star formation, with a special emphasis on the role of turbulence. First, recent observations of magnetic fields (intensity and direction) are reviewed. The interplay between turbulence, magnetic fields, self-gravity, thermal instabilities and energy injection is studied and results are interpreted to account for the formation, lifetime and star formation activity of clouds. Diagnostic tools are presented that allow a quantitative comparison between numerical modeling and the observable universe. A scenario of star formation which reproduces the stellar initial mass function (IMF) is proposed. The stability of filaments of matter threaded by helical fields is discussed and compared to observations. Turbulence in accretion disks is also reviewed. The last chapter is devoted to new scenarios of magnetic reconnection, in particular in collisionless or turbulent plasmas, and their relation with dynamo theory. The role of boundaries and helicity in astrophysical dynamos is particularly stressed.

We wish to express our special thanks to the lecturers for their stimulating presentations and to all the participants who contributed to the success of this meeting. We greatly appreciated the involvement of anonymous referees whose comments were very valuable in making the papers readable by a large audience.

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