

Dynamical Systems in Cosmology



Edited by
J. Wainwright and
G. F. R. Ellis

Dynamical Systems And Cosmology Dynamical Systems And Cosmology

N. Chan



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Dynamical Systems and Cosmology A.A. Coley, 2003-10-31 Dynamical systems theory is especially well suited for determining the possible asymptotic states at both early and late times of cosmological models particularly when the governing equations are a finite system of autonomous ordinary differential equations In this book we discuss cosmological models as dynamical systems with particular emphasis on applications in the early Universe We point out the important role of self similar models We review the asymptotic properties of spatially homogeneous perfect fluid models in general relativity We then discuss results concerning scalar field models with an exponential potential both with and without barotropic matter Finally we discuss the dynamical properties of cosmological models derived from the string effective action This book is a valuable source for all graduate students and professional astronomers who are interested in modern developments in cosmology

Dynamical Systems in Cosmology J. Wainwright, G. F. R. Ellis, 2005-06-30 This authoritative volume shows how modern dynamical systems theory can help us in understanding the evolution of cosmological models It also compares this approach with Hamiltonian methods and numerical studies A major part of the book deals with the spatially homogeneous Bianchi models and their isotropic subclass the Friedmann Lemaitre models but certain classes of inhomogeneous models for example silent universes are also examined The analysis leads to an understanding of how special high symmetry models determine the evolution of more general families of models and how these families relate to real cosmological observations This is the first book to relate modern dynamical systems theory to both cosmological models and cosmological observations It provides an invaluable reference for graduate students and researchers in relativity cosmology and dynamical systems theory

Dynamical Systems in Cosmology and Astrophysics Ulf Nilsson, 1998 Dynamical Systems in Cosmology Nyein Chan, 2012 *Dynamical Systems in Cosmology* N. Chan, 2012 In this PhD thesis the role of dynamical systems in cosmology has been studied Many systems and processes of cosmological interest can be modelled as dynamical systems Motivated by the concept of hypothetical dark energy that is believed to be responsible for the recently discovered accelerated expansion of the universe various dynamical dark energy models coupled to dark matter have been investigated using a dynamical systems approach The models investigated include quintessence three form and phantom fields interacting with dark matter in different forms The properties of these models range from mathematically simple ones to those with better physical motivation and justification It was often encountered that linear stability theory fails to reveal behaviour of the dynamical systems As part of this PhD programme other techniques such as application of the centre manifold theory construction of Lyapunov functions were considered Applications of these so called methods of non linear stability theory were applied to cosmological models Aforementioned techniques are powerful tools that have direct applications not only in applied mathematics theoretical physics and engineering but also in finance economics theoretical immunology neuroscience and many more One of the main aims of this thesis is to bridge the gap between dynamical

systems theory an area of applied mathematics and cosmology an exciting area of physics that studies the universe as a whole

Dynamical And Complex Systems Shaun Bullett, Tom Fearn, Frank Smith, 2016-12-22 This book leads readers from a basic foundation to an advanced level understanding of dynamical and complex systems It is the perfect text for graduate or PhD mathematical science students looking for support in topics such as applied dynamical systems Lotka Volterra dynamical systems applied dynamical systems theory dynamical systems in cosmology aperiodic order and complex systems dynamics Dynamical and Complex Systems is the fifth volume of the LTCC Advanced Mathematics Series This series is the first to provide advanced introductions to mathematical science topics to advanced students of mathematics Edited by the three joint heads of the London Taught Course Centre for PhD Students in the Mathematical Sciences LTCC each book supports readers in broadening their mathematical knowledge outside of their immediate research disciplines while also covering specialized key areas

Methods in the Qualitative Theory of Dynamical Systems in Astrophysics and Gas Dynamics O.I. Bogoyavlensky, 1985-08 Homogeneous cosmological models self similar motion of self gravitating gas and motion of gas with homogeneous deformation have important applications in the theory of evolution of the universe In particular they can be applied to the theory of explosions of stars formation of galaxies pulsation of alternating stars etc The equations of general relativity and Newtonian gas dynamics in the cases mentioned above are reduced to systems of a finite but quite large number of ordinary differential equations In the last two decades these multi dimensional dynamical systems were and still are being analyzed by means of traditional analytic and numerical methods Important dynamical modes of some solutions were thus established These include oscillatory modes of the space time metric near a cosmological singularity self similar motion of self gravitating gas with a shock wave and an expanding cavity inside as in an explosion of a star collapse of an ellipsoid of self gravitating dust into a disc and others However the multi dimensional dynamical systems in question are so complex that a complete analysis of all dynamical modes of the solutions by means of well known traditional analytic methods does not seem feasible Therefore the development of effective methods of qualitative analysis of multi dimensional dynamical systems and their application to the problems of astrophysics and gas dynamics previously unsolved by traditional methods becomes especially urgent

Primordial Cosmology Giovanni Montani, 2011 Primordial Cosmology deals with one of the most puzzling and fascinating topics debated in modern physics the nature of the Big Bang singularity The authors provide a self consistent and complete treatment of the very early Universe dynamics passing through a concise discussion of the Standard Cosmological Model a precise characterization of the role played by the theory of inflation up to a detailed analysis of the anisotropic and inhomogeneous cosmological models The most peculiar feature of this book is its uniqueness in treating advanced topics of quantum cosmology with a well traced link to more canonical and pedagogical notions of fundamental cosmology This book traces clearly the backward temporal evolution of the Universe starting with the Robertson-Walker geometry and ending with the recent results of loop quantum cosmology in view of

the Big Bounce The reader is accompanied in this journey by an initial technical presentation which thanks to the fundamental tools given earlier in the book never seems heavy or obscure *Proceedings of the 2nd International Conference on BioGeoSciences* Rolando Cárdenas,Vladimir Mochalov,Oscar Parra,Osmel Martin,2018-12-18 This book features a selection of works presented in the 2nd International Conference on BioGeoSciences in a unified framework First it describes several theoretical tools for the mathematical modelling of natural processes and environments such as Quantitative Habitability Theory dynamical systems and artificial intelligence It then outlines applications to the broad and multifaceted area of the natural sciences and environmental engineering This highly interdisciplinary book includes case studies with a wide range of spatio temporal scales from ecosystem to astrobiological cosmological scales **Modern Theoretical and Observational Cosmology** Manolis Plionis,Spiros Cotsakis,2012-12-06 Proceedings of the second Hellenic Cosmology Meeting held in the National Observatory of Athens Penteli 19 20 April 2001 **Advances in Computational Methods and Modeling for Science and Engineering** Hari M Srivastava,Geeta Arora,Firdous Shah,2025-02-04 Advances in Computational Methods and Modelling in Science and Engineering explores the application of computational techniques and modeling approaches in science and engineering providing practical knowledge and skills for tackling complex problems using numerical simulations and data analysis This book addresses the need for a cohesive and up to date resource in the rapidly evolving field of computational methods It consolidates diverse topics serving as a one stop guide for individuals seeking a comprehensive understanding of the subject matter Sections focus on mathematical techniques that provide global solutions for models arising in engineering and scientific research applications by considering their long term benefits The mathematical treatment of these models is very helpful in understanding these models and their real world applications The methods and modeling techniques presented are useful for mathematicians engineers scientists and researchers working on the mathematical treatment of models in a wide range of applications including disciplines such as engineering physics chemistry computer science and applied mathematics Provides comprehensive coverage of computational methods and modeling techniques applicable to science and engineering Emphasizes practical application by providing real world examples Offers practical guidance and step by step examples to help readers overcome challenges related to implementing algorithms interpreting results and effectively applying computational methods in their work *Thirteenth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics And Relativistic Field Theories - Proceedings Of The Mg13 Meeting On General Relativity (In 3 Volumes)* Remo Ruffini,Kjell Rosquist,Robert T Jantzen,2015-01-26 The Marcel Grossmann Meetings seek to further the development of the foundations and applications of Einstein s general relativity by promoting theoretical understanding in the relevant fields of physics mathematics astronomy and astrophysics and to direct future technological observational and experimental efforts The meetings discuss recent developments in classical and quantum aspects of gravity and in cosmology and relativistic

astrophysics with major emphasis on mathematical foundations and physical predictions having the main objective of gathering scientists from diverse backgrounds for deepening our understanding of spacetime structure and reviewing the current state of the art in the theory observations and experiments pertinent to relativistic gravitation The range of topics is broad going from the more abstract classical theory quantum gravity branes and strings to more concrete relativistic astrophysics observations and modeling The three volumes of the proceedings of MG13 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 33 morning plenary talks during 6 days and 75 parallel sessions over 4 afternoons Volume A contains plenary and review talks ranging from the mathematical foundations of classical and quantum gravitational theories including recent developments in string brane theories to precision tests of general relativity including progress towards the detection of gravitational waves and from supernova cosmology to relativistic astrophysics including such topics as gamma ray bursts black hole physics both in our galaxy and in active galactic nuclei in other galaxies and neutron star and pulsar astrophysics Volumes B and C include parallel sessions which touch on dark matter neutrinos X ray sources astrophysical black holes neutron stars binary systems radiative transfer accretion disks quasars gamma ray bursts supernovas alternative gravitational theories perturbations of collapsed objects analog models black hole thermodynamics numerical relativity gravitational lensing large scale structure observational cosmology early universe models and cosmic microwave background anisotropies inhomogeneous cosmology inflation global structure singularities chaos Einstein Maxwell systems wormholes exact solutions of Einstein's equations gravitational waves gravitational wave detectors and data analysis precision gravitational measurements quantum gravity and loop quantum gravity quantum cosmology strings and branes self gravitating systems gamma ray astronomy and cosmic rays and the history of general relativity

Dynamical and Complex Systems Shaun Bullett, T. Fearn, Frank T. Smith, 2017

Cosmological Crossroads Spiros Cotsakis, Eleftherios Papantonopoulos, 2002-11-07 This book has grown out of lectures held at a summer school on cosmology in response to an ever increasing need for an advanced textbook that addresses the needs of both postgraduate students and nonspecialist researchers from various disciplines ranging from mathematical physics to observational astrophysics Bridging the gap between standard textbook material in cosmology and the forefront of research this book also constitutes a modern source of reference for the experienced researcher in classical and quantum cosmology

Order and Chaos in Dynamical Astronomy George Contopoulos, 2004-06-16 This book is one of the first to provide a general overview of order and chaos in dynamical astronomy The progress of the theory of chaos has a profound impact on galactic dynamics It has even invaded celestial mechanics since chaos was found in the solar system which in the past was considered as a prototype of order The book provides a unifying approach to these topics from an author who has spent more than 50 years of research in the field The first part treats order and chaos in general The other two parts deal with order and chaos in galaxies and with other

applications in dynamical astronomy ranging from celestial mechanics to general relativity and cosmology *At the Frontier of Spacetime* Torsten Asselmeyer-Maluga, 2016-04-28 In this book leading theorists present new contributions and reviews addressing longstanding challenges and ongoing progress in spacetime physics In the anniversary year of Einstein's General Theory of Relativity developed 100 years ago this collection reflects the subsequent and continuing fruitful development of spacetime theories The volume is published in honour of Carl Brans on the occasion of his 80th birthday Carl H Brans who also contributes personally is a creative and independent researcher and one of the founders of the scalar tensor theory also known as Jordan Brans Dicke theory In the present book much space is devoted to scalar tensor theories Since the beginning of the 1990s Brans has worked on new models of spacetime collectively known as exotic smoothness a field largely established by him In this Festschrift one finds an outstanding and unique collection of articles about exotic smoothness Also featured are Bell's inequality and Mach's principle Personal memories and historical aspects round off the collection

Eleventh Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Gravitation And Relativistic Field Theories (In 3 Volumes) - Proceedings Of The Mg11 Meeting On General Relativity Hagen Kleinert, Robert T Jantzen, Remo Ruffini, 2008-09-04 The Marcel Grossmann Meetings are three yearly forums that meet to discuss recent advances in gravitation general relativity and relativistic field theories emphasizing their mathematical foundations physical predictions and experimental tests These meetings aim to facilitate the exchange of ideas among scientists to deepen our understanding of space time structures and to review the status of ongoing experiments and observations testing Einstein's theory of gravitation either from ground or space based experiments Since the first meeting in 1975 in Trieste Italy which was established by Remo Ruffini and Abdus Salam the range of topics presented at these meetings has gradually widened to accommodate issues of major scientific interest and attendance has grown to attract more than 900 participants from over 80 countries This proceedings volume of the eleventh meeting in the series held in Berlin in 2006 highlights and records the developments and applications of Einstein's theory in diverse areas ranging from fundamental field theories to particle physics astrophysics and cosmology made possible by unprecedented technological developments in experimental and observational techniques from space ground and underground observatories It provides a broad sampling of the current work in the field especially relativistic astrophysics including many reviews by leading figures in the research community *The Little Book of Time* Klaus Mainzer, 2013-03-14 chapter 1 Time in the Classical and Medieval Worldviews From the Beginnings to the Pre Socratic School Zeno's Time Arrow and Aristotle's Continuum 6 Time and Creation According to Saint Augustine 15 Time and Medieval Astronomy 18 20 Calendars and Clocks chapter 2 Time in the Worldview of Classical Physics 25 Absolute Time According to Newton 26 Relational Time According to Leibniz 30 Time in Classical Mechanics 31 Time in Kant's Epistemology 35 chapter 3 Relativistic Spacetime 43 Time in Special Relativity Theory 44 Time in General Relativity Theory 50 Time in Relativistic Cosmology 54 chapter 4 Time and the Quantum World 61

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Impulsive and Hybrid Dynamical Systems Wassim M. Haddad,VijaySekhar Chellaboina,Sergey G. Nersesov,2014-09-08 This book develops a general analysis and synthesis framework for impulsive and hybrid dynamical systems Such a framework is imperative for modern complex engineering systems that involve interacting continuous time and discrete time dynamics with multiple modes of operation that place stringent demands on controller design and require implementation of increasing complexity whether advanced high performance tactical fighter aircraft and space vehicles variable cycle gas turbine engines or air and ground transportation systems Impulsive and Hybrid Dynamical Systems goes beyond similar treatments by developing invariant set stability theorems partial stability Lagrange stability boundedness ultimate boundedness dissipativity theory vector dissipativity theory energy based hybrid control optimal control disturbance rejection control and robust control for nonlinear impulsive and hybrid dynamical systems A major contribution to mathematical system theory and control system theory this book is written from a system theoretic point of view with the highest standards of exposition and rigor It is intended for graduate students researchers and practitioners of engineering and applied mathematics as well as computer scientists physicists and other scientists who seek a fundamental understanding of the rich dynamical behavior of impulsive and hybrid dynamical systems

A Dynamical Systems Theory of Thermodynamics Wassim M. Haddad,2019-06-04 A brand new conceptual look at dynamical thermodynamics This book merges the two universalisms of thermodynamics and dynamical systems theory in a single compendium with the latter providing an ideal language for the former to develop a new and unique framework for dynamical thermodynamics In particular the book uses system theoretic ideas to bring coherence clarity and precision to an important and poorly understood classical area of science The dynamical systems formalism captures all of the key aspects of thermodynamics including its fundamental laws while providing a mathematically rigorous formulation for thermodynamical systems out of equilibrium by unifying the theory of mechanics with that of classical thermodynamics This book includes topics on nonequilibrium irreversible thermodynamics Boltzmann thermodynamics mass action kinetics and chemical reactions finite time thermodynamics thermodynamic critical phenomena with continuous and discontinuous phase transitions information theory continuum and stochastic thermodynamics and relativistic

thermodynamics A Dynamical Systems Theory of Thermodynamics develops a postmodern theory of thermodynamics as part of mathematical dynamical systems theory The book establishes a clear nexus between thermodynamic irreversibility the second law of thermodynamics and the arrow of time to further unify discreteness and continuity indeterminism and determinism and quantum mechanics and general relativity in the pursuit of understanding the most fundamental property of the universe the entropic arrow of time

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