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Introduction to Black Hole Astrophysics

Springer

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To Blumina.

Preface

This book is based on the lecture notes of the course on black hole astrophysics given at the University of La Plata, Argentina, by one of us (GER). The material aims at advanced undergraduate and graduate students with interest in astrophysics. The course takes one semester and is usually complemented by a course on high-energy astrophysics. The material included goes beyond what is found in classic textbooks like that by Shapiro and Teukolsky and is focused exclusively on black holes. We do not consider applications to other compact objects, such as neutron stars and white dwarfs. Instead, we provide more details on astrophysical manifestations of black holes. In particular, we include abundant material on jet physics and accounts of objects such as microquasars, active galactic nuclei, gamma-ray bursts, and ultraluminous X-ray sources. Other topics, normally not covered in introductory texts, like black holes in alternative theories of gravity, are discussed since we have found that they are highly stimulating for the students. Obviously, in a book of this kind, completeness is not possible, and some selection criterion must be applied to the material. Ours has been quite personal: we selected the topics on which GER has been working for around 20 years now, and we think that these topics form the core and starting point for basic research in this fascinating area of astrophysics.

In writing the book, we tried to avoid unnecessary technicalities, and to some degree the book is self-contained. Some previous knowledge of General Relativity would be desirable, but the reader will find the basic tools in Chap. 1. The appendices provide some additional mathematical details that will be useful to pursue the study and a guide to the bibliography on the subject.

La Plata
May 2013

Gustavo E. Romero
Gabriela S. Vila

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Contents

Acronyms

ADAF	Advection-Dominated Accretion Flow
ADIOS	Advection-Dominated Inflow Outflow Solution
AGN	Active Galactic Nucleus (Nuclei)
ANEC	Average Null Energy Condition
AWEC	Average Weak Energy Condition
BATSE	Burst and Transient Source Experiment
BH	Black Hole
BLRG	Broad Line Radio Galaxy
BLR	Broad Line Region
CDAF	Convection-Dominated Accretion Flow
CDI	Current-Driven Instability
CMB	Cosmic Microwave Background
CTA	Cherenkov Telescope Array
CTC	Closed Time-like Curve
DECIGO	DECI-Hertz Interferometer Gravitational wave Observatory
EGRET	Energetic Gamma-Ray Experiment Telescope
FLRW	Friedmann-Lemaitre-Robertson-Walker (metric)
FR	Fanaroff-Riley (radio galaxy)
FSRQ	Flat Spectrum Radio Quasar
GRB	Gamma-Ray Burst
HMXRB	High-Mass X-Ray Binary
HS	High-Soft (X-ray state)
IC	Inverse Compton (scattering)
IGM	Inter Galactic Medium
IMBH	Intermediate-Mass Black Hole
ISM	Inter Stellar Medium
KHI	Kelvin-Helmholtz Instability
LAT	Large Area Telescope
LED	Large Extra Dimension(s)
LH	Low-Hard (X-ray state)
LIGO	Laser Interferometer Gravitational-wave Observatory

LISA	Laser Interferometer Space Antenna
LMXRB	Low-Mass X-Ray Binary
MAGIC	Major Atmospheric Gamma-ray Imaging Cherenkov Telescopes
MDAF	Magnetically-Dominated Accretion Flow
MHD	Magneto-Hydro-Dynamics
MQ	MicroQuasar
NGO	New Gravitational wave Observatory
NLRG	Narrow Line Radio Galaxy
NLR	Narrow Line Region
NS	Neutron Star
PSC	Principle of Self-Consistency
PTA	Pulsar Timing Array
QPO	Quasi-Periodic Oscillation
QSO	Quasi-Stellar Object
QSRS	Quasi-Stellar Radio Source
RIAF	Radiatively Inefficient Accretion Flow
SLS	Stationary Limit Surface
SPH	Smoothed Particle Hydrodynamics
ULX	Ultra Luminous X-ray (source)
VH	Very High (X-ray state)
VLBI	Very Large Baseline Interferometry
XRB	X-Ray Binary