ACCRETION PROCESSES IN ASTROPHYSICS

It has been more than fifty years since the first significant paper on accretion flows was written. In recent years, X-ray satellites capable of identifying accretion disks and radiation jets – indications that accretion has taken place – have significantly advanced our understanding of these phenomena. This volume presents a comprehensive and up-to-date introduction to the major theoretical and observational topics associated with accretion processes in astrophysics. Comprising lectures presented at the twenty-first Winter School of the Canary Islands Institute of Astrophysics, the text emphasizes the physical aspects of accretion, investigating how radiation jets are produced, how accretion power is divided between jets and radiated energy, the geometry of accretion flow, and the accretion processes of active galactic nuclei. Written by an international team of experienced scientists, chapters offer young researchers key analytical tools for supporting and carrying out the next generation of front-line research.

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Canary Islands Winter School of Astrophysics

Volume XXI

Accretion Processes in Astrophysics

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Preface

It was more than 50 years ago when the first significant paper on accretion flows was written. Since then, the subject has grown incredibly, and today many X-ray satellites are engaged in research into observational signatures and tests of theoretical models for accretion processes in astrophysics. Recognizing the continued importance of this field, the Instituto de Astrofísica de Canarias organized the XXIst in its Winter School series around the topic "Accretion Processes in Astrophysics."

The primary aim of the school was to provide a wide-ranging and up-to-date overview of the theoretical, experimental, and analytical tools necessary for carrying out front-line research in the study of accretion processes. The school was particularly designed to offer young researchers guidelines to support their research in these areas.

The 40 lectures presented a fairly comprehensive and up-to-date introduction to the major observational and theoretical topics associated with accretion. With emphasis on the physical processes involved, this includes applications to close binary systems such as cataclysmic variables and X-ray binaries and their evolution, as well as the theory of relativistic accretion flows and the accretion processes in active galactic nuclei. The lectures were given by eight experienced scientists who are actively working on a variety of leading research projects and who have played key roles in the advances made in the field in recent years.

The Editors

Acknowledgments

The editors would like to express their warmest gratitude to all the lecturers for their time in preparing their classes, attending the school, and writing the chapters for this book. We know that this has been a major effort on their part, but we hope that it has been rewarding for them. In particular we would like to thank Prof. John F. Hawley for his entertaining public lecture on "Black Holes" and Prof. Brian Warner for his ad hoc lecture dedicated to Charles Piazzi Smyth, who built the first (temporary) major observatory on Tenerife.

The key to the success of the school has been without any doubt our secretary Lourdes González. Without her help and diligence, the school would not have worked as smoothly as it did. We also thank Nieves Villoslada, who started the preparation and organization of the school; Jesús Burgos of the OTRI, who provided invaluable help with the preparation of applications needed to receive funding; persons at the IAC's Centro de Cálculo for their IT assistance; and Ismael Martínez Delgado, for the technical editing of this book for Cambridge University Press.

We are extremely grateful to the local artist Macu Anelo, who designed the school's poster that depicts an accretion disk around a black hole, superimposed on a background of Guanches sketches, which we hope may entice young scholars to enter this field. The school's poster was prepared by Ramón Castro. We thank Annia Domènech and the Gabinete de Dirección of the IAC for taking the time to conduct interviews and submit press releases for all the lecturers.

We greatly acknowledge the financial assistance from the Spanish Ministerio de Educación y Ciencia and from the Cabildo de Tenerife, who kindly provided the excellent facilities of the Congress Palace of Puerto de la Cruz where the event took place. Last, but not least, we would like to acknowledge all the participants of the school: lecturers, students, and supporting personnel.

The Editors

Abbreviations

AAVSO	American Association of Variable Star Observers
ACF	Auto Correlation Function
ACIS	AXAF CCD Imaging Spectrometer
ADAF	Advection Dominated Accretion Flows
ADC	Accretion Disk Corona
AGB	Asymptotic Giant Branch
AGN	Active Galactic Nucleus
ASCA	Advanced Satellite for Cosmology and Astrophysics
AU	Astronomical Unit
BAL	Broad Absorption Line
BATSE	Burst And Transient Source Experiment
BB	Black Body
BH	Black Hole
BHB	Black Hole Binaries
BHXRT	Black Hole X-Ray Transient
BLR	Broad Line Region
BPS	Binary Population Synthesis
CCD	Charge Coupled Device
CCF	Cross Correlation Function
CE	Common Envelope
CGRO	Compton Gamma-Ray Observatory
CT	Constrained Transport
CV	Cataclysmic Variable
CXB	Cosmological X-ray Background
DD	Double Degenerate
DIM	Disk Instability Model
DN	Dwarf Nova
DNe	Dwarf Novae
DNO	Dwarf Nova Oscillation
DNS	Double Neutron Star
EMF	Electromotive Force
FIR	Far Infra Red
FRED	Fast Rise Exponential Decay
GC	Globular Cluster
GRB	Gamma Ray Burst
GRMHD	General Relativistic Magneto Hydrodynamics
HID	Hardness Intensity Diagram
HMXB	High Mass X-ray Binary
HST	Hubble Space Telescope
IAC	Instituto de Astrofísica de Canarias
IMBH	Intermediate-Mass Black Hole
IMXB	Intermediate-Mass X-ray Binary
IP	Intermediate Polar
IR	Infrared
ISAF	Ion Supported Accretion Flow
ISCO	Innermost Stable Circular Orbit
ISM	Interstellar Medium
IUE	International Ultraviolet Explorer
KG	Kilo Gauss
LARPS	Low Accretion Rate Polars

LGRB	Long-Duration Gamma Ray Burst
LIGO	Laser Interferometer Gravitational-wave Observatory
LINER	Low Ionization Nuclear Emission-line Region
LL	Landau and Lifshitz (1959)
LMC	Large Magellanic Cloud
LMXB	Low-Mass X-ray Binary
LOFAR	Low-Frequency Array
lpDNO	longer-period Dwarf Nova Oscillation
MG	Mega Gauss
MHD	Magneto Hydrodynamics
MRI	Magneto Rotational Instability
MWA	Murchison Widefield Array
NASA	National Aeronautics and Space Administration
NLR	Narrow Line Region
NS	Neutron Star
NSE	Nuclear Statistical Equilibrium
NTT	New Technology Telescope
PPM	Piecewise Parabolic Method
PS	Population Synthesis
PSF	Point Spread Function
QPO	Quasi Periodic Oscillation
RLOF	Roche Lobe Overflow
ROSAT	Röentgen Satellite
RXTE	Rossi X-ray Timing Explorer
SALT	Southern African Large Telescope
SD	Single Degenerate
sdB	subdwarf Binary
SED	Spectral Energy Distribution
SFR	Star Formation Rate
SLE	Shapiro-Lightman-Eardley solutions
SPY	SN Ia Progenitor SurveY
SS	Shakura-Sunyaev
STIS	Space Telescope Imaging Spectrograph
SXT	Soft X-ray Transient
SyS	Symbiotic Star
TZO	Thorne Żytkow Object
UCXB	Ultracompact X-ray Binary
ULX	Ultra Luminous X-ray source
UV	Ultraviolet
VLBI	Very Long Baseline Interferometry
WD	White Dwarf
WRLOF	Wind Roche Lobe Overflow
XLF	X-ray Luminosity Function
XMM	European Space Agency's X-ray Multi-mirror Mission
XRB	X-Ray Binary