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Celestial Mechanics

The aim of this book is to demonstrate to a wider audience, as well as to a more skilled audience, the many fascinating aspects of modern celestial mechanics. It sets out to do this without the use of mathematics. After giving the reader the technical tools needed for a basic understanding of the underlying physical phenomena (using only elementary mathematics), facts and figures are provided on historical events, modern discoveries and future applications. Contents are divided into major topics where the three "souls" of modern celestial mechanics (dynamical systems, Solar System and stellar systems, spaceflight dynamics) play a major role.

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Celestial Mechanics

This volume is designed as an introductory text and reference book for graduate students, researchers and practitioners in the fields of astronomy, astrodynamics, satellite systems, space sciences and astrophysics. The purpose of the book is to emphasize the similarities between celestial mechanics and astrodynamics, and to present recent advances in these two fields so that the reader can understand the inter-relations and mutual influences. The juxtaposition of celestial mechanics and astrodynamics is a unique approach that is expected to be a refreshing attempt to discuss both the mechanics of space flight and the dynamics of celestial objects. "Celestial Mechanics and Astrodynamics: Theory and Practice" also presents the main challenges and future prospects for the two fields in an elaborate, comprehensive and rigorous manner. The book presents homogenous and fluent discussions of the key problems, rendering a portrayal of recent advances in the field together with some basic concepts and essential infrastructure in orbital mechanics. The text contains introductory material followed by a gradual development of ideas interweaved to yield a coherent presentation of advanced topics.

Celestial Mechanics and Astrodynamics: Theory and Practice

This overview of classical celestial mechanics focuses the interplay with dynamical systems. Paradigmatic models introduce key concepts – order, chaos, invariant curves and cantori – followed by the investigation of dynamical systems with numerical methods.

Stability and Chaos in Celestial Mechanics

This book is intended as an introduction to the field of planetary systems at the postgraduate level. It consists of four extensive lectures on Hamiltonian dynamics, celestial mechanics, the structure of extrasolar planetary systems and the formation of planets. As such, this volume is particularly suitable for those who need to understand the substantial connections between these different topics.

Chaos and Stability in Planetary Systems

G. Beutler's *Methods of Celestial Mechanics* is a coherent textbook for students as well as an excellent reference for practitioners. The first volume gives a thorough treatment of celestial mechanics and presents all the necessary mathematical details that a professional would need. The reader will appreciate the well-written chapters on numerical solution techniques for ordinary differential equations, as well as that on orbit determination. In the second volume applications to the rotation of earth and moon, to artificial earth satellites and to the planetary system are presented. The author addresses all aspects that are of importance in high-tech applications, such as the detailed gravitational fields of all planets and the earth, the oblateness of the earth, the radiation pressure and the atmospheric drag. The concluding part of this monumental treatise explains and details state-of-the-art professional and thoroughly-tested software for celestial mechanics.

Methods of Celestial Mechanics

This monograph presents the first comprehensive and detailed explanation for the planetary rings of Saturn, Uranus, Jupiter, and Neptune, exploring their striking, recently discovered structures such as narrow ringlets, spiral waves, and chain of vortices. This authoritative book is written in an accessible and engrossing style and is supplemented with an array of informative illustrations that will be of interest to professional and amateur astronomers, physicists, and students.

Physics of Planetary Rings

The book provides the most recent advances of Celestial Mechanics, as provided by high-level scientists working in this field. It covers theoretical investigations as well as applications to concrete problems. Outstanding review papers are included in the book and they introduce the reader to leading subjects, like the variational approaches to find periodic orbits and the space debris polluting the circumterrestrial space.

Periodic, Quasi-Periodic and Chaotic Motions in Celestial Mechanics: Theory and Applications

This book on recent investigations of the dynamics of celestial bodies in the solar and extra-Solar System is based on the elaborated lecture notes of a thematic school on the topic, held as a result of cooperation between the SYRTE Department of Paris Observatory and the section of astronomy of the Vienna University. Each chapter corresponds to a lecture of several hours given by its author(s). The book therefore represents a necessary and very precious document for teachers, students, and researchers in the field. The first two chapters by A. Lemaître and H. Skokos deal with standard topics of celestial mechanics: the first one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, secular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun. The second one deals with approximative methods of describing chaos. These methods, some of them being classical, as the Lyapounov exponents, other ones being developed in the very recent past, are explained in full detail. The second one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, s- ular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun. The following three chapters by A. Cellino, by P. Robutel and J.

Dynamics of Small Solar System Bodies and Exoplanets

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Chaos and Stability in Planetary Systems

This accessible text on classical celestial mechanics, the principles governing the motions of bodies in the Solar System, provides a clear and concise treatment of virtually all of the major features of solar system dynamics. Building on advanced topics in classical mechanics such as rigid body rotation, Lagrangian mechanics and orbital perturbation theory, this text has been written for advanced undergraduates and beginning graduate students in astronomy, physics, mathematics and related fields. Specific topics covered include Keplerian orbits, the perihelion precession of the planets, tidal interactions between the Earth, Moon and Sun, the Roche radius, the stability of Lagrange points in the three-body problem and lunar motion. More than 100 exercises allow students to gauge their understanding and a solutions manual is available to instructors. Suitable for a first course in celestial mechanics, this text is the ideal bridge to higher level treatments.

An Introduction to Celestial Mechanics

The investigation of minor solar system bodies, such as comets and asteroids, using spacecraft requires an understanding of orbital motion in strongly perturbed environments. The solutions to a wide range of complex and challenging problems in this field are reviewed in this comprehensive and authoritative work.

Orbital Motion in Strongly Perturbed Environments

This is the first monograph dedicated entirely to problems of stability and chaotic behaviour in planetary systems and its subsystems. The author explores the three rapidly developing interplaying fields of resonant and chaotic dynamics of Hamiltonian systems, the dynamics of Solar system bodies, and the dynamics of exoplanetary systems. The necessary concepts, methods and tools used to study dynamical chaos (such as symplectic maps, Lyapunov exponents and timescales, chaotic diffusion rates, stability diagrams and charts) are described and then used to show in detail how the observed dynamical architectures arise in the Solar system (and its subsystems) and in exoplanetary systems. The book concentrates, in particular, on chaotic diffusion and clearing effects. The potential readership of this book includes scientists and students working in astrophysics, planetary science, celestial mechanics, and nonlinear dynamics.

Dynamical Chaos in Planetary Systems

This book on recent investigations of the dynamics of celestial bodies in the solar and extra-Solar System is based on the elaborated lecture notes of a thematic school on the topic, held as a result of cooperation between the SYRTE Department of Paris Observatory and the section of astronomy of the Vienna University. Each chapter corresponds to a lecture of several hours given by its author(s). The book therefore represents a necessary and very precious document for teachers, students, and researchers in the field. The first two chapters by A. Lemaître and H. Skokos deal with standard topics of celestial mechanics: the first one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, secular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun. The second one deals with approximative methods of describing chaos. These methods, some of them being classical, as the Lyapounov exponents, other ones being developed in the very recent past, are explained in full detail. The second one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, secular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun. The following three chapters by A. Cellino, by P. Robutel and J.

Dynamics of Small Solar System Bodies and Exoplanets

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Methods of Celestial Mechanics

In the last 20 years, researchers in the field of celestial mechanics have achieved spectacular results in their effort to understand the structure and evolution of our solar system. Modern Celestial Mechanics uses a solid theoretical basis to describe recent results on solar system dynamics, and it emphasizes the dynamics of planets and of small bodies. To grasp celestial mechanics, one must comprehend the fundamental concepts of Hamiltonian systems theory, so this volume begins with an explanation of those concepts. Celestial mechanics itself is then considered, including the secular motion of planets and small bodies and mean motion resonances. Graduate students and researchers of astronomy and astrophysics will find Modern Celestial Mechanics an essential addition to their bookshelves.

Modern Celestial Mechanics

A fascinating introduction to the basic principles of orbital mechanics It has been three hundred years since Isaac Newton first formulated laws to explain the orbits of the Moon and the planets of our solar system. In so doing he laid the groundwork for modern science's understanding of the workings of the cosmos and helped pave the way to the age of space exploration. Adventures in Celestial Mechanics offers students an enjoyable way to become acquainted with the basic principles involved in the motions of natural and human-made bodies in space. Packed with examples in which these principles are applied to everything from a falling stone to the Sun, from space probes to galaxies, this updated and revised Second Edition is an ideal introduction to celestial mechanics for students of astronomy, physics, and aerospace engineering. Other features that helped make the first edition of this book the text of choice in colleges and universities across North America include: * Lively historical accounts of important discoveries in celestial mechanics and the men and women who made them * Superb illustrations, photographs, charts, and tables * Helpful chapter-end examples and problem sets

Adventures in Celestial Mechanics

This is the most comprehensive and up-to-date book on the topic of planetary rings systems yet written. The book is written in a style and at a language level easily accessible to the interested non-expert. The authors cover the scientific significance of ring studies, the history of their discovery and characterization, the observations of Pioneer 10 at Jupiter, Pioneer 11 and Voyager 1 at Jupiter and Saturn, Voyager 2 at all four giant planets of the solar system, and Galileo at Jupiter. Each chapter includes extensive notes, references, figures and tables. A bibliography is included at the end of each chapter.

Planetary Ring Systems

The present book represents to a large extent the translation of the German "Vorlesungen über Himmelsmechanik" by C. L. Siegel. The demand for a new edition and for an English translation gave rise to the present volume which, however, goes beyond a mere translation. To take account of recent work in this field a number of sections have been added, especially in the third chapter which deals with the stability theory. Still, it has not been attempted to give a complete presentation of the subject, and the basic organization of Siegel's original book has not been altered. The emphasis lies in the development of results and analytic methods which are based on the ideas of H. Poincare, G. D. Birkhoff, A. Liapunov and, as far as Chapter I is concerned, on the work of K. F. Sundman and C. L. Siegel. In recent years the measure-theoretical aspects of mechanics have been revitalized and have led to new results which will not be discussed here. In this connection we refer, in particular, to the interesting book by V. I. Arnold and A. Avez on "Problemes Ergodiques de la Mecanique Classique"

Lectures on Celestial Mechanics

This book explores the dynamics of planetary and stellar fluid layers, including atmospheres, oceans, iron cores, and convective and radiative zones in stars, describing the different theoretical, computational and experimental methods used to study these problems in fluid mechanics, including the advantages and limitations of each method for different problems. This scientific domain is by nature interdisciplinary and multi-method, but while much effort has been devoted to solving open questions within the various fields of mechanics, applied mathematics, physics, earth sciences and astrophysics, and while much progress has been made within each domain using theoretical, numerical and experimental approaches, cross-fertilizations have remained marginal. Going beyond the state of the art, the book provides readers with a global introduction and an up-to-date overview of relevant studies, fully addressing the wide range of disciplines and methods involved. The content builds on the CISM course “Fluid mechanics of planets and stars”, held in April 2018, which was part of the research project FLUDYCO, supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program.

Fluid Mechanics of Planets and Stars

It is now a well-established tradition that every four years, at the end of winter, a group of 'celestial mechanicians' from all over the world gather in the Austrian Alps at the invitation of R. Dvorak. This time the colloquium was held at Badhofgastein from March 19 to March 25, 2000 and was devoted to the 'New Developments in the Dynamics of Planetary Systems'. The papers covered a large range of questions of current interest: theoretical questions (resonances, KAM theory, transport, ...) and questions about numerical tools (synthetic elements, indicators of chaos, ...) were particularly well represented; of course planetary theories and Near Earth Objects were also quite popular. Three special lectures were delivered in honor of deceased colleagues whom, to our dismay, we will no longer meet at the 'Austrian Colloquia'. W. Jefferys delivered the Heinrich Eichhorn lecture on 'Statistics for the Twenty-first Century Astrometry', a topic on which Heinrich Eichhorn was a specialist. A. Roy delivered a lecture honoring Victor Szehebely on 'Lifting the Darkness: Science in the Third Millenium', in which he wove anecdotes and remembrances of Victor which moved the audience very much. A. Lemaître spoke in honor of Michele Moons on 'Mechanism of Capture in External Resonance'. The end of her talk was devoted to a short and moving biography of Michele illustrated by many slides.

New Developments in the Dynamics of Planetary Systems

IAU Symposium 172 Dynamics, Ephemerides and Astrometry of the Solar System was held in Paris in July, 1995. 250 scientists from 33 countries attended the symposium; 24 invited lectures and 165 contributed papers were presented (117 of which were posters). The papers covered topics on celestial mechanics (chaos and evolution of the solar system, asteroids, theories of the motion of the planets, the moon and the natural satellites), methods (symplectic mappings and elliptic functions), astrometry (CCD observations, VLBI and radar observations), ephemerides (representation and numerical integration) and on the history of celestial mechanics.

Dynamics, Ephemerides and Astrometry of the Solar System

This brief book provides an overview of the gravitational orbital evolution of few-body systems, in particular those consisting of three bodies. The authors present the historical context that begins with the origin of the problem as defined by Newton, which was followed up by Euler, Lagrange, Laplace, and many others. Additionally, they consider the modern works from the 20th and 21st centuries that describe the development of powerful analytical methods by Poincaré and others. The development of numerical tools, including modern symplectic methods, are presented as they pertain to the identification of short-term chaos and long term integrations of the orbits of many astronomical architectures such as stellar triples, planets in binaries, and single stars that host multiple exoplanets. The book includes some of the latest discoveries from the Kepler and now K2 missions, as well as applications to exoplanets discovered via the radial velocity method. Specifically, the authors give a unique perspective in relation to the discovery of planets in binary star systems and the current search for extrasolar moons.

Three Body Dynamics and Its Applications to Exoplanets

Taking both a theoretical and observational perspective, this book is an introduction to recent developments in the field of celestial mechanics. It emphasizes the application to extended celestial bodies and devotes much attention to rotational aspects. In particular, it explains the state of art for

accurate modelling of the rotation of celestial bodies such as the Earth, the Moon, and Mercury, which involves principles related to hydrodynamics and geodesy. Comparisons between the light curves of the asteroids and their rotational state are made and spatial techniques leading to the determination of the Earth's gravitational field are explained. Also, the book provides a general overview of the collisional processes in the solar system and of the dynamics of the rings. It is addressed to graduate students and researchers in space sciences and celestial dynamics.

The Lidov-Kozai Effect - Applications in Exoplanet Research and Dynamical Astronomy

The book is written mainly to advanced graduate and post-graduate students following courses in Perturbation Theory and Celestial Mechanics. It is also intended to serve as a guide in research work and is written in a very explicit way: all perturbation theories are given with details allowing its immediate application to real problems. In addition, they are followed by examples showing all steps of their application.

Dynamics of Extended Celestial Bodies And Rings

The book "Relativity in Astrometry, Celestial Mechanics and Geodesy" represents a significant contribution to modern relativistic celestial mechanics and astrometry. In these branches of astronomy the theory of general relativity is used nowadays as an efficient practical framework for constructing accurate dynamical theories of motion of celestial bodies and discussing high-precision observations. The author develops the useful tools for this purpose and introduces the reader into the modern state of the art in these domains. More specifically, the distinctive feature of the book is the wide application of the tetrad formalism to astronomical problems. One may not agree with the author's opinion that this is the only method so far to be able to treat the relativistic astronomical problems in a consistent and satisfactory manner. (On the contrary, one may foresee in the nearest future other books on relativistic celestial mechanics and astrometry based on different approaches solving the same problems.) However, we are now at the beginning of practical relativistic astronomy and it will demand much effort to reconstruct in a relativistic manner all Newtonian conceptions of ephemeris astronomy and geodesy. In particular, this concerns the definitions of reference frames, time scales and astronomical units of measurement. This book is one of the first steps in the correct direction. V. A.

Canonical Perturbation Theories

A fascinating introduction to the basic principles of orbital mechanics It has been three hundred years since Isaac Newton first formulated laws to explain the orbits of the Moon and the planets of our solar system. In so doing he laid the groundwork for modern science's understanding of the workings of the cosmos and helped pave the way to the age of space exploration. *Adventures in Celestial Mechanics* offers students an enjoyable way to become acquainted with the basic principles involved in the motions of natural and human-made bodies in space. Packed with examples in which these principles are applied to everything from a falling stone to the Sun, from space probes to galaxies, this updated and revised Second Edition is an ideal introduction to celestial mechanics for students of astronomy, physics, and aerospace engineering. Other features that helped make the first edition of this book the text of choice in colleges and universities across North America include: * Lively historical accounts of important discoveries in celestial mechanics and the men and women who made them * Superb illustrations, photographs, charts, and tables * Helpful chapter-end examples and problem sets

Relativity in Astrometry, Celestial Mechanics and Geodesy

Introduction to the Mechanics of the Solar System introduces the reader to the mechanics of the solar system and covers topics ranging from the periods of the planets to their flattening and its effects on the orbits of satellites. Kepler's three laws of planetary motion are also discussed, along with the law of gravity; the two-body problem; and perturbations in the motions of the moon and the planets. This book is comprised of four chapters and begins with an analysis of the kinematics of a single planet, focusing on the work of Johannes Kepler, particularly his determination of the orbits of the Earth and Mars and his formulation of his three laws of planetary motion. The following chapters explore systems of ordinary differential equations; determination of orbits using Laplace's method and Gauss' method; the equations of motion and their integrals; the perturbation equations of celestial mechanics; and Lagrange's solution of the three-body problem. The notations of the Earth and the moon are also considered. This monograph is intended for astronomers and astronomy students.

Modern Celestial Mechanics

Providing a broad overview of foundational concepts, this second edition of *Fundamentals of Astronomy* covers topics ranging from spherical astronomy to reference systems, and celestial mechanics to astronomical photometry and spectroscopy. It expounds arguments of classical astronomy that provided the foundation for modern astrometry, whilst presenting the latest results of the very-long-baseline interferometry (VLBI) radio technique, optical interferometers and satellites such as Hipparcos and GAIA, and recent resolutions of the IAU and IERS regarding precession, forced and free nutation, and Earth figure and rotation. Concepts of general relativity are explored, such as the advance of Mercury's perihelion, light deflection and black holes, in addition to the physical properties, orbits, and ephemerides of planets, comets and asteroids with an extension to visual binary stars orbital reconstruction. Extrasolar planets are also discussed, with reference to radial velocity and transits measurements by ground and space telescopes. Basic concepts of astronomical photometry, spectroscopy and polarimetry are given, including the influence of the terrestrial atmosphere. Classical works, such as Hipparchus, are mentioned in order to provide a flavor of the historical development of the field. It is an ideal textbook for undergraduate and graduate students studying astronomy, astrophysics, mathematics, and engineering. Supplementary and explanatory notes provide readers with references to additional material published in other literature and scientific journals, whilst solved and unsolved exercises allow students to review their understanding of the material. Features: Provides an introductory vision of arguments from spherical astronomy to celestial mechanics to astronomical photometry and spectroscopy Presents the information at an introductory level without sacrificing scientific rigor Fully updated throughout with the latest results in the field

Adventures in Celestial Mechanics

It is now a well established tradition that every four years, at the end of winter, a group of "celestial mechanics" from all over the world gather at the "Alpen gasthof Peter Rosegger" in the Styrian Alps (Ramsau, Austria). This time the colloquium was held from March 17 to March 23, 1996 and was devoted to the Dynamical Behaviour of our Planetary System. The papers covered a large range of questions of current interest: theoretical questions (resonances, universal properties, non integrability, transport, ...) and questions about numerical tools (symplectic maps, indicators of chaos, ...) were particularly well represented; the never ending problem of the sculpting of the asteroid belt was also quite popular. You will find in the following pages a pot-pourri of what we listen to; you will miss of course the diversity of accents with which the tunes were delivered: from China, from Japan, from Brazil, from the United-States of America and from all over Europe, East and West. Let us not forget that the comet 199682 (Hyakutake) came to visit us; many an evening was spent on the deck of the Alpengasthof contemplating this celestial visitor who liked to play hide-and-seek behind the spruce trees.

Introduction to the Mechanics of the Solar System

This textbook provides details of the derivation of Lagrange's planetary equations and of the closely related Gauss's variational equations, thereby covering a sorely needed topic in existing literature. Analytical solutions can help verify the results of numerical work, giving one confidence that his or her analysis is correct. The authors—all experienced experts in astrodynamics and space missions—take on the massive derivation problem step by step in order to help readers identify and understand possible analytical solutions in their own endeavors. The stages are elementary yet rigorous; suggested student research project topics are provided. After deriving the variational equations, the authors apply them to many interesting problems, including the Earth-Moon system, the effect of an oblate planet, the perturbation of Mercury's orbit due to General Relativity, and the perturbation due to atmospheric drag. Along the way, they introduce several useful techniques such as averaging, Poincaré's method of small parameters, and variation of parameters. In the end, this textbook will help students, practicing engineers, and professionals across the fields of astrodynamics, astronomy, dynamics, physics, planetary science, spacecraft missions, and others. "An extensive, detailed, yet still easy-to-follow presentation of the field of orbital perturbations." - Prof. Hanspeter Schaub, Smead Aerospace Engineering Sciences Department, University of Colorado, Boulder "This book, based on decades of teaching experience, is an invaluable resource for aerospace engineering students and practitioners alike who need an in-depth understanding of the equations they use." - Dr. Jean Albert Kéchichian, The Aerospace Corporation, Retired "Today we look at perturbations through the lens of the modern computer. But knowing the why and the how is equally important. In this well organized and thorough compendium of equations and derivations, the authors bring some of the relevant gems from the past back into the contemporary

literature.” - Dr. David A Vallado, Senior Research Astrodynamacist, COMSPOC “The book presentation is with the thoroughness that one always sees with these authors. Their theoretical development is followed with a set of Earth orbiting and Solar System examples demonstrating the application of Lagrange’s planetary equations for systems with both conservative and nonconservative forces, some of which are not seen in orbital mechanics books.” - Prof. Kyle T. Alfriend, University Distinguished Professor, Texas A&M University

Fundamentals of Astronomy

The Alexander von Humboldt Colloquium on Celestial Mechanics (sub titled "The Stability of Planetary Systems") was held in Ramsau, Styria, in the Austrian Alps, from March the 25th to the 31st, 1984. The dedication of the meeting to Alexander von Humboldt presented participants with the challenge that the discussions during the week should reflect the spirit of that great scientist of the last century, that the very many interesting ideas presented and developed during the sessions should be interpreted in the light of a broad view of astronomy and astrophysics. The topics of the meeting ranged from astrometric questions relating to the specification of inertial reference systems, motion of planets (including minor planets) and satellites, with the recurring topic of the search for criteria of stability of the systems, resonances, periodic orbits, and to the origin of the systems. Each session began with one or more invited review papers, followed by offered contributions and discussion. Three evening discussions were held, devoted respectively to inertial systems, to numerical integration techniques, and to cosmogonic problems and ring systems. On the evening of Wednesday, March 28th, a recital of chamber music was given by Bernhard Piberauer, on the violin, and Meinhard Prinz, on the piano.

The Dynamical Behaviour of our Planetary System

An accessible exposition of gravitation theory and celestial mechanics, this classic volume was written by a distinguished Soviet astronomer. It explains with exceptional clarity the methods used by physicists in studying celestial phenomena, including perturbed motion, satellite technology, planetary rotation, and the motions of the stars. 58 figures. 1959 edition.

Introduction to Orbital Perturbations

Chaos theory plays an important role in modern physics and related sciences, but -, the most important results so far have been obtained in the study of gravitational systems applied to celestial mechanics. The present set of lectures introduces the mathematical methods used in the theory of singularities in gravitational systems, reviews modeling techniques for the simulation of close encounters and presents the state of the art about the study of diffusion of comets, wandering asteroids, meteors and planetary ring particles. The book will be of use to researchers and graduate students alike.

The Stability of Planetary Systems

This set of lectures collects surveys of open problems in celestial dynamics and dynamical astronomy applied to solar, extra-solar and galactic systems. The discovery and thus the possibility to study many new extra-solar planetary systems have spurred new developments in the field and enabled the testing and enlargement of the domains of validity of theoretical predictions through the Nekhoroshev theorem.

An Elementary Survey of Celestial Mechanics

In their approach to Earth dynamics the authors consider the fundamentals of Jacobi Dynamics (1987, Reidel) for two reasons. First, because satellite observations have proved that the Earth does not stay in hydrostatic equilibrium, which is the physical basis of today's treatment of geodynamics. And secondly, because satellite data have revealed a relationship between gravitational moments and the potential of the Earth's outer force field (potential energy), which is the basis of Jacobi Dynamics. This has also enabled the authors to come back to the derivation of the classical virial theorem and, after introducing the volumetric forces and moments, to obtain a generalized virial theorem in the form of Jacobi's equation. Thus a physical explanation and rigorous solution was found for the famous Jacobi's equation, where the measure of the matter interaction is the energy. The main dynamical effects which become understandable by that solution can be summarized as follows: • the kinetic energy of oscillation of the interacting particles which explains the physical meaning and nature of the gravitation forces; • separation of the shell's rotation of a self-gravitating body with respect to the mass density; difference in angular velocities of the shell rotation; • continuity in changing the potential of the

outer gravitational force field together with changes in density distribution of the interacting masses (volumetric center of masses); • the nature of the precession of the Earth, the Moon and satellites; the nature of the rotating body's magnetic field and the generation of the planet's electromagnetic field. As a final result, the creation of the bodies in the Solar System having different orbits was discussed. This result is based on the discovery that all the averaged orbital velocities of the bodies in the Solar System and the Sun itself are equal to the first cosmic velocities of their proto-parents during the evolution of their redistributed mass density. Audience The work is a logical continuation of the book Jacobi Dynamics and is intended for researchers, teachers and students engaged in theoretical and experimental research in various branches of astronomy (astrophysics, celestial mechanics and stellar dynamics and radiophysics), geophysics (physics and dynamics of the Earth's body, atmosphere and oceans), planetology and cosmogony, and for students of celestial, statistical, quantum and relativistic mechanics and hydrodynamics.

Singularities in Gravitational Systems

Topics in Gravitational Dynamics