



The Gamma-Ray Pulsar Phenomenology in View of 3D Kinetic Global Magnetosphere Models

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Received 2023 February 28; revised 2023 July 8; accepted 2023 July 17; published 2023 September 7

Abstract

We develop kinetic plasma models of pulsar magnetospheres with magnetic-field-line-dependent plasma injection that reveal the importance of various magnetosphere regions in regulating the γ -ray emission. We set different particle injection rates for the so-called open, closed, and separatrix zones. Moderate particle injection rates in open and closed zones ensure a global field structure close to the force-free structure, while the dissipation occurs mainly in and around the equatorial current sheet. The particles that are injected into the separatrix zone affect the particle populations that enter the equatorial current sheet region, and therefore the corresponding accelerating electric fields, particle energies, the spectral cutoff energy, and γ -ray efficiency. The separatrix zone models reproduce the recently discovered fundamental plane of γ -ray pulsars consistent with curvature radiation emission, the γ -ray light-curve shapes, and the radio-lag versus peak-separation correlation reported in the Fermi second pulsar catalog. The model beaming factors indicate that the pulsar total γ -ray luminosities listed in the Fermi catalogs are overestimations of the actual ones. We find that the radiation reaction limited regime starts ceasing to govern the high-energy emission for $\dot{E} \lesssim 10^{34}$ erg s⁻¹. Our results also indicate that toward high magnetic inclination angles, the V point around the rotational equator migrates well inside the light cylinder, sparking additional peaks in the γ -ray pulse profiles. We find that an equivalent enhanced particle injection beyond the V point strengthens these features, making the model γ -ray light curves inconsistent with those observed.

Unified Astronomy Thesaurus concepts: Pulsars (1306); Gamma-rays (637); Gamma-ray telescopes (634);

Computational methods (1965); Neutron stars (1108)

1. Introduction

Over the past decade, the Fermi Large Area Telescope (LAT) has greatly increased the number of γ -ray rotation-powered pulsars detected between 30 MeV and 300 GeV. The LAT has detected over 270 new γ -ray pulsars to date, 117 of which were compiled in the Second Fermi Pulsar Catalog (2PC; Abdo et al. 2013) and more are expected later this year in the forthcoming Third Pulsar Catalog (3PC).

The Fermi data largely ruled out the possibility that the observed γ -rays originate from near the stellar surface, implicating the outer magnetosphere as the region of the pulsar γ -ray emission in most pulsars. Moreover, the patterns of the γ -ray light curves show clear dependence of the γ -ray pulse peak separation Δ on the phase-lag between radio and γ -ray emission δ . This important multi-wavelength correlation sets strict constraints on the pulsar emission physics and geometry (Bai & Spitkovsky 2010; Contopoulos & Kalapotharakos 2010; Kalapotharakos et al. 2014). These studies indicated that the equatorial current sheet (ECS), a characteristic feature of the force-free (FF) global magnetosphere solutions (Contopoulos et al. 1999; Spitkovsky 2006; Timokhin 2006) emerging at and beyond the light cylinder (LC), was a prime candidate region for the observed γ -ray pulsar emission.

Kalapotharakos et al. (2017), assuming curvature radiation in the radiation reaction limited (RRL) regime that occurs at the ECS region near the LC, demonstrated that the LAT data imply

the corresponding accelerating electric-field components, E_{acc} , and their dependence on the spin-down power \dot{E} , uncovering the corresponding operational regime, i.e., the dissipation degree of the emitting region.

More recently, Kalapotharakos et al. (2019), using 88 γ -ray pulsars from the 2PC, showed that the entire γ -ray pulsar population, i.e., millisecond pulsars (MPs) and young pulsars (YPs), lie on a fundamental plane (FP)

$$L_{\gamma} \propto \epsilon_{\text{cut}}^{1.18 \pm 0.24} B_{\text{LC}}^{0.17 \pm 0.05} \dot{E}^{0.41 \pm 0.08} \quad (1)$$

that relates their total γ -ray luminosity, L_{γ} , spectral cutoff energy, ϵ_{cut} , stellar surface magnetic field, B_{LC} , and spin-down power, \dot{E} . Remarkably, the observed FP is consistent with the theoretically expected behavior

$$L_{\gamma} \propto A_{\text{cut}}^{1/3} B_{\text{LC}}^{1/6} \dot{E}^{5/12} \quad (2)$$

that attributes the pulsar γ -ray emission to curvature radiation in the RRL¹ by particles accelerated in the ECS just outside the LC.

Kalapotharakos et al. (2022)² expanded the pulsar sample by more than two-fold to 190, which they used to update the FP

¹ Kalapotharakos et al. (2022) showed that the RRL regime is a sufficient but not necessary condition for the derivation of the FP theoretical scaling, i.e., Equation (2).

² They adopted the spectral analysis data from the 12 yr incremental version of the fourth Fermi-LAT catalog of point γ -ray sources (4FGL, Abdollahi et al. 2020; 4FGL-DR1, for Data Release 1, Fermi-LAT collaboration et al. 2022) combined with data from the Australia Telescope National Facility (ATNF) Pulsar Catalog (Manchester et al. 2005).



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Jerzy Giedymin



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Beyond Standard Model Phenomenology at the LHC Priscila de Aquino, 2013-09-16 This thesis provides an introduction to the physics of the Standard Model and beyond and to the methods used to analyse Large Hadron Collider LHC data The hierarchy problem astrophysical data and experiments on neutrinos indicate that new physics can be expected at the now accessible TeV scale This work investigates extensions of the Standard Model with gravitons and gravitinos in the context of supergravity The production of these particles in association with jets is studied as one of the most promising avenues for researching new physics at the LHC Advanced simulation techniques and tools such as algorithms allowing the computation of Feynman graphs and helicity amplitudes are first developed and then employed Particle Theory and Phenomenology International Kazimierz Meeting on Particle Physics 1995, Iowa State University, Kenneth E. Lassila, 1996 In this book leading researchers in theoretical and experimental particle physics summarize the recent developments in their areas of expertise There are also concentrated presentations on top quark discoveries and new theory consequences of top data

Standard Model Phenomenology Shaaban Khalil, Stefano Moretti, 2022-06-20 This new book is fully up to date with all the latest developments on both theoretical and experimental investigations of the Standard Model SM of particle physics with a particular emphasis on its historical development on both sides It further stresses the cross fertilisation between the two sub disciplines of theoretical and experimental particle physics which has been instrumental in establishing the SM In other words the book develops a truly phenomenological attitude to the subject In addition to emphasising the successes of the SM this book also critically assesses its limitations and raises key unanswered questions for the purpose of presenting a new perspective of how to further our knowledge above and beyond it It also contains both historical information from past experiments and latest results from the Large Hadron Collider at CERN This book will be an invaluable reference to advanced undergraduate and postgraduate students in addition to early stage researchers in the field

Key Features Provides a unique approach not found in current literature in developing and verifying the SM Presents the theory pedagogically but rigorously from basic knowledge of quantum field theory Brings together experimental and theoretical practice in one cohesive text

Mathematical, Theoretical And Phenomenological Challenges Beyond The Standard Model: Perspectives Of The Balkan Collaborations Goran Djordjevic, Ljubisa Netic, Julius Wess, 2005-03-28 This book contains invited lectures and shorter contributions to the workshop Mathematical Theoretical and Phenomenological Challenges Beyond the Standard Model Perspectives of the Balkan Collaborations BW2003 which was held in Vrnjacka Banja Serbia 29 August 3 September It was one of the first high level HEP workshops in the South East European region after many years and the papers give a clear perspective on the scientific potential of this area The contributions cover topics and problems under research in high energy particle physics and quantum field theory in particular string theory and M theory grand unification quantum gravity and cosmology standard and noncommutative quantum field theory Some papers concern

more mathematical topics such as the integrability topology of gauge groups and operator matrices The contributors are leading international scientists such as G Arutyunov K Behrndt G Cardoso M Chaichian G Lazarides D Luest N Kaloper G Senjanovic and J Wess with an emphasis on researchers from South East Europe including B Bajc A Mikovic and B Sazdovic The proceedings have been selected for coverage in Index to Scientific Technical Proceedings ISTP ISI Proceedings Index to Scientific Technical Proceedings ISTP CDRom version ISI Proceedings CC Proceedings Engineering Physical Sciences

The Phenomenological Theory of Linear Viscoelastic Behavior Nicholas W. Tschoegl, 2012-12-06 One of the principal objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity J Willard Gibbs This book is an outgrowth of lectures I have given on and off over some sixteen years in graduate courses at the California Institute of Technology and in abbreviated form elsewhere It is nevertheless not meant to be a textbook I have aimed at a full exposition of the phenomenological theory of linear viscoelastic behavior for the use of the practicing scientist or engineer as well as the academic teacher or student The book is thus primarily a reference work In accord with the motto above I have chosen to describe the theory of linear viscoelastic behavior through the use of the Laplace transformation The treatment of linear time dependent systems in terms of the Laplace transforms of the relations between the excitation and response variables has by now become commonplace in other fields With some notable exceptions it has not been widely used in viscoelasticity I hope that the reader will find this approach useful

Phenomenology of Gauge Theories J. Thanh Van Tran, 1984 Theory And Phenomenology Of Sparticles: An Account Of Four-dimensional $N=1$ Supersymmetry In High Energy Physics Manuel Drees, Rohini Godbole, Probir Roy, 2005-01-18 Supersymmetry or SUSY one of the most beautiful recent ideas of physics predicts sparticles existing as superpartners of particles This book gives a theoretical and phenomenological account of sparticles Starting from a basic level it provides a comprehensive pedagogical and user friendly treatment of the subject of four dimensional $N=1$ supersymmetry as well as its observational aspects in high energy physics and cosmology Part One of the book introduces the requisite formal theory preceded by a discussion of the naturalness problem Part Two describes the supersymmetrization of the Standard Model of particle interactions as well as the origin of soft supersymmetry breaking and how it can be mediated from higher energies Search strategies for sparticles supersymmetric Higgs bosons nonminimal scenarios and cosmological implications are some of the other topics covered Novel features of the book include a dictionary between two component and four component spinor notation a step by step derivation of the nonrenormalization theorem an extended discussion of supersymmetric renormalization group evolution detailed analyses of minimal and nonminimal models with gravity including anomaly mediated and gauge mediated supersymmetry breaking as well as elaborate self contained presentations of collider signals of sparticles plus supersymmetric Higgs bosons and of supersymmetric cosmology Appendices list all Feynman rules for the vertices of the Minimal Supersymmetric Standard Model

An Introduction to the Phenomenological Theory of

Ferroelectricity J. Grindlay, 2017-08-26 An Introduction to the Phenomenological Theory of Ferroelectricity covers topics about the basis and derivation of the macroscopic or phenomenological theory of the elastic dielectric and thermal properties of crystals as applied in the field of ferroelectricity The monograph discusses the elastic dielectric and thermal properties of ferroelectric crystals the standard linear time dependent electroelastic theory the non linear static properties of an elastic dielectric on a variational principle and the phenomenological theory of the static thermal elastic and dielectric properties of a homogeneous material The book also describes the theory of the static non linear behavior of an elastic dielectric as well as the phenomenological models for ferroelectricity Students taking physics courses and practicing physicists will find the book invaluable

Phenomenology and Media Paul Majkut, Alberto J. L. Carrillo Canán, 2010 During the first decade of its existence from 1999 to 2008 the Society for Phenomenology and Media held annual international conferences in San Diego California Puebla Mexico Krakow Poland Helsinki Finland Buenos Aires Argentina Provo Utah and Monmouth Oregon Papers delivered at these conferences were published in the Society's journal Glimpse The current volume is an anthology of essays drawn from the first ten years of Glimpse From its birth the Society sought to bridge the gap between contemporary media theory and practice and phenomenological insight Essays in this anthology include work on digital representation film mobile communication cyberspace medieval manuscripts print radio the stage TV virtual reality and other media as well as theoretical papers dealing with media aesthetics epistemology ethics politics and ontology

Science and Convention Jerzy Giedymin, 2014-05-20 Science and Convention Essays on Henri Poincaré's Philosophy of Science and The Conventionalist Tradition contains essays concerned with Henri Poincaré's philosophy of science physics in particular and with the conventionalist tradition in philosophy that he revived and reshaped simultaneously with but independently of Pierre Duhem Separating five essays as chapters the book discusses the main ideas of the philosophy Essays 1 and 5 traces at least some of its historical background Essays 1 2 and 3 and provides some of its developments Essays 2 and 4

Phenomenological Aspects Of Superstring Theories, Past '97 Goran Senjanovic, Alexei Smirnov, 1999-01-25

Critical Theory and Disability Teodor Mladenov, 2016-06-30 Critical Theory and Disability explores social and ontological issues encountered by present day disabled people applying ideas from disability studies and phenomenology It focuses on disabling contexts in order to highlight and criticize the ontological assumptions of contemporary society particularly those related to the meaning of human being In empirical terms the book explores critically social practices that undermine disabled people's well being drawing on cases from contemporary Bulgaria It includes in depth examination of key mechanisms such as disability assessment personal assistance direct payments and disability based discrimination On this basis wider sociological and ontological claims are made concerning the body identity otherness and exclusion

Foundations of Sensation and Perception George Mather, 2016-08-12 Do you wonder how movies sequences of static frames appear to move or why 3 D films look different from traditional movies Why does ventriloquism work and why can airliner flights make you feel

disoriented The answers to these and other questions about the human senses can be found within the pages of Foundations of Sensation and Perception This third edition maintains the standard for clarity and accessibility combined with rigor which was set in previous editions making it suitable for a wide range of students As in the previous editions the early chapters allow students to grasp fundamental principles in relation to the relatively simple sensory systems smell taste touch and balance before moving on to more complex material in hearing and vision The text has been extensively updated and this new edition includes a new chapter devoted to attention and perception over 200 new references over 30 new figures and improved more colorful visual presentation a new companion website with a range of resources for students and lecturers The book contains a range of pedagogical features including tutorial sections at the end of each chapter This distinctive feature introduces areas of the subject which are rarely included in student texts but are crucial for establishing a firm foundation of knowledge Some tutorials are devoted to more advanced and technical topics optics light measurement Bayesian inference but treated in an accessible manner while others cover topics a little outside of the mainstream music perception consciousness visual art Foundations of Sensation and Perception will enable the reader to achieve a firm grasp of current knowledge concerning the processes that underlie our perception of the world and will be an invaluable resource for those studying psychology neuroscience and related disciplines

Extended Objects And Bound Systems: From Relativistic Description To Phenomenological Application - Proceedings Of The International Symposium S

Naka,O Hara,S Ishida,1993-02-08 Counterfeiting which has emerged as a recent global phenomenon has arisen due to economic liberalisation the changing nature of society and new competitive structures Branding has become an increasingly important area of research in marketing as well as a crucial decision making area in strategic marketing management Counterfeit related activities challenge the existing theoretical and methodological framework in many ways particularly consumer behavior and branding This book brings together the three areas counterfeiting branding and consumer behaviour within a very robust methodological and statistical modelling framework In the Shadow of Phenomenology Stephen H.

Watson,2009-04-07 A new monograph exploring the theoretical status of Merleau Ponty s contributions to epistemology and rationality in his account of phenomenology **The Standard Model** Cliff Burgess,Guy Moore,2007 This 2006 book uses

the standard model as a vehicle for introducing quantum field theory **Beyond Mimesis and Convention** Roman Frigg,Matthew Hunter,2010-04-28 Representation is a concern crucial to the sciences and the arts alike Scientists devote substantial time to devising and exploring representations of all kinds From photographs and computer generated images to diagrams charts and graphs from scale models to abstract theories representations are ubiquitous in and central to science Likewise after spending much of the twentieth century in proverbial exile as abstraction and Formalist aesthetics reigned supreme representation has returned with a vengeance to contemporary visual art Representational photography video and ever evolving forms of new media now figure prominently in the globalized art world while this return of the real has re

energized problems of representation in the traditional media of painting and sculpture. If it ever really left representation in the arts is certainly back. Central as they are to science and art, these representational concerns have been perceived as different in kind and as objects of separate intellectual traditions. Scientific modeling and theorizing have been topics of heated debate in twentieth-century philosophy of science in the analytic tradition, while representation of the real and ideal has never moved far from the core humanist concerns of historians of Western art. Yet both of these traditions have recently arrived at a similar impasse. Thinking about representation has polarized into oppositions between mimesis and convention. Advocates of mimesis understand some notion of mimicry or similarity, resemblance or imitation as the core of representation: something represents something else if and only if the former mimics the latter in some relevant way. Such mimetic views stand in stark contrast to conventionalist accounts of representation, which see voluntary and arbitrary stipulation as the core of representation. Occasional exceptions only serve to prove the rule that mimesis and convention govern current thinking about representation in both analytic philosophy of science and studies of visual art. This conjunction can hardly be dismissed as a matter of mere coincidence. In fact, researchers in philosophy of science and the history of art have increasingly found themselves trespassing into the domain of the other community, pilfering ideas and approaches to representation. Cognizant of the limitations of the accounts of representation available within the field, philosophers of science have begun to look outward toward the rich traditions of thinking about representation in the visual and literary arts. Simultaneously, scholars in art history and affiliated fields like visual studies have come to see images generated in scientific contexts as not merely interesting illustrations derived from high art but as sophisticated visualization techniques that dynamically challenge our received conceptions of representation and aesthetics.

Beyond Mimesis and Convention: Representation in Art and Science is motivated by the conviction that we students of the sciences and arts are best served by confronting our mutual impasse and by recognizing the shared concerns that have necessitated our covert acts of kleptomania. Drawing leading contributors from the philosophy of science, the philosophy of literature, art history, and visual studies, our volume takes its brief from our title. That is, these essays aim to put the evidence of science and of art to work in thinking about representation by offering third or fourth or fifth ways beyond mimesis and convention. In so doing, our contributors explore a range of topics: fictionalism, exemplification, neuroaesthetics, approximate truth, that build upon and depart from ongoing conversations in philosophy of science and studies of visual art in ways that will be of interest to both interpretive communities. To put these contributions into context, the remainder of this introduction aims to survey how our communities have discretely arrived at a place wherein the perhaps surprising collaboration between philosophy of science and art history has become not only salubrious but a matter of necessity.

The Higgs Hunter's Guide John F. Gunion, 2018-03-05. The Higgs Hunter's Guide is a definitive and comprehensive guide to the physics of Higgs bosons. In particular, it discusses the extended Higgs sectors required by those recent theoretical approaches that go beyond the Standard Model, including supersymmetry and superstring-inspired

models **Mathematical Modeling and Simulation** Mr. Rohit Manglik, 2024-07-08 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels **Nuclear Science Abstracts** , 1976

Reviewing **Models Of Phenomenology Conven**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is really astonishing. Within the pages of "**Models Of Phenomenology Conven**," an enthralling opus penned by a highly acclaimed wordsmith, readers attempt an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve in to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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