

PARSEC-SCALE JETS IN EXTRAGALACTIC RADIO SOURCES¹

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ABSTRACT

Observations of parsec-scale radio jets associated with active galactic nuclei are reviewed, with a particular emphasis on high-luminosity core-dominated sources where the most detailed information on individual objects exists. Extensive imaging surveys with very long baseline interferometry (VLBI) have made possible a morphologic classification of compact radio sources and systematic studies of the statistics of apparent (often faster-than-light) motions found in an increasing number of sources. VLBI monitoring studies at centimeter and millimeter wavelengths, enhanced by spectral and polarization imaging, of representative types of AGN can discriminate detailed physical models. The observations are especially discussed in light of the variant of the relativistic beaming model that explains kinematic, spectral, and polarization properties of parsec-scale jets through shocks in an underlying continuous jet flow.

INTRODUCTION

The radio emission from radio-loud active galactic nuclei (AGN) ordinarily takes the form of collimated “jets” that connect a compact central region with kiloparsec-scale extended lobes and hot spots. For the past two decades, the structure and emission properties of these jets have been studied extensively

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Parsec Scale Radio Jets

Sandip K. Chakrabarti



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Parsec-Scale Radio Jets J. Anton Zensus, Timothy J. Pearson, 1990-08-16 Quasars and active galaxies are the most powerful emitters of radiation in the universe Modern radio telescope arrays have shown that the ultimate energy source resides in the central few parsecs of the galactic nucleus and powers the emitting regions by way of two oppositely directed relativistic jets of energy This volume presents the latest observations and theories of these remarkable objects Topics discussed include superluminal motions the physics of jets and shock fronts in jets related optical observations and cosmic evolution Particular attention is given to the unified theories which attempt to show that many of the phenomena in powerful extragalactic objects are different aspects of a single basic mechanism the main difference in their appearance is a result of their different orientation with respect to the observer

Parsec-scale Radio Jets J. Anton Zensus, Timothy J. Pearson, 1990 *Transverse Polarization Structure of Parsec-scale Radio Jets* Andreas Papageorgiou, 2005 Astrophysical Jets D. Burgarella, M. Livio, C. P. O'Dea, 1993-11-11 A collection of edited review articles presented at a workshop at the Space Telescope Science Institute which gathered astrophysicists from the fields of extragalactic and galactic stellar jets Jets from Stars and Galactic Nuclei Wolfgang Kundt, 2007-01-05 Jets are ubiquitous in the Universe but ill understood Conservative books base their interpretations on focused stellar winds ejected bullets black hole central engines and in situ upgrading of electron energies via shocks This volume however attempts a uniform interpretation of the bipolar flow family involving extremely relativistic pair plasma as the jet substance and rotating magnets possibly burning disks as the central engines Among the discussed sources are SS 433 YSO jets planetary nebulae our galactic center and the class of extragalactic QSOs both radio loud and radio quiet Astrophysical Jets and Beams Michael D. Smith, 2012-02-16 An up to date study of astrophysical jets that will appeal to students and researchers in all areas of astrophysics

Magnetic Field Structures in the Parsec-scale Radio Jets of Blazars Joanne Merrill Attridge, 1998 **High-Sensitivity Radio Astronomy** N. Jackson, R. J. Davis, 1997-01-28 Enhanced sensitivity radio telescopes are producing dramatic results An international conference was held in Jodrell Bank to take stock of these advances This timely volume presents the review articles presented by a host of world experts who gathered at this meeting We are shown how high sensitivity is advancing our understanding in radio spectral line analysis radio continuum observations of galaxies cosmology pulsars and radio emission from stars what new and enhanced instruments are now available and those planned for the future This volume provides graduate students and researchers with an up to date and wide ranging review of the new and future research possible with high sensitivity radio telescopes

Relativistic Jets from Active Galactic Nuclei Markus Boettcher, Daniel E. Harris, Henric Krawczynski, 2012-02-02 Written by a carefully selected consortium of researchers working in the field this book fills the gap for an up to date summary of the observational and theoretical status As such this monograph includes all used wavelengths from radio to gamma the FERMI telescope a history and theory refresher and jets from gamma ray bursts

For astronomers nuclear physicists and plasmaphysicists **Jets in Young Stellar Objects** A.J.L. Fernandes, Paulo J.V. Garcia, J.J.G. Lima, 2012-12-06 A JENAM 2002 Workshop Porto Portugal 3 5 September 2002 **Current High-energy Emission Around Black Holes** H?n-y?ng Chang, 2002 Black holes exist in galactic nuclei and in some X ray binaries found in our own galaxy and the large Magellanic Cloud This volume focuses on astrophysical high energy emission processes around black holes and the development of theoretical frameworks for interesting observational results Contents Black Hole Observations Accretion Disk Formation of Jets Energy Extraction from Rotating Black Holes Supernova and Gamma Ray Bursts Black Hole Astrophysics Readership Graduate students post docs and academics in astrophysics astronomy cosmology and high energy physics *Los Alamos Science* ,1985 **The Jet Paradigm** Tomaso Belloni, 2009-12-21 The discovery of the rst case of superluminal radio jets in our galaxy in 1994 from the bright and peculiar X ray source GRS 1915 105 has opened the way to a major shift in the direction of studies of stellar mass accreting binaries The past decade has seen an impressive increase in multi wavelength studies It is now known that all black hole binaries in our galaxy are radio sources and most likely their radio emission originates from a powerful jet In addition to the spectacular events related to the ejection of superluminal jets steady jets are known from many systems Compared with their supermassive cousins the nuclei of active galaxies stellar mass X ray binaries have the advantage of varying on time scales accessible within a human life sometimes even much shorter than a second This has led to the rst detailed studies of the relation between accretion and ejection It is even possible that excluding their soft periods the majority of the power in gal tic sources lies in the jets and not in the accretion ows This means that until a few years ago we were struggling with a physical problem accretion onto compact objects without considering one of the most important components of the system Models that associate part of the high energy emission and even the fast aperiodic variability to the jet itself are now being proposed and jets can no longer be ignored *Active Galactic Nuclei* Francoise Combes, 2022-08-23 All galaxies host a super massive black hole in their center These black holes grow their mass in symbiosis with their host galaxy and moderate their star formation When matter is driven towards the nucleus an accretion disk is formed to transfer angular momentum and considerable energy is released when the material falls into the black hole this is the phenomenon of active galactic nuclei AGN A nucleus can shine one thousand times more brightly than the entire galaxy with its 200 billion stars The nuclear activity can take many forms from very powerful quasars to more ordinary Seyfert galaxies passing by radio galaxies which eject a collimated plasma at ten times the radius of the galaxy This book examines all of these manifestations and presents a unified view When two galaxies merge a binary black hole is formed and the two black holes will spiral inwards and merge emitting long gravitational waves which could be detected by the future LISA satellite **Radio Galaxies at TeV Energies** Dorit Glawion, 2020-05-13 It is common believe that the centers of all galaxies exhibit supermassive black holes with masses ranging from millions up to billions of the mass of our Sun By accreting surrounding matter the luminosity of these galactic nuclei can outshine the

emission of their host galaxies. If this is the case they are called active galactic nuclei. Some of these objects eject powerful outflows composed of plasma called jets. These jets can produce non thermal radiation which is observable across the entire electromagnetic spectrum from radio up to the gamma ray frequencies. At highest frequencies TeV range most of the detected active galaxies have jets directed along or close to the line of sight. However also galaxies with larger angles to the line of sight showing fascinating features were discovered in seeming contradiction to traditional models for these so called radio galaxies. Thus the latter are of particular importance for understanding active galactic nuclei in general. This Special Issue contains reviews and research articles about the current knowledge of radio galaxies at TeV energies including observational results and theoretical models. It is intended to guide the interested reader deeper into this fascinating discipline of modern day astronomy.

Observational Evidence for Black Holes in the Universe Sandip K. Chakrabarti, 2012-12-06. A conference on Observational Evidence for Black Holes in the Universe was held in Calcutta during January 10-17 1998. This was the first time that experts had gathered to debate and discuss topics such as: Should black holes exist? If so how to detect them? Have we found them? This book is the essence of this gathering. Black holes are enigmatic objects since it is impossible to locate them through direct observations. State of the art theoretical works and numerical simulations have given us enough clues of what to look for. Observations from both ground and space based missions have been able to find these tell tale signatures. This book is a compendium of our present knowledge about these theories and observations. Combined they give a thorough idea of whether black holes galactic as well as extragalactic have been detected or not. Forty one experts of the subject have contributed to this volume to make it the most comprehensive to date.

Variability of Blazars E. VALTAOJA (Ed), Mauri Valtonen, 1992. Blazars also known as BL Lac objects first discovered in 1978 are unusually energetic objects in the extragalactic universe. About 200 are known or suspected. They are radio sources with highly variable optical and radio emission as well as high polarisation and their optical spectra normally have no distinguishable features. It is generally accepted that they belong to that class of galaxies with active galactic nuclei which are presumed to be driven by infall of matter to a supermassive black hole. In this book researchers give a complete summary of the observations of blazars and the theoretical interpretation. A comprehensive listing of confirmed and candidate objects is included. Mechanisms in which the variability can arise from shocks and relativistic jets are discussed. There are at least four different answers given to the question what is a blazar. This book is a complete overview of the violent activity observed in these extreme active galactic nuclei.

Circular Polarisation from Relativistic Jet Sources J.-P. Macquart, R.P. Fender, 2004-01-31. Proceedings of a Workshop Amsterdam 17-19 July 2002.

Computational Methods for Astrophysical Fluid Flow Randall J. LeVeque, Dimitri Mihalas, E.A. Dorfi, Ewald Müller, 2006-04-18. This book leads directly to the most modern numerical techniques for compressible fluid flow with special consideration given to astrophysical applications. Emphasis is put on high resolution shock capturing finite volume schemes based on Riemann solvers. The applications of such

schemes in particular the PPM method are given and include large scale simulations of supernova explosions by core collapse and thermonuclear burning and astrophysical jets Parts two and three treat radiation hydrodynamics The power of adaptive moving grids is demonstrated with a number of stellar physical simulations showing very crispy shock front structures

Extragalactic Radio Sources R. Ekers, C. Fanti, L. Padrielli, 2012-12-06 On the 100th anniversary of Marconi's successful experiment on radio broadcasting 250 astronomers from all over the world met in Bologna Italy for five days to update their knowledge of the physics and statistical properties of powerful extragalactic radio sources Since their discovery in the fifties enormous progress has been made The existence of superluminal motions in the cores of radio sources the presence there of a black hole surrounded by an absorbing dust torus as inferred mostly from studies at other wavelengths are now accepted ideas Nevertheless in spite of these efforts there are many questions still unanswered For instance we do not know which mechanism produces the huge amount of energy supplied to radio sources how the jets connecting the engine to the lobes are formed and collimated which of the differences observed among the various classes of radio sources are apparent and which are real These and other related topics are discussed in this book

Parsec Scale Radio Jets Book Review: Unveiling the Power of Words

In some sort of driven by information and connectivity, the power of words has be much more evident than ever. They have the capability to inspire, provoke, and ignite change. Such may be the essence of the book **Parsec Scale Radio Jets**, a literary masterpiece that delves deep to the significance of words and their affect our lives. Compiled by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we will explore the book is key themes, examine its writing style, and analyze its overall effect on readers.

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