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Preface

Complexity in the Earth's magnetospheric dynamics

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The dynamics of the near-Earth space region, i.e. the so-called Earth's magnetosphere, has been historically studied using mainly the concepts of classical magnetohydrodynamics (MHD). This approach has led, in past, to significant progresses in description of magnetospheric phenomena. However, in the last decade it was realised that a deeper understanding of the magnetospheric dynamics requires to investigate the coupling of processes on a wide range of scales ranging from small kinetic scales up to MHD scales, involving space-time cross-scale coupling and intermittent turbulence. As an example, we recall the sporadic and intermittent character of the magnetotail dynamics, where the space-time coupling of intermittent and localized turbulent fluctuations seems to play a fundamental role. Moreover, a huge number of observational evidences and theoretical cosiderations suggested that as a consequence of the continuous solar wind driving magnetospheric dynamics might be similar to that of a complex system operating in an out-of-equilibrium dynamical configuration. In the recent past, several studies have appeared on the role that chaos, turbulence and near-criticality dynamics might play in the magnetospheric dynamics. In this framework, new research perspectives to the investigation of the magnetospheric dynamics were opened by the recent advances in the study of *complexity* and *complex systems*.

In the late of 70's the emergence of *complexity* in various fields has triggered the birth of a new science: the *Science of Complexity*. In the framework of statistical mechanics this new field of investigation was named *the physics of complex systems*. Although the term *complexity* is today widely used in several research field, a simple, rigourous and universal definition of it still seems to lack. For example, this word was used to address: criticality and long-ranged correlation in out-of-equilibrium systems; strange dynamics in systems at the *edge of chaos*; the occurrence of ordered spatio-temporal patterns in disordered and noisy systems. However, a common feature of systems displaying complexity is that all these systems are generally made of a huge number of interconnected and cross-coupled parts. Even if the study of complex systems is still at an early stage, the investigation of such systems allowed the introduction of several new concepts, dealing, for example, with the appearance of self-organization, criticality and scale-invariance in out-of-equilibrium systems, and the role that disorder and fractal topologies might play in many natural systems. Moreover, a central role in the behavior of complex systems is played by the concept of *emergence*. Such a concept refers to the occurrence of higher level features and behaviours that cannot be simply surmised from the lower level properties.

This special issue of *Annales Geophysicae* presents a collection of papers contributed by some authoritative experts dealing with complexity, turbulence, chaos and criticality in the magnetospheric processes. Some of these papers are based on the presentations given by the authors at the International Symposium on Complexity in the Earth's Magnetospheric Dynamics, held on May 6-10, 2002 at the Palazzo Papadopoli in Venice, Italy, under the auspices and with the financial support of the Italian National Research Council (CNR - Agenzia 2000) and the Italian Project for Antarctic Research (PNRA). The symposium, attended by scientists representing 5 countries, provided a special forum to discuss some new approaches to magnetospheric dynamics, based on the new developments in the framework of the *physics of the complex systems*.

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