

Preface

Astrophysics has always left an important imprint on Les Houches summer school. Thirty years after the famous session on “Black Holes” organized by Evry Schatzman (1972), where many great ideas of modern astrophysics were launched, and where many of the students became renowned astrophysicists, we felt it timely to take stock of all the impressive progresses made in the domains of compact galactic and extragalactic objects, young stellar objects and high energy astrophysics, from both the theoretical developments and observational standpoints. These topics are at a watershed and are blossoming at the forefront of new trends opened by the so-called “astroparticles” physics, which proposes new means of investigation of the universe where particles (neutrinos, cosmic rays, and also gravitational waves) serve as messengers of cosmic information. Therefore, we felt it was important, as one of the schools goals, to prepare the community for new breakthroughs.

During this school, several classes of phenomena have been studied such as X-ray binary systems, microquasars, active galactic nuclei, young stellar objects, pulsars and gamma ray bursts. They all share common features, namely: a central compact object, an accretion disk, outflows (sometimes collimated jets), and high energy radiations. These topics address important key-issues of modern astrophysics.

A series of fundamental lectures (Sect. 1) provided the audience with both the required background and the new physical processes involved in the research field. They covered Magnetohydrodynamics (Jean Heyvaerts), Relativistic Hydrodynamics (Vasily Beskin), Physics of accretion disks around Black Holes (Omer Blaes), Physics of Astrophysical Jets and Accretion-Ejection models (Ralph Pudritz). The important issue of the excitation of turbulence in magnetised accretion disks recently recieved a decisive insight, analysed by impressive numerical simulations.

The lectures devoted to high energy astrophysics (Sect. 2) opened our minds to new frontiers of Astrophysics. Gamma Ray Bursts (Frédéric Daigne) are probably the most attractive phenomena of high energy astrophysics nowadays, because they are not only the favorite events of gamma ray astronomy, but also potential candidates for future neutrino astronomy,

as well as promising sources of gravitational waves. They could also be the main astronomical sources of ultra high energy cosmic rays (UHECR's), whose origin remains an enigma. New important progresses in Fermi acceleration, especially in the relativistic regime, have been derived recently (Abraham Achterberg), reviving the possibility of UHECRs generation by some astrophysical objects; this is the so-called “bottom up” scenario to solve the enigm of UHECR origin (note that, because of an unexpected impediment to Abraham Achterberg's coming, the lecture was given by Guy Pelletier). The “top down” scenario, on the other hand, involves new physics, beyond the standard model of particle physics (Venya Berezhinski).

The investigation of Active Galactic Nuclei (Sect. 3) has benefited from a new impulse provided by new high energy observatories and multiwavelength campaigns from radio to gamma rays, including very crucial observations in the X-ray range, allowing a deeper understanding of their nature. Together with X-ray binary systems (Rachid Sunyaev, not reported in the book), they are one of the main manifestations of Black Hole environments (Max Camenzind), giving the opportunity of testing the General Relativity Theory. The accretion that takes place in these environments is particularly rich and has been studied in detail for many years (Bozena Czerny). These objects are also powerful sources of high energy emission, originating close to the central Black Hole at the beginning of the jets (Analisa Celotti). Intermediate mass Black Holes would now complete the bestiary but they were not, at the time of the school, in a stage of clear identification. Pulsars were also presented as interesting high energy objects with their specific nebulae (not reported in the book). Strange Quark Stars were not yet discovered at the time of the school. If they really exist, they will be at the origin of a high energy emission that will have to be compared with neutron stars and stellar black holes.

At first sight, it may look strange to have included lectures on young stellar objects (YSO's) (Sect. 4) in a school discussing, for the large part, high energy astrophysics. Rapid inspection quickly reveals however that the similarities are numerous. Furthermore, their proximity, *i.e.*, the solar neighbourhood, guarantees that their accretion disks are well resolved and well studied (Lee Hartmann), with promises of one day looking directly at its interface with the central engine when large interferometers become operational. The powerful outflows and jets they drive are also reminiscent of jets in other classes of objects. Accurate diagnostics of accretion can therefore be obtained by studying them (Nuria Calvet). YSO's also emit X-rays abundantly and their production mechanisms and impact on the immediate circumstellar environment are now being studied with unprecedented details with the new facilities available (Thierry Montmerle).

In that context, comparing and cross fertilising both fields of astrophysics, that of compact objects and that of young stellar objects, held the promises of a very exciting and fruitful summer school for a large community of astrophysicists.

At the time of the school, several important instrumental projects were nearly completed and the first observation campaigns are expected rapidly, especially the Pierre Auger Observatory (Cyril Lachaud) and Gamma Ray Observatories (Conor Masterson) such as HESS and VERITAS. Seminars have been also given on Neutrino Observatories and Gravitational Waves Observatories (they are not reported in the book).

We thank all contributors for the effort they have made in preparing these lecture notes, which often cover much more material than the lectures themselves. We strongly hope that this set of lectures will, in the tradition of many earlier volumes of the Les Houches series, provide a useful introduction and serve as a reference for several years for researchers and students in this very open and rapidly evolving field.

People from Chamonix valley are used to enjoying conferences on astrophysics topics, given by lecturers of Les Houches school. Gilles Henri gave a very successful public conference on “Black Holes” at Les Houches village.

Acknowledgments

The 78th Les Houches summer school and the present volume have been made possible by the financial support of the following institutions, whose contribution is gratefully acknowledged:

- the “High level scientific conference” program of the Research Directorate of the European Commission under grant HPCF-CT-2001-00018.
- the “Advanced Scientific Institute” program of the Scientific and Environmental Affairs division of NATO, under grant ASI-978104.
- the “Lifelong learning” program and the “Groupement de recherche Phénomènes Cosmiques des Hautes Énergies” of the Centre National de la Recherche Scientifique (France).
- the Université Joseph Fourier, the French Ministry of Research and the Commissariat à l’Énergie Atomique, through their constant support to the Physics School.

The permanent staff of the School, especially Brigitte Rousset and Isabelle Lelièvre, have been of invaluable assistance at every stage of the preparation and development of the school, and we would like to thank them warmly on behalf of all students and lecturers. We also thank the former director François David for his help during the early stages of preparation, and the school scientific council for encouraging us in preparing a session on this topic.

Guy PELLETIER
Gilles HENRI
François MENARD
Vasily BESKIN
Jean DALIBARD