



Research Article

Special Issue: In honor of Joel Spruck

Yisong Yang*

Nonlinear problems inspired by the Born–Infeld theory of electrodynamics

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Abstract: It is shown that nonlinear electro-dynamics of the Born–Infeld theory type may be exploited to shed insight into a few fundamental problems in theoretical physics, including rendering electromagnetic asymmetry to energetically exclude magnetic monopoles, achieving finite electromagnetic energy to relegate curvature singularities of charged black holes, and providing theoretical interpretation of equations of state of cosmic fluids via k-essence cosmology. Also discussed are some nonlinear differential equation problems.

Keywords: Born–Infeld electrodynamics; black holes; curvature singularities; k-essence cosmology; equation of state; early universe

Mathematics subject classifications (2020): 35Q75; 78A25; 83C22; 83C57; 83F05

1 Introduction

Fundamental physics thrives and even relies on nonlinearities which often lead to highly challenging nonlinear differential equation problems. For example, the free motion of a particle of mass m and velocity v is governed in Newtonian mechanics by the Lagrangian action function $\frac{1}{2}mv^2$ but that in Einstein's special relativity is by $mc^2(1 - \sqrt{1 - v^2/c^2})$ where c is the speed of light in vacuum; in order to obtain a full description of the quantum-mechanical motion of a charged particle, the conventional partial derivative ∂_μ with respect to the Minkowski spacetime coordinate x_μ in the Schrödinger equation needs to be replaced by the gauge-covariant derivative $D_\mu = \partial_\mu - iA_\mu$, where A_μ is a real-valued gauge field with induced electromagnetic field $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$, giving rise to nonlinear interaction between the wave function and gauge field in the coupled theory; the Yang–Mills gauge field theory describing weak and strong interactions between subatomic particles is formulated in terms of matrix-valued field tensors of the form $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu + [A_\mu, A_\nu]$ where A_μ is a matrix-valued gauge field and $[\cdot, \cdot]$ the matrix commutator, introducing nonlinear self-interaction of the gauge field; the gravitational theory of Einstein is built over a pseudo-Riemannian or Lorentzian manifold that relates the spacetime metric tensor to the matter presence through coupling its Ricci tensor and curvature scalar to the matter stress tensor, which inevitably gives rise to a highly nonlinear partial differential equation problem. Interestingly, in many situations, even when the original theoretical setups are linear and successful, it

In honor of Professor Joel Spruck on the occasion of his retirement with affection and admiration.

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Nonlinear Problems In Relativity And Cosmology

Ying-Ying Zheng



Nonlinear Problems In Relativity And Cosmology:

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Kandrup, 1998 Nonlinear dynamics and chaos pervade dynamical problems on all astrophysical scales ranging from the sun and solar system to galaxies and cosmology This volume the 13th in a series devoted to problems in nonlinear astronomy and physics presents the work of 18 senior scientists from around the world as well as that of several postdoctoral associates to honour their mentor and colleague George Contopoulos a seminal figure in this area of astrophysical research Some of the topics considered are plasma physics accelerator dynamics several formal problems in nonlinear dynamics and several applied to astronomical problems on cosmology accretion phenomena and the structure and evolution of galaxies

Texas/ESO-CERN Symposium on Relativistic Astrophysics, Cosmology, and Fundamental Physics John D. Barrow, Leon Mestel, Peter Andrew Thomas, 1991 This volume begins with 21 articles on the major topics recent developments and new results in astrophysics and relativity and features a paper on The Beginning of the Universe by S W Hawking In addition there are symposia on particle astronomy on neutron stars and black hole astrophysics and on large scale structure and galaxy formation **International Aerospace Abstracts** ,1997 Acta Cosmologica ,1997

Mathematical Reviews ,2006 **Physics Briefs** ,1993 **Annals of the New York Academy of Sciences** Thomas Lincoln Casey, Gilbert Van Ingen, Charles Lane Poor, Edmund Otis Hovey, Ralph Winfred Tower, 1991 Records of meetings 1808 1916 in v 11 27 **The Cumulative Book Index** ,1991 A world list of books in the English language

Astrophysical Disks S. F. Dermott, James H. Hunter, Robert E. Wilson, 1992 A companion to earlier volumes 497 536 596 617 and 631 of the Annals this entry in the nonlinear astronomy series has contributions by most of the acknowledged experts in the field They write on many topics all of current interest As several hold strong opposing views this is a lively important and timely publication *General physics, relativity, astronomy and mathematical physics and methods* ,1993

10th International Conference on General Relativity and Gravitation: Relativistic astrophysics, experimental gravitation, quantum gravity ,1983 **Directory of Published Proceedings** ,1996 Nonlinear Physical Fields and Anomalous Phenomena Alexander S. Rabinowitch, 2009 The monograph is devoted to a number of poorly explored problems of non linear

electrodynamics nuclear physics and general relativity that are very important for astrophysics geophysics and cosmology In it new theoretical methods are proposed to solve the problems under consideration and to explain a number of puzzling experimental and observational data In the book the authors study the non linear equations of the Yang Mills theory and their applications to several unsolved problems of electrodynamics They find and investigate a non linear generalisation of the Yukawa meson theory to describe the phenomenon of nuclear saturation and various properties of nuclei They propose a generalised Dirac s equation to describe the quark structure and anomalous magnetic moments of nucleons They consider a number of unsolved problems of general relativity and study anomalous properties of gravitational waves Finally they find and investigate a generalisation of the Einstein gravitational equations based on Weyl s geometry to explain puzzling properties of spiral galaxies and to apply it to several unsolved problems of cosmology *Nuclear Science Abstracts* ,1971-03 *Vistas in Astronomy* ,1992 *Proceedings of Symposia in Pure Mathematics* ,1986 **INIS Atomindex** ,1987
Catalogue American Mathematical Society,2000

Unveiling the Magic of Words: A Report on "**Nonlinear Problems In Relativity And Cosmology**"

In a global defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their ability to kindle emotions, provoke contemplation, and ignite transformative change is really awe-inspiring. Enter the realm of "**Nonlinear Problems In Relativity And Cosmology**," a mesmerizing literary masterpiece penned with a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve in to the book is central themes, examine its distinctive writing style, and assess its profound affect the souls of its readers.

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