black hole definition

black hole definition refers to a region in space where the gravitational pull is so strong that nothing, not even light, can escape from it. This phenomenon occurs when a massive star collapses under its own gravity at the end of its life cycle. Black holes are among the most mysterious and fascinating objects in the universe, captivating scientists and astronomers for decades. Understanding the black hole definition involves exploring concepts like event horizons, singularities, and the effects of intense gravity on space-time. This article provides a comprehensive overview of black holes, including their formation, types, characteristics, and significance in astrophysics. Additionally, the article discusses observational methods and the role black holes play in the evolution of galaxies. The following sections will guide readers through the essential aspects of black holes, offering a detailed and SEO-optimized explanation.

What Is a Black Hole?

A black hole is an astronomical object with a gravitational field so intense that nothing, including light, can escape from it. The black hole definition emphasizes its nature as a region in space where gravity has overcome all other forces. The boundary surrounding a black hole is known as the event horizon, marking the point beyond which escape becomes impossible.

Event Horizon

The event horizon is a critical concept in black hole physics. It represents the “point of no return” around the black hole. Once an object crosses this boundary, it is inevitably pulled into the black hole’s singularity. The size of the event horizon depends on the black hole’s mass and is often described by the Schwarzschild radius.

Singularity

At the center of a black hole lies the singularity, a point where matter is thought to be infinitely dense, and the laws of physics as currently understood cease to function normally. The singularity is the core that creates the black hole’s powerful gravitational pull.

Formation of Black Holes

Black holes form from the remnants of massive stars that have ended their life cycles. The process involves the collapse of a star’s core under extreme gravitational forces. This section explains the stages leading to the creation of a black hole and the conditions required.

Stellar Collapse

When a star with sufficient mass exhausts its nuclear fuel, it can no longer support itself against gravitational collapse. The core contracts, and depending on the original mass, it may become a neutron star or continue collapsing into a black hole.

Mass Thresholds

Stars with initial masses greater than approximately 20 to 25 times that of the Sun are candidates for black hole formation. Below this threshold, the core may stabilize as a neutron star. The exact mass limits depend on factors such as metallicity and rotation.

Other Formation Mechanisms

Besides stellar collapse, black holes can also form through other astrophysical processes:

- Primordial black holes, which may have formed shortly after the Big Bang.
- Black hole mergers, where two black holes collide to form a larger black hole.
- Accretion-induced collapse in binary star systems.

Types of Black Holes

Black holes are classified into several types based on their mass, origin, and physical properties. Understanding these categories helps clarify the black hole definition and its various manifestations in the cosmos.

Stellar Black Holes

These black holes originate from the collapse of massive stars. They typically have masses ranging from about 3 to 20 solar masses. Stellar black holes are the most common type observed within our galaxy.

Supermassive Black Holes

Located at the centers of most galaxies, supermassive black holes have masses that range from millions to billions of times that of the Sun. Their formation is less understood but is believed to involve the merging of smaller black holes and the accretion of matter over cosmic time.

Intermediate Black Holes

These black holes have masses between stellar and supermassive black holes, typically in the range of hundreds to thousands of solar masses. Their existence is hypothesized but difficult to confirm observationally.

Micro Black Holes

Also known as quantum or miniature black holes, these hypothetical objects would have very small masses and sizes, possibly formed in high-energy processes like those in the early universe or particle accelerators.

Key Characteristics of Black Holes

The black hole definition includes several defining attributes that distinguish these objects from other celestial bodies. These characteristics are essential for understanding their behavior and effects on surrounding matter and space-time.

Gravitational Pull

Black holes exert an extremely strong gravitational force, capable of bending light and warping space-time. This force is the result of the black hole’s mass concentrated in an infinitely small volume.

Accretion Disk

Material falling toward a black hole often forms a rotating disk called an accretion disk. As matter spirals inward, it heats up and emits X-rays and other radiation, which can be detected by telescopes.

Hawking Radiation

Proposed by physicist Stephen Hawking, this theoretical radiation suggests that black holes can emit particles and gradually lose mass over time. Although not yet observed, Hawking radiation has important implications for black hole thermodynamics.

Time Dilation

The intense gravity near a black hole causes time to pass more slowly relative to an outside observer. This effect is a consequence of Einstein’s theory of general relativity and has been confirmed through various experiments.

Observing Black Holes

Despite their invisible nature, black holes can be detected and studied through indirect methods. Observational astronomy has advanced to provide valuable insights into black hole properties and their interactions with the environment.

X-ray Emissions

Accretion disks around black holes emit high-energy X-rays, which can be observed with space-based telescopes. These emissions help identify the presence of black holes and estimate their masses.

Gravitational Waves

The collision and merger of black holes produce ripples in space-time known as gravitational waves. Detected by observatories like LIGO and Virgo, these waves provide direct evidence of black hole interactions.

Event Horizon Imaging

The Event Horizon Telescope collaboration achieved the first direct image of a black hole’s event horizon in the galaxy M87. This milestone confirmed theoretical predictions and opened new avenues for black hole research.

The Role of Black Holes in the Universe

Black holes play a significant role in the structure and evolution of the universe. Their influence extends from galactic dynamics to fundamental physics, making them key objects of study in modern astronomy.

Galactic Centers

Supermassive black holes reside at the centers of most galaxies, including the Milky Way. They affect star formation, galaxy shape, and the behavior of surrounding matter through powerful gravitational and energetic processes.

Cosmic Evolution

Black holes contribute to the growth and transformation of galaxies over billions of years. Their mergers and accretion activities release enormous energy, impacting the interstellar medium and large-scale cosmic structures.

Testing Physics

Black holes provide natural laboratories for testing theories of gravity, quantum mechanics, and the behavior of matter under extreme conditions. Research on black holes continues to challenge and refine our understanding of fundamental physics.

Frequently Asked Questions

What is the definition of a black hole?

A black hole is a region in space where the gravitational pull is so strong that nothing, not even light, can escape from it.

How is a black hole formed?

A black hole is formed when a massive star collapses under its own gravity at the end of its life cycle, compressing its mass into an extremely small point called a singularity.

What is the event horizon of a black hole?

The event horizon is the boundary surrounding a black hole beyond which nothing can escape the gravitational pull, effectively marking the point of no return.

Can black holes be observed directly?

Black holes cannot be observed directly because they emit no light, but their presence is inferred by observing the behavior of nearby matter and gravitational effects.

What is the singularity in a black hole?

The singularity is the core of a black hole where matter is thought to be infinitely dense and gravitational forces become infinitely strong.

Are black holes the same as wormholes?

No, black holes are regions of intense gravity, while wormholes are theoretical passages through spacetime that could create shortcuts between distant points.

What role do black holes play in the universe?

Black holes influence galaxy formation, regulate star growth, and help scientists understand gravity, quantum mechanics, and the nature of spacetime.

How do scientists detect black holes?

Scientists detect black holes by observing X-ray emissions from accretion disks, gravitational waves from black hole mergers, and the effects on nearby stars and gas.

Can anything escape from a black hole?

According to current physics, nothing can escape from within a black hole's event horizon, not even light, making it invisible to direct observation.

Additional Resources

1. *Black Holes: The Reith Lectures*
This book by Stephen Hawking offers an accessible introduction to the nature and significance of black holes. It explores the fundamental principles of black holes, including their formation, properties, and the paradoxes they present in physics. Hawking explains complex concepts in a clear, engaging manner suitable for both students and general readers.

2. *The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics*
Authored by Leonard Susskind, this book details the scientific debate over the nature of black holes and information loss. It delves into the conflict between classical and quantum physics perspectives, explaining the significance of black hole definitions in modern theoretical physics. The narrative combines personal memoir with deep scientific insight.

3. *Black Holes and Time Warps: Einstein's Outrageous Legacy*
Written by Kip S. Thorne, this book covers the discovery and theoretical understanding of black holes and their implications for time travel and the fabric of spacetime. Thorne presents the history and science behind black holes, making complex topics accessible through vivid storytelling. It’s a comprehensive overview of black hole physics grounded in Einstein’s theories.

4. *Gravity's Fatal Attraction: Black Holes in the Universe*
This work by Mitchell Begelman and Martin Rees explores the astrophysical phenomena related to black holes. It discusses how black holes form, their role in galaxy evolution, and the observational evidence supporting their existence. The book balances technical detail with readability for an enthusiastic audience.

5. *Black Holes: An Introduction*
This textbook by Derek J. Raine and Edwin George Thomas provides a thorough introduction to the physics of black holes. It covers the mathematical definitions, event horizons, singularities, and thermodynamics associated with black holes. Ideal for students beginning their study of black hole astrophysics, it combines theory with practical examples.

6. *Black Hole Blues and Other Songs from Outer Space*
Janna Levin narrates the story of the search for gravitational waves and how black holes play a crucial role in this quest. The book illuminates the scientific and human challenges involved in detecting signals from black hole collisions. It offers insight into the evolving definition of black holes as understood through experimental evidence.

7. *Black Holes and Relativity: The Ultimate Guide*
This book provides a detailed explanation of how black holes fit within Einstein's theory of general relativity. It discusses the Schwarzschild radius, event horizons, and the warping of spacetime caused by massive objects. Readers gain a clear understanding of the theoretical underpinnings that define black holes.

8. *Introduction to Black Hole Physics*
Hans J. A. R. Müller's book serves as a primer on the fundamental concepts defining black holes, including their metrics, horizons, and thermodynamic properties. It bridges classical and quantum perspectives, offering a concise yet comprehensive overview suitable for advanced undergraduates and graduate students.

9. *The Event Horizon: Exploring the Edge of Black Holes*
This book focuses specifically on the event horizon, the boundary that defines a black hole. It examines the physical and theoretical significance of this region, including how it relates to information theory and Hawking radiation. The text is designed to clarify one of the most crucial aspects of black hole definitions for readers at all levels.

Black Hole Definition

black hole definition: Encyclopedia of Astrobiology Muriel Gargaud, William M. Irvine, Ricardo Amils, Philippe Claeys, Henderson James Cleaves, Maryvonne Gerin, Daniel Rouan, Tilman Spohn, Stéphane Tirard, Michel Viso, 2023-07-27 Now in its third edition the Encyclopedia of Astrobiology serves as the key to a common understanding in the extremely interdisciplinary community of astrobiologists. Each new or experienced researcher and graduate student in adjacent fields of astrobiology will appreciate this reference work in the quest to understand the big picture. The carefully selected group of active researchers contributing to this work are aiming to give a comprehensive international perspective on and to accelerate the interdisciplinary advance of astrobiology. The interdisciplinary field of astrobiology constitutes a joint arena where provocative discoveries are coalescing concerning, e.g. the prevalence of exoplanets, the diversity and hardiness

of life, and its chances for emergence. Biologists, astrophysicists, (bio)-chemists, geoscientists and space scientists share this exciting mission of revealing the origin and commonality of life in the Universe. With its overview articles and its definitions the Encyclopedia of Astrobiology not only provides a common language and understanding for the members of the different disciplines but also serves for educating a new generation of young astrobiologists who are no longer separated by the jargon of individual scientific disciplines. This new edition offers ~170 new entries. More than half of the existing entries were updated, expanded or supplemented with figures supporting the understanding of the text. Especially in the fields of astrochemistry and terrestrial extremophiles but also in exoplanets and space sciences in general there is a huge body of new results that have been taken into account in this new edition. Because the entries in the Encyclopedia are in alphabetical order without regard for scientific field, this edition includes a section “Astrobiology by Discipline” which lists the entries by scientific field and subfield. This should be particularly helpful to those enquiring about astrobiology, as it illustrates the broad and detailed nature of the field.

black hole definition: General Relativity and the Einstein Equations Yvonne Choquet-Bruhat, 2009 General Relativity has passed all experimental and observational tests to model the motion of isolated bodies with strong gravitational fields, though the mathematical and numerical study of these motions is still in its infancy. It is believed that General Relativity models our cosmos, with a manifold of dimensions possibly greater than four and debatable topology opening a vast field of investigation for mathematicians and physicists alike. Remarkable conjectures have been proposed, many results have been obtained but many fundamental questions remain open. In this monograph, aimed at researchers in mathematics and physics, the author overviews the basic ideas in General Relativity, introduces the necessary mathematics and discusses some of the key open questions in the field.

black hole definition: Philosophy of Astrophysics Nora Mills Boyd, Siska De Baerdemaeker, Kevin Heng, Vera Matarese, 2023-06-28 This is an open access book. This book, the first edited collection of its kind, explores the recent emergence of philosophical research in astrophysics. It assembles a variety of original essays from scholars who are currently shaping this field, and it combines insightful overviews of the current state of play with novel, significant contributions. It therefore provides an ideal source for understanding the current debates in philosophy of astrophysics, and it offers new ideas for future cutting-edge research. The selection of essays offered in this book addresses methodological and metaphysical questions that target a wide range of topics, including dark matter, black holes, astrophysical observations and modelling. The book serves as the first standard resource in philosophy of astrophysics for all scholars who work in the field and want to expand or deepen their knowledge, but it also provides an accessible guide for all those philosophers and scientists who are interested in getting a first, basic understanding of the main issues in philosophy of astrophysics.

black hole definition: The Physics of the Early Universe Eleftherios Papantonopoulos, 2005-01-07 The Physics of the Early Universe is an edited and expanded version of the lectures given at a recent summer school of the same name. Its aim is to present an advanced multi-authored textbook that meets the needs of both postgraduate students and young researchers interested in, or already working on, problems in cosmology and general relativity, with emphasis on the early universe. A particularly strong feature of the present work is the constructive-critical approach to the present mainstream theories, the careful assessment of some alternative approaches, and the overall balance between theoretical and observational considerations. As such, this book will also benefit experienced scientists and nonspecialists from related areas of research.

black hole definition: Understanding the properties and behavior of the COSMOS Don Hainesworth, 2011

black hole definition: Introduction to 3+1 Numerical Relativity Miguel Alcubierre, 2008-04-10 This book is a self-contained introduction to the field of numerical relativity. Starting from basic general relativity, it introduces all the concepts and tools necessary for the fully relativistic simulation of astrophysical systems with strong and dynamical gravitational fields.

black hole definition: “Progress in Physics,” vol. 21, no. 1, 2025 Dmitri Rabounski, Pierre Millette, Andreas Ries, Florentin Smarandache, Larissa Borissova, Ebenezer Chifu, This issue of “Progress in Physics” features a collection of articles on theoretical and experimental physics, as well as related topics in mathematics. The main theme appears to be a re-evaluation of fundamental concepts in physics, with several papers discussing alternatives to established theories. One article proposes correct solutions for rotating and charged black holes, suggesting they have an oblate spheroid shape rather than being perfectly spherical. Another paper presents a new cosmology framework based on a Krogh gravity theory that predicts the Hubble redshift curve without needing concepts like dark energy or expansion. Other topics include an analysis of fundamental forces from numerical relations, a re-examination of quantum mechanics in the microworld, and the feasibility of non-quantum teleportation.

black hole definition: A Study of Black Hole Attack Solutions Iraj Sadegh Amiri, Elahe Fazeldehkordi, Oluwatobi Ayodeji Akanbi, 2015-11-03 Mobile Ad Hoc Networks (MANETs) are a popular form of network for data transfer due to the fact that they are dynamic, require no fixed infrastructure, and are scalable. However, MANETs are particularly susceptible to several different types of widely perpetrated cyberattack. One of the most common hacks aimed at MANETs is the Black Hole attack, in which a particular node within the network displays itself as having the shortest path for the node whose packets it wants to intercept. Once the packets are drawn to the Black Hole, they are then dropped instead of relayed, and the communication of the MANET is thereby disrupted, without knowledge of the other nodes in the network. Due to the sophistication of the Black Hole attack, there has been a lot of research conducted on how to detect it and prevent it. The authors of this short format title provide their research results on providing an effective solution to Black Hole attacks, including introduction of new MANET routing protocols that can be implemented in order to improve detection accuracy and network parameters such as total dropped packets, end-to-end delay, packet delivery ratio, and routing request overhead. - Elaborates on the basics of wireless networks, MANETs - Explains the significance behind the need of wireless networks and MANET security - Understand MANET routing protocols, namely the ADOV method

black hole definition: Introduction to Superstrings and M-Theory Michio Kaku, 2012-12-06 Superstrings - provocative, controversial, possibly untestable, but unarguably one of the most interesting and active areas of research in current physics. Called by some, the theory of everything, superstrings may solve a problem which has eluded physicists for the past 50 years - the final unification of the two great theories of the twentieth century, general relativity and quantum field theory. Now, here is a course-tested comprehensive introductory graduate text on superstrings which stresses the most current areas of interest, not covered in other presentation, including: - string field theory - multi loops - Teichmueller spaces - conformal field theory - four-dimensional strings The book begins with a simple discussion of point particle theory, and uses the Feynman path integral technique to unify the presentation of superstrings. Prerequisites are an aquaintance with quantum mechanics and relativity. This second edition has been revised and updated throughout.

black hole definition: Complexity, Entropy And The Physics Of Information Wojciech H. Zurek, 2018-03-08 This book has emerged from a meeting held during the week of May 29 to June 2, 1989, at St. John’s College in Santa Fe under the auspices of the Santa Fe Institute. The (approximately 40) official participants as well as equally numerous “groupies” were enticed to Santa Fe by the above “manifesto.” The book—like the “Complexity, Entropy and the Physics of Information” meeting explores not only the connections between quantum and classical physics, information and its transfer, computation, and their significance for the formulation of physical theories, but it also considers the origins and evolution of the information-processing entities, their complexity, and the manner in which they analyze their perceptions to form models of the Universe. As a result, the contributions can be divided into distinct sections only with some difficulty. Indeed, I regard this degree of overlapping as a measure of the success of the meeting. It signifies consensus about the important questions and on the anticipated answers: they presumably lie somewhere in the “border territory,” where information, physics, complexity, quantum, and computation all meet.

black hole definition: *Astrophysics: A Formula Handbook* N.B. Singh, Astrophysics: A Formula Handbook is an essential guide that condenses the vast field of astrophysics into a concise and accessible resource. Designed for students, astronomers, and enthusiasts, this handbook provides a quick reference for key equations and formulas integral to understanding celestial phenomena. Covering topics from gravitational dynamics and stellar structure to cosmological principles, the book facilitates a deeper comprehension of the universe's fundamental principles. With clarity and precision, it serves as an invaluable tool for those navigating the complex equations that govern the mysteries of astrophysics, offering a handy reference for anyone delving into the wonders of the cosmos.

black hole definition: *An Introduction to the Relativistic Theory of Gravitation* Petr Hajicek, 2008-08-26 The contemporary theoretical physics consists, by and large, of two independent parts. The rst is the quantum theory describing the micro-world of elementary p- ticles, the second is the theory of gravity that concerns properties of macroscopic systems such as stars, galaxies, and the universe. The relativistic theory of gr- itation which is known as general relativity was created, at the beginning of the last century, by more or less a single man from pure idea combinations and bold guessing. The task was to “marry” the theory of gravity with the theory of special relativity. The rst attempts were aimed at considering the gravitational potential as a eld in Minkowski space–time. All those attempts failed; it took 10 years until Einstein nally solved the problem. The dif culty was that the old theory of gravity as well as the young theory of special relativity had to be modi ed. The next 50 years were dif cult for this theory because its experimental basis remained weak and its complicated mathematical structure was not well understood. However, in the subsequent period this theory ourished. Thanks to improvements in the te- nology and to the big progress in the methods of astronomical observations, the amount of observable facts to which general relativity is applicable was consid- ably enlarged. This is why general relativity is, today, one of the best experimentally tested theories while many competing theories could be disproved. Also the conc- tual and mathematical fundamentals are better understood now.

black hole definition: Geometric Relativity Dan A. Lee, 2021-12-20 Many problems in general relativity are essentially geometric in nature, in the sense that they can be understood in terms of Riemannian geometry and partial differential equations. This book is centered around the study of mass in general relativity using the techniques of geometric analysis. Specifically, it provides a comprehensive treatment of the positive mass theorem and closely related results, such as the Penrose inequality, drawing on a variety of tools used in this area of research, including minimal hypersurfaces, conformal geometry, inverse mean curvature flow, conformal flow, spinors and the Dirac operator, marginally outer trapped surfaces, and density theorems. This is the first time these topics have been gathered into a single place and presented with an advanced graduate student audience in mind; several dozen exercises are also included. The main prerequisite for this book is a working understanding of Riemannian geometry and basic knowledge of elliptic linear partial differential equations, with only minimal prior knowledge of physics required. The second part of the book includes a short crash course on general relativity, which provides background for the study of asymptotically flat initial data sets satisfying the dominant energy condition.

black hole definition: The Universe Naresh Dadhich, Ajit Kembhavi, 2012-12-06 It is with great joy that we present a collection of essays written in honour of Jayant Vishnu Narlikar, who completed 60 years of age on July 19, 1998, by his friends and colleagues, including several of his for mer students. Jayant has had a long research career in astrophysics and cosmology, which he began at Cambridge in 1960, as a student of Sir Fred Hoyle. He started his work with a big bang, expounding on the steady state theory of the Universe and creating a new theory of gravity inspired by Mach's principle. He also worked on action-at-a-distance electrodynamics, inspired by the explorations of Wheeler, Feynman and Hogarth in that direction. This body of work established Jayant's rep utation as a bold and imaginative physicist who was ever willing to take a fresh look at fundamental issues, undeterred by conventional wis dom. This trait, undoubtedly inherited from his teacher and mentor, has always remained with Jayant. It is now most evident in his untir ing efforts

to understand anomalies in quasar astronomy, and to develop the quasi-steady state cosmology, along with a group of highly distin guished astronomers including Halton Arp, Geoffrey Burbidge and Fred Hoyle. In spite of all this iconoclastic activity, Jayant remains a part of the mainstream; he appreciates as well as encourages good work along conventional lines by his students and colleagues. This is clear from the range of essays included in this volume, and the variety and distribution of the essayists.

black hole definition: Numerical Relativity Masaru Shibata, 2015-11-05 This book is composed of two parts: First part describes basics in numerical relativity, that is, the formulations and methods for a solution of Einstein's equation and general relativistic matter field equations. This part will be helpful for beginners of numerical relativity who would like to understand the content of numerical relativity and its background. The second part focuses on the application of numerical relativity. A wide variety of scientific numerical results are introduced focusing in particular on the merger of binary neutron stars and black holes.--

black hole definition: Proceedings of the Cornelius Lanczos International Centenary Conference J. David Brown, 1994-01-01

black hole definition: 1st Karl Schwarzschild Meeting on Gravitational Physics Piero Nicolini, Matthias Kaminski, Jonas Mureika, Marcus Bleicher, 2015-10-28 These proceedings collect the selected contributions of participants of the First Karl Schwarzschild Meeting on Gravitational Physics, held in Frankfurt, Germany to celebrate the 140th anniversary of Schwarzschild's birth. They are grouped into 4 main themes: I. The Life and Work of Karl Schwarzschild; II. Black Holes in Classical General Relativity, Numerical Relativity, Astrophysics, Cosmology, and Alternative Theories of Gravity; III. Black Holes in Quantum Gravity and String Theory; IV. Other Topics in Contemporary Gravitation. Inspired by the foundational principle ``By acknowledging the past, we open a route to the future, the week-long meeting, envisioned as a forum for exchange between scientists from all locations and levels of education, drew participants from 15 countries across 4 continents. In addition to plenary talks from leading researchers, a special focus on young talent was provided, a feature underlined by the Springer Prize for the best student and junior presentations.

black hole definition: *Philosophical Essays* Nicolae Sfetcu, 1900 A collection of personal essays in philosophy of science (physics, especially gravity), philosophy of information and communication technology, current social issues (emotional intelligence, COVID-19 pandemic, eugenics, intelligence), philosophy of art, and logic and philosophy of language. The distinction between falsification and refutation in the demarcation problem of Karl Popper Imre Lakatos - Heuristics and methodological tolerance Isaac Newton on the action at a distance in gravity: With or without God? Causal Loops in Time Travel The singularities as ontological limits of the general relativity Epistemology of Experimental Gravity - Scientific Rationality Philosophy of Blockchain Technology - Ontologies Big Data Ethics in Research Emotions and Emotional Intelligence in Organizations COVID-19 Pandemic - Philosophical Approaches Evolution and Ethics of Eugenics Epistemology of Intelligence Agencies Solaris, directed by Andrei Tarkovsky - Psychological and philosophical aspects Causal theories of reference for proper names CONTENTS: The distinction between falsification and refutation in the demarcation problem of Karl Popper - - - Abstract - - - Introduction - - - 1 The demarcation problem - - - 2 Pseudoscience - - - 3 Falsifiability - - - 4 Falsification and refutation - - - 5 Extension of falsifiability - - - 6 Criticism of falsifiability - - - 7 Support of falsifiability - - - 8 The current trend - - - Conclusions - - - Bibliography - - - Notes Imre Lakatos - Heuristics and methodological tolerance - - - Rational reconstruction of science through research programmes - - - Dogmatic Falsificationism - - - Justificationism - - - Bibliography Isaac Newton vs. Robert Hooke on the law of universal gravitation - - - Abstract - - - Introduction - - - Robert Hooke's contribution to the law of universal gravitation - - - Isaac Newton's contribution to the law of universal gravitation - - - Robert Hooke's claim of his priority on the law of universal gravitation - - - Newton's defense - - - The controversy in the opinion of other contemporary scientists - - - What the supporters of Isaac Newton say - - - What the supporters of Robert Hooke say - - - Conclusions - - - Bibliography - - - Notes Isaac Newton on the action at a distance in gravity: With or

without God? - - - Abstract - - - Introduction - - - Principia - - - Correspondence with Richard Bentley - - - Queries in Opticks - - - Conclusions - - - Bibliography Causal Loops in Time Travel - - - Abstract - - - Introduction - - - History of the concept of time travel - - - Grandfather paradox - - - The philosophy of time travel - - - Causal loops - - - Conclusions - - - Bibliography - - - Notes The singularities as ontological limits of the general relativity - - - Abstract - - - Introduction - - - - - - Classical Theory and Special Relativity - - - - - - General Relativity (GR) - - - 1 Ontology of General Relativity - - - 2 Singularities - - - - - - Black Holes - - - - - - - - - Event Horizon - - - - - - Big Bang - - - - - - Are there Singularities? - - - 3 Ontology of Singularities - - - - - - Ontology of black holes - - - - - - The hole argument - - - - - - There are no singularities - - - Conclusions - - - Notes - - - Bibliography Epistemology of Experimental Gravity - Scientific Rationality - - - Introduction - - - - - - Gravity - - - - - - Gravitational tests - - - - - - Methodology of Lakatos - Scientific rationality - - - - - - The natural extension of the Lakatos methodology - - - - - - - - - Bifurcated programs - - - - - - - - - Unifying programs - - - 1. Newtonian gravity - - - - - - 1.1 Heuristics of Newtonian gravity - - - - - - 1.2 Proliferation of post-Newtonian theories - - - - - - 1.3 Tests of post-Newtonian theories - - - - - - - - - 1.3.1 Newton's proposed tests - - - - - - - - - 1.3.2 Tests of post-Newtonian theories - - - - - - 1.4 Newtonian gravity anomalies - - - - - - 1.5 Saturation point in Newtonian gravity - - - 2. 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- - - - 2.1.4 Petrides' model of traits - - - - - - 2.2 Emotional intelligence in research and education - - - - - - 2.3 The philosophy of emotional intelligence - - - - - - - - - 2.3.1 Emotional intelligence in Eastern philosophy - - - 3. Emotional intelligence in organizations - - - - - - 3.1 Emotional labor - - - - - - 3.2 The philosophy of emotional intelligence in organizations - - - - - - 3.3 Critique of emotional intelligence in organizations - - - - - - 3.4 Ethics of emotional intelligence in organizations - - - - - - Conclusions - - - Bibliography COVID-19 Pandemic - Philosophical Approaches - - - Abstract - - - Introduction - - - 1 Viruses - - - - - - 1.1 Ontology - - - 2 Pandemics - - - - - - 2.1 Social dimensions - - - - - - 2.2 Ethics - - - 3 COVID-19 - - - - - - 3.1 Biopolitics - - - - - - 3.2 Neocommunism - - - - - - 3.3 Desocialising - - - 4 Forecasting - - - Bibliography Evolution and Ethics of Eugenics - - - Abstract - - - Introduction - - - New Eugenics - - - The Future of Eugenics - - - Conclusions - - - Bibliography Epistemology of Intelligence Agencies - - - Abstract - - - 1 Introduction - - - - - - 1.1. History - - - 2. Intelligence activity - - - - - - 2.1. Organizations - - - - - - 2.2. Intelligence cycle - - - - - - 2.3 Intelligence gathering - - - - - - 2.4. Intelligence analysis - - - - - - 2.5. Counterintelligence - - - - - - 2.6. Epistemic communities - - - 3. Ontology - - - 4. Epistemology - - - - - - 4.1. The tacit knowledge (Polanyi) - - - 5. Methodologies - - - 6. Analogies with other disciplines - - - - - - 6.1. Science - - - - - - 6.2. Archeology - - - - - - 6.3. Business - - - - - - 6.4. Medicine - - - 7. Conclusions - - - Bibliography Solaris, directed by Andrei Tarkovsky - Psychological and philosophical aspects - - - Abstract - - - Introduction - - - 1 Cinema technique - - - 2 Psychological Aspects - - - 3 Philosophical aspects - - - Conclusions - - - Bibliography - - - Notes Causal theories of reference for proper names - - - Abstract - - - Introduction - - - 1. The causal theory of reference - - - 2. Saul Kripke - - - 3. Gareth Evans - - - 4. Michael Devitt - - - 5. Blockchain and the causal tree of reference - - - Conclusions - - - Bibliografie About the author - - - Nicolae Sfetcu - - - - - - Contact Publishing House - - - MultiMedia Publishing

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