

PARSEC-SCALE JETS IN EXTRAGALACTIC RADIO SOURCES¹

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KEY WORDS: compact radio sources, radio source morphology, radio jets, VLBI jets, superluminal motion, jet models

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

Andreas Papageōrgiou



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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

Magnetic Field Structures in the Parsec-scale Radio Jets of Blazars Joanne Merrill Attridge, 1998

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

Relativistic Jets from Active Galactic Nuclei Markus Boettcher, Daniel E. Harris, Henric Krawczynski, 2012-02-13 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

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

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 **Quasars and Active Galactic Nuclei** Ajit K. Kembhavi, Jayant V. Narlikar, 1999-03-11 The latest observations and theoretical models are combined in this clear pedagogic textbook for advanced undergraduates and graduate students **Astrophysical Jets** Denis Burgarella, Mario Livio, Christopher P. O'Dea, 1992 **Extragalactic Radio Sources** Jacques Roland, Hélène Sol, Guy Pelletier, 1992-06-26 The physics of active galactic nuclei the origin of extragalactic jets and the formation of extended extragalactic radio sources are among the most interesting challenges of modern astrophysics This book contains the proceedings of the 7th meeting of the Institut d'Astrophysique de Paris which drew together both theorists and observers in this exciting field Recent observational data at X ray optical and radio wavelengths is discussed and new theoretical developments concerning beam and jet formation models are considered Special treatment is given to plasma physics problems related to particle acceleration magnetic reconnection beam plasma interaction and coherent emission The volume will be of use to all students and researchers who are working in this field **Physics Briefs**, 1994 **Optical Jets in Galaxies** B. Battrick, J. Mort, 1981

Extragalactic Jets Travis Arthur Rector, David De Young, 2008 These proceedings of an international meeting held May 2007 in Girdwood Alaska USA provide a comprehensive overview of recent theoretical and observational work on the nature of extragalactic jets from parsec to kiloparsec scales Special emphasis is given to the interaction of jets with their environment and to the insights this interaction can provide The invited reviews contributed talks and poster sessions form a detailed summary of the latest findings as well as illustrate outstanding questions that remain to be resolved This book is suitable for researchers and graduate students The origin and evolution of highly collimated and highly energetic outflows from the nuclei of some galaxies remains after over 30 years of intensive study and enigmatic process We still do not know how these jets are collimated or what they contain beyond relativistic particles and magnetic fields much less how they come to be in the first place If we could unravel the mystery of their origins then it is clear that new and significant constraints could also be placed on the origin and evolution of the central engine presumably a massive black hole that creates them This in turn would give rise to new constraints on the formation and evolution of the parent galaxies and their environment The quest for insights into the nature of these objects has always been made difficult by the lack of information conveyed by their simple power law radiation spectrum and so much of the information gained must be inferential However the hope remains that by gaining an understanding of the interaction of these objects with their environment we may be able to deduce the key

parameters of the jets themselves This strategy of working from the outside in is showing increasing promise as higher resolution observations with increasing sensitivity are being made over increased coverage in wavelength especially as these are cast against results from sophisticated theoretical calculations that include three dimensional MHD simulations Publisher's website *Radio Emission from Galactic and Extragalactic Compact Sources* J. Anton Zensus, Greg B. Taylor, Joan Marie Wrobel, 1998 Imaging Simulated Relativistic Radio Jets Carrie M. Swift, 2002 **Radio Galaxies at TeV Energies** Dorit Glawion, 2020-05-13 It is common belief 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 **Compact Extragalactic Radio Sources** J. Anton Zensus, Kenneth I. Kellermann, 1994 Veröffentlichungen Max-Planck-Gesellschaft zur Förderung der Wissenschaften, 1991 Energy Transport in Radio Galaxies and Quasars Philip E. Hardee, Alan H. Bridle, J. Anton Zensus, 1996

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