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Jets from Young Stars V

High Performance Computing and Applications

Springer

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Preface

One of the most interesting and spectacular phenomena in star-forming regions is the presence of extended and well-collimated jets of material moving away from the protostar. The study of the formation of these jets and their propagation provides important clues about the early stages of stellar evolution. In particular, it is possible to study their key role in the extraction of angular momentum from the collapsing gas cloud and their effect on the internal structure of protoplanetary disks. In order to understand the dynamics of the accretion disk–star system and the processes responsible for the ejection, collimation, and evolution of outflows from these systems, it is necessary to solve a set of differential equations. Due to the complexity of this system of equations, there is only a small number of analytical solutions available. Often their very nature limits their application to real astrophysical systems. Therefore numerical methods are necessary to understand the majority of the physical processes involved.

Modern observational facilities, on the other hand, are now producing huge amounts of data often requiring considerable computational resources to fully exploit them. In most cases this data becomes publicly available within a reasonably short time. Virtual observatories allow access not only to public data archives, but also allow to interface coherently different repositories running on distributed hardware, i.e., Computational Grids.

JETSET (JET Simulations Experiments and Theory) is a four-year Marie Curie Research Training Network (RTN) designed to build a vibrant interdisciplinary European Research and Training community centered on rigorous and novel approaches to plasma jet studies, with a focus on flows produced during star formation. The theme of the network is at the confluence of astrophysical observations, theoretical and computational modeling, laboratory experiments, and Grid technology. The network scientific goals focused on understanding (i) the driving mechanisms of jets around young stars including their possible link with planet-forming disks; (ii) the cooling–heating processes, instabilities, and shock structures in stellar and laboratory jets; (iii) and the impact of jets on energy balance and star formation in the galactic medium. Central to these overall goals are the series of JETSET schools dedicated to the training of our young researchers in key jet topics.

The first school (Villard-de-Lans, France, January 2006) was focused on the magnetohydrodynamic (MHD) theoretical models used to describe jets from young stars, while the second school (Marciana Marina, Elba Island, Italy, September 2006) was devoted to the current techniques to observe Jets, Outflows, and Circumstellar Disks at high angular resolution, and on the procedures applicable to the data towards an initial interpretation. The third school (Sauze d'Oulx, Italy, January 2007) had as its main topic "Numerical MHD and Instabilities", with a special session dedicated to Visualization techniques and virtual reality. Finally, the fourth school (Azores, Portugal, June 2007) aimed at bridging the gap between models, observations, and experiments of jets.

This book is a collection of the lectures from the fifth and last school of the JETSET network, "Jets From Young Stars: High Performance Computing in Astrophysics", held in Galway, Ireland, in January 2008. Stellar jets are complex physical systems. Their study necessitates incorporating nonlinear effects which occur on a wide variety of length and timescales. As a result of this one of the primary methods used to study the physics of jets is numerical simulations. Since the physics is so complex, the problems are large enough to make mandatory the use of high-performance computing techniques. Further, modern astrophysical datasets associated with observations are becoming so large that standard analysis methods are no longer efficient. The aim of this school was, therefore, to address the methods used to simulate astrophysical jets and to derive useful information from large datasets, focusing on techniques involving high-performance computing.

The first part of the book is devoted to general aspects of high performance in astrophysics. First, Honoré Tapamo introduces us to parallel techniques, with emphasis on MPI. John Walsh reviews grid technology techniques. The chapter by Nicholas Walton is a practical introduction to Virtual Observatory (with particular reference to AstroGrid). The second part of the book is devoted to applications of high-performance computing techniques to jet and star formation processes. Roby Banerjee describes the processes leading to the formation of jets from the collapse of magnetized cloud cores. Jürgen Steinacker shows the techniques underlying a three-dimensional radiation transfer code, and its application to astrophysical problems. Claudio Zanni, Rony Keppens, and Turlough Downes illustrate the three fundamental aspects of the stellar jet phenomena: jet ejection and its relation to the star/disk interaction (Claudio Zanni), jet stability (Rony Keppens) and the large scale propagation of jets and consequent interaction with the ambient medium (Turlough Downes).

The editors would like to thank all the lecturers for their excellent presentations and contributions to this book. We are also thankful to all school participants who, in collaboration with the lecturers, made the school an enjoyable, exciting, and informative occasion for everyone involved.

We would like to aknowledge the other members of the scientific committee: Sylvie Cabrit, Max Camenzind, Catherine Dougados, and Tom Ray for their help in organizing the scientific aspects of the school and Eileen Flood, Matt Redman, and

Emma Whelan for their superb contribution to the organization of all the practical aspects of this school.

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