Abstract Booklet

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(Invited) The ghost of Galileo and the Spirit of Copenhagen

John Heilbron

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The title refers to two examples of the appropriation of scientific ideas and the prestige of science to interests far from the original context and content of the ideas. The earlier episode has the merit of a puzzle; the later, of the familiar. The Ghost of Galileo refers to a painting made at Oxford during the first years of the English Civil War. It contains two sitters, a globe, a telescope, and a veiled reference to Galileo in the form of an impressionistic drawing of the frontispiece to his *Dialogue on the two chief world systems*. The first part of my talk offers a guess at the meaning of this hieroglyph to those who made and viewed the painting. The second part deals with extrapolations from the uncertainty principle and complementarity to questions of philosophy, psychology, and politics. These extrapolations provide parallels to my construal of the Galilean painting and perhaps add to its plausibility. In any case, both episodes, the Ghost and the Spirit, exemplify the adaptability of images and symbols taken from science to domains in which many scientists find themselves uncomfortable. Galileo's image has been exploited by advocates of freedom of thought and makers of salami; Heisenberg's uncertainty by defenders of religion and enemies of Marxism.

(Invited) To G or not to G: J H Poynting and the gravitational constant in the 19th century

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In 1891 John Henry Poynting announced the results of his experiment with a common balance to determine the mean density of the Earth. The experiment was highly regarded by his contemporaries, even though it was rapidly superseded by Boys' improved torsion balance method. Poynting himself was proud of the precision of his measurement, though he assigned no numerical value to it, but portrayed it through an image: "Imagine a balance large enough to contain on one pan the whole population of the British Islands, and that all the population were placed there but one medium-sized boy. Then the increase in weight which had to be measured was equivalent to measuring the increase due to putting that boy on with the rest. The accuracy of measurement was equivalent to observing from the increase in weight whether or not he had taken off one of his boots before stepping on to the pan."

Although Poynting also gave the corresponding value of the gravitational constant, he persistently refused to cast this as his aim. Despite his detailed analysis, in his subsequent Adams Prize Essay of 1894, of the improvements in experimental method that were enabling ever more precise measurement, he similarly interpreted all previous measurements as of the mean density of the earth. His reservations about *G* alert us to the mathematical, physical and metaphysical interpretative work involved in the shift that had occurred during the previous 100 years, from expressing the laws of physics as ratio equations to expressing them as functional relationships between algebraic symbols that denoted the numerical values of physical quantities.

This paper will explore some of the questions raised by Poynting's reservations about *G* as a valid physical construct.

[1] J.H. Poynting, *A history of the methods of weighing the Earth*, Birmingham Phil. Soc. Proc. **9** (1893) 1–23

(Invited) The Marie Curie effect

Patricia Fara

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Initiatives such as the Athena Swan project frequently stress the importance of role models for women, but Marie Skłodowska Curie remains the only renowned female scientist, even though her relevance for modern students has diminished. She is represented by several stereotyped versions – the scientific martyr, the unique genius, the saintly benefactor of humanity – that are unrealistic and reinforce the notion that female scientists are abnormal. Her unique fame has eclipsed recognition not only of her contemporaries but also of her successors, most notably Dorothy Hodgkin, Britain's unsung Nobel laureate. This paper presents two other X-ray pioneers during World War One, Helena Gleichen and Edith Stoney, before exploring the career of Skłodowska Curie's close friend, the award-winning physicist Hertha Ayrton.

(Invited) Political inopportunism and friendly disservice: on the premature Nobel Prize to Otto Hahn and the missed Nobel Prize to Lise Meitner

Karl Grandin

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In 1944 the Nobel committee for chemistry unanimously proposed Otto Hahn for the Nobel Prize in chemistry. But the Academy of Sciences in Stockholm decided to postpone the award. In 1944 there were however no nominations for Lise Meitner. Next year, in 1945, Meitner received one nomination (in physics), whereas Hahn received two nominations in physics and one in chemistry. With just one nomination Meitner can still be considered to have been a contender since there was a special report written on her work. As the power of the fission process later that year became evident to everyone, the case for awards for the discovery of fission became very strong. However, both committees in physics and chemistry decided to recommend postponing since they assumed further essential information was to be had from the Manhattan project. This assessment was shared by the Academy when it first voted for the Nobel Prize in physics, so the 1945 prize went to Wolfgang Pauli instead. At the following decision point of the agenda the chemistry committee's expert proposal was nonetheless challenged by a member of the medical class of the Academy, and with a small margin he managed to have the reserved 1944 Nobel Prize in chemistry awarded to Hahn. It can be interpreted that this decision was motivated by making a politically inopportune decision to stress the political independence of and purely scientific considerations by the Academy. Among Meitner's supporters there was still a good hope that Meitner could be awarded the physics prize the next year. However, this did not happen, probably because one of her supporters publicly criticized the committee's expert evaluator, an attempt that backfired resulting in a friendly disservice that sealed the fate of Meitner's chances of being awarded the Nobel Prize. This and some other aspects of Meitner's time in Sweden will be addressed.

(Invited) Unpublished correspondence with Kelvin and others – the Rayleigh archive

Paul Ranford

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The private archive of the Rayleigh family at Terling Place in Essex contains much of great importance to historians of science. In my studies of the historiography of C19th physics – and in particular that relating to Sir George Gabriel Stokes – the 6th Baron Rayleigh granted me access to the correspondence of his great-grandfather, the 3rd Baron (1842-1919), recipient of the Nobel prize for physics in1904 for the discovery of argon and James Clerk Maxwell's successor as Professor of Experimental Physics at the Cavendish Laboratory in Cambridge. This talk introduces some of Lord Rayleigh's unpublished yet historically important correspondence with Lord Kelvin, JJ Thomson, PG Tait and others. The extensive nature of this correspondence makes it an important, unexploited source for scholars of Kelvin in particular.

(Invited) Challenges in the measurement and understanding of electromotive force

Hasok Chang

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Electromotive force (EMF) is one of the most fundamental concepts in the areas of physics, chemistry and engineering relating to electricity. Historically, the concept of EMF has been used in many different senses, starting with Volta's employment of the term in 1800 in announcing his invention of the battery. EMF is still not often understood with perfect clarity, but it is not a subject for cutting-edge research, either. Therefore it make a topic perfectly suited for what I call "complementary science", which deploys historical and philosophical methods to address scientific questions that today's scientists do not focus on. In this talk I will start by clarifying the meaning of EMF by disentangling some ambiguities concerning the terms "EMF", "potential", and "voltage", following John Roche's work. Then I will examine the long-running debate from the history about where the "seat" of EMF was in a voltaic circuit, which was an important part of the contention between the chemical and the contact theories of batteries. I will also revisit a quandary that is now rarely remembered: when cells are connected up in series, how is it that their EMFs simply add up arithmetically? I will argue that a better grip on EMF was obtained through empirical measurements. However, this was not a simple matter, either. There were two main methods, one relying on Ohm's law and the other relying on energy conservation. These measurements were deeply theory-laden, and the relevant theories and measurement methods have grown up together in an intertwined way.

(Invited) Bruno Touschek and the genesis of electron-positron colliders

Giulia Pancheri

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In the history of the great discovery tools of last century particle physics, central stage is taken by elementary particle accelerators and in particular by colliders, whose exploitation for society's needs includes medical diagnostics and therapeutics, industrial applications, cultural heritage. In their start and early development, a major role was played by the Austrian born Bruno Touschek, whose life and accomplishments we have been studying for many years [1].

Touschek's major accomplishment is AdA, the first electron positron collider, a Storage Ring of elementary particles, built in Frascati, Italy, in 1960. To Touschek we owe the conceptual design, leading its construction, discovering and understanding internal beam dynamics, and obtaining proof of feasibility. This milestone has its roots in European pre-war and post-war modern physics, in Austria - where he was born and started his physics studies in Germany where he worked on a betatron with the Norwegian Rolf Wideroe during World War II, and where he studied for his Diploma in 1946, and in the United Kingdom, where he completed his formation as a theoretical physicist, before moving to Italy, where a national laboratory with an electron synchrotron was being envisaged, in the context of the creation of CERN. In this scenario, Touschek's genius blossomed in the unique creation of AdA, and a collaboration between two European Laboratories, Frascati and Orsay, led to establish particle colliders as a major search and discovery tool.

In my presentation I shall highlight Touschek's accomplishment as the pinnacle of converging roads which criss-crossed Europe, through the devastation of war and toward the path to reconstruction. I shall present a

period of Touschek's life barely explored in the literature in the context of highlighting the roots of to-day's particle accelerators at a time during which the post-war asset of European accelerator physics was built. This will cover the immediate post-war period, from May 1945 in Hamburg and the Diploma studies in Gottingen [2], and the years he spent at the University of Glasgow, which he joined in 1947 to pursue his doctorate in theoretical physics.

[1] L.Bonolis and G. Pancheri, EUR. Phys. J. H36 (2011) 1-61
[2[L. Bonolis and G. Pancheri, *Bruno Touschek in Germany after the war: 1945-46,* ArXiv:1910.09075.

Poster Session

P1. 1937 Large Numbers hypothesis year

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In 1937, a debate about large numbers in cosmology emerged in the famous review *Nature*. In February, Dirac suggested in a letter to the Editor the idea that large dimensionless numbers in cosmology are simple functions of the epoch, the age of the universe expressed in atomic units. A couple months later, in May, Chandrasekhar published his own article *The Cosmological constants*. The observed and analyzed numerical coincidence is different from Dirac's but leads to the same interpretation: large numbers are functions of the epoch; matter must be created to conserve this relation; and G, the gravitational constant, must vary. The week after, Herbert Dingle published *Modern Aristotelianism*. In Dingle's approach, it is typically Aristotelian to establish theoretical laws, purely deductively, without any observational or experimental support. His words are strong, especially against Dirac.

These successive publications opened a debate, in the June *Nature Supplement*, on the origin of laws of nature. After a brief context introduction by Milne, a large bench of authors were invited to present their personal position about this question: Eddington, Dirac, McCrea, Haldane, etc.

Our contribution would present the historical development and twists of the question of large numbers study along 1937. It should aim to link scientific progress and the epistemological, or philosophical, position of the above-mentioned authors. It would also be a possibility to discuss relative fastness of publication in the 1930s. Finally, this fabulous year for the large numbers hypothesis would be put in echo with subsequent Dirac's and Jordan's works as well as with more recent studies about likely constants variation in cosmology.

P2. Albert Einstein's Practical Geometry and the Spatially of the Universe

Taimara Passero

University of São Paulo, Brazil

The aim of this talk is to present and discuss the role of geometry in the development of Einstein proposal concerning the spatially of the Universe. Albert Einstein discussed this topic on the paper "Geometry and Experience", given as a public address on January 27, 1921 at the Prussian Academy of Sciences. In his paper, Einstein distinguishes between "purely axiomatic geometry" and "practical geometry". In the first one, geometry deals with objects denoted by words as straight line, point, etc, which must be considered in a purely formal sense, without intuition or experience content. In the second one, it is possible to make assertions regarding the behavior of real objects, which Einstein called practically-rigid bodies, through relating the practically rigid bodies "with respect to their possible dispositions, as are bodies in Euclidean geometry of three dimensions". Einstein attached special importance to the view of practical geometry, because without it he would be unable to formulate the general theory of relativity. Moreover, the question whether the Universe is spatially finite or not is to Einstein a meaningful question in the sense of practical geometry. He presents a beautiful argument to illustrate the theory of a finite Universe by means of a mental picture using his notion of practical geometry. To obtain this, Einstein goes from the thinking and visualization offered by Euclidean geometry to acquire a mental picture of the spherical geometry. This process leads him to conclude that "the human faculty of visualization is by no means bound to capitulate to non-Euclidean geometry".

P3. Are the Ashover Stones prehistoric star charts: testing the hypothesis by studying modern human approaches to a free hand naked eye star mapping task

Alison McMillan

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The Ashover Stones were discovered during an excavation for building work on the site of the Ashover School near Derby in 2000. They were found to have tooled cup and ring markings, similar to other prehistoric stones that have been found in other parts of the United Kingdom. Powers [1] hypothesised that such markings might be star charts, depicting constellations visible at significant times in the agricultural year. He suggested that the first Ashover stone represented the Pleiades, and the second Taurus including the Pleiades at magnified scale.

To test this hypothesis, eleven volunteers were recruited to carry out a star mapping task between 17th and 24th March 2021. This time was selected because Taurus would be easily visible in the early evening, and this year, Mars would be passing through the constellation, and would provide a control object. Participants were given an approximate star chart with a rectangle to be completed [Figure 1], which was blank apart from providing the reference position of Aldebaran. A questionnaire was used to identify the extent of astronomical knowledge or artistic skill: these being considered possible attributes that might assist in that task.

The results [Figure 2] showed that there was a huge variation in observation, and the precision of relative placement of stars within the cluster varied considerably irrespective of astronomical knowledge or artistic skill. Only about half the observers indicated differences in star brightness in their charts. Four participants did not seem to observe Mars, despite it being comparable in brightness to Aldebaran at that time. Five participants were able to pick out four or more individual stars in the Pleiades, and in each case the scale was significantly magnified compared with the other stars of Taurus.

We concluded that the hypothesis was not incompatible with the study results.

P4. Evolution of relativistic quantum field theories through the history of renormalization

Zachos Christodoulopoulos

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Renormalization dominates the relevance of relativistic quantum field theories [QFT] to experience (experiments) and contracts exemplary relationships. Renormalization is undoubtedly one of the great successes of 20th century physics. On the other hand, according to Teller (Teller 1995 chap. 7, p. 149 and Teller 1990) seems like a "methodologist's nightmare. This, coupled with the lack of mathematically rigorous models of interacting quantum fields in 4-dimensional space, has led many philosophers but also physicists (including QFT pioneers such as Dirac, Dyson and Feynman), challenged the stability of renormalization theory, and others as Landau and Chew denounced the framework of QFTs.

During 1930-1970, QFTs went through crises that threatened their existence as a dominant research program. There are three approaches to conceive renormalization :

1. As a "technique" to avoid , "bypassing" and "curing" the infinities, an ad hoc method that "saves the phenomena". (a “conservative” point of view according Cao and Schweber)
2. As an argument of choice of theories, as a methodological requirement. It’s the result of "good luck" that theories that describe the interactions satisfy this requirement. Renormalization is thus understood as a regulatory principle for the construction and selection of a QFT.
3. Third point of view is interested in explaining this "good luck" and was based on studies by the renormalization group started by Wilson, Fisher, Kadanoff et al. (see also Huggett 2002).

In this paper I hope to prove that the history of renormalization (concept and methods of renormalization) is an interesting path to determine the evolution of QFTs but also to explore philosophical aspects concerning the concepts of approximation and idealization in "mathematical" physical theories.

P5. In Search of the Wholeness: Detecting Dark Matter

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It is widely accepted by the scientific community that the majority of the universe (~95%) is made of dark matter and dark energy in which dark matter is responsible for the formation of galaxies and dark energy is for the expansion of the universe [1]. The historical approaches of detecting dark matter includes galactic rotation curves, gravitational lensing, and observing peaks in the cosmic microwave background radiation spectra etc., falls under the galactic scale observations. These necessities the need of identifying dark matter at the laboratory scales and possibly inside the International Space Station (ISS). The quest for miniaturizing the equipment with ultra-high precision calibration sources (able to detect optical transitions) is of a particular interest among the physics community over the last few years since the stability of the cesium clocks is restricted to 10^{-16} when compared to that of the optical clocks (10^{-18}) [2]. The research over the last 15 years suggest that the laser frequency combs are the suitable candidates for optical transition measurements in which the transitions of the optical clocks are deviated by the dark matter interactions. But, the goal of miniaturizing is still persisting for the future space-based observations and can be complemented by introducing the field of nanophotonics for the generation of frequency combs.

In this work, we will go through the historical perspective of dark matter detection techniques and the future challenges of achieving the ultra-high precision measurements of dark matter along with our current work on Vernier based microcombs with ultra-high Q micro resonators for Thz level comb generation.

[1] Feng, J. L. Dark matter candidates from particle physics and methods of detection. Ann. Rev. Astron. Astrophys. 48, 495–545 (2010).
[2] Andrei Derevianko 2016 J. Phys.: Conf. Ser. 723 012043.

P6. Johann Puluj's Contribution to Physics of XIX Century

Roman Plyatsko

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In [1] one can find Johann Puluj’s name among other prominent physicists. We consider his main achievements in different branches of physics. He worked in physics for only 10 years, mainly in 1874-1883, and in a short time obtained fundamental results. During 1880-1882 Puluj published very important papers devoted to the study of cathode rays. He reasonably criticized Crookes’s hypothesis about the spontaneous decay of molecules and atoms in rarefied gases, and his statement about the fourth aggregate state [2]. Puluj's monograph was published by the London Physical Society in a series Physical Memoirs on the most important works in the world’s physics at the time [3]. He designed and produced evacuated glass

tubes by himself. One of his tube produced in 1881 entered the history of science and technology as a Puluj's tube. It was this tube he used in January-February 1896 to obtain the best quality images in X-rays. Due to this tube Puluj discovered the ionization property of X-rays, determine the place of their occurrence and distribution in space, and, most importantly was the first to give a scientific explanation of their nature and mechanism of their formation [4]. Puluj made the first image of a child skeleton (journal The Photogram. 1896. Vol. 3, No 28). His tube was used for the first X-ray clinical diagnostic in America.

[1] L'Annunziata M.F. Radioactivity: Introduction and History, From the Quantum to Quarks. 2016. 932 p. (P. 83-89).
[2] Puluj J, Glaser G. The Fourth State of Matter. A Refutation. Science. 1880. Vol. 1. P. 58-59.
[3] Puluj J. Radiant Elektrode Matter and the So-Called Fourth State. Physical Memoirs. 1889. Vol. 1. P. 233--331.
[4] Puluj J. Über die Entstehung der Röntgenschenstrahlen und ihre photographische Wirkung. Wiener Berichte. 1896. Bd. 105. S. 228-238; 243-245.

P7. The Flow of Ideas Leading to the Ising Model

Reinhard Folk

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The understanding of magnetism on the microscopic scale of atoms and on the macroscopic scale of permanent ferromagnet was a big problem after the First World War. Although the Curie-Weiss theory with its internal magnetic field offered a practical approach to the phenomenon but it was clear that classical electrodynamics and magnetic interactions are not able to explain the ferromagnetic phase transition.

Ideas of Lenz 1921 of directional ordering up and down magnetons and ideas of Schottky 1922 how Coulomb energy might induce an interaction which orders these elementary magnetons made possible the formulation of a corresponding model, now known as the Ising model, which should explain the phase transition in solid state systems. The model could not be solved apart for a chain, where it did not lead to a magnetic phase at finite temperature as Ising published 1925.

Only the development of the new quantum mechanics after the discovery of the spin degree of freedom of the electron 1925 by Pauli led to an understanding of the microscopic basis of ferromagnetism 1928 by Heisenberg's exchange interaction. Pauli formulated the Ising model as we know it nowadays 1930 at the Solvay conference.

The poster presents these parallel developments made by physicists whose academic career crossed in the 1920's at the University of Hamburg the first democratic foundation of a German university [1,2].

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[1] T. Ising, R. Folk, R. Kenna, B. Berche, Yu. Holovatch The Fate of Ernst Ising and the Fate of His Model Journal of Physical Studies v. 21, No. 3 3002(19 p.) (2017) doi: 10.30970/jps.21.3002
[2] R. Folk, Yu. Holovatch in preparation

P8. The Quantum Physics of Atoms, Molecules, Nuclei, and Authors, Readers and Editors: a cultural history of the book "Quantum Physics", by Resnick and Eisberg

André Fantin

Interdisciplinary Program on Science Teaching of the University of São Paulo, Brazil

In the present work, we critically examine the popular Modern Physics textbook Quantum Physics, by Robert Resnick and Robert Eisberg (Eisberg & Resnick, 1974, 1985), focusing in the features which David Kaiser has acknowledged as novel in the american quantum physics textbook tradition, features such as the large number of conceptual questions and qualitative problems (Kaiser, 2007), a positive evidence for his overarching analysis of the transformations in the identity of the discipline Physics and it's practitioners through the second half of the twentieth century (Kaiser, 2004, 2011). We argue that Kaiser's use of the book as evidence is adequate, and that this transformation in physics teaching might have been brewing at least since the mid sixties, through a diachronic analysis of Eisberg and Resnick's textbook writings. We also refer to Resnick's public speech at his awarding of the Oersted Medal by the American Association of Physics Teachers in 1975.

[1] EISBERG, Robert & RESNICK, Robert. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. John Wiley & Sons, 1974.
[2] EISBERG, Robert & RESNICK, Robert. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. John Wiley & Sons. Second Edition. 1985.
[3] KAISER, David. How the Hippies Saved Physics: Science, Counterculture and the Quantum Revival. W.W. Norton & Company, 2011.

[4] KAISER, David. The Postwar Suburbanization of American Physics. American Quarterly, Vol. 56, No. 4 (Dec. 2004), pp.851-888.
[5] KAISER, David. Turning physicists into quantum mechanics. Physics World (May 2007): 28-33.

P9. The Undulatory Theory of Light at the Beginning of the 19th century: A Comparison between French and English Approaches

Carole Nahum

Independent Researcher, France

In 1819, young French engineer Augustin Fresnel was the winner of the Competition of the French Academy of Science for his Memoir about light diffraction1. This phenomenon, discovered by Grimaldi in 1665, occurs when light encounters a small obstacle such as a thin wire, and gives rise to a range of colours in the shadow of the wire.

Fresnel's explanations are based on light interferences from which he could build a complete theory and persuade French scholars of the validity of the undulatory conception. Furthermore, he provided convincing justifications for various phenomena.

However, when on the other side of the channel, Sir Thomas Young had published several of his experiments about "interferences"2,3,4, he had been strongly criticized and even attacked because he pretended that the patterns he observed on a screen proved that light travelled through the aether like a wave.

We determine the reasons why the latter experiments could be misinterpreted. On one hand Young used two slots4 in order to split the light beam, while Fresnel preferred two mirrors. Also, Fresnel sustained his

experiment with mathematics in order to calculate and estimate the interference patterns for any number of light rays.

Even though, Young's experiments were taught from 1820 at "École Poytechnique", the most prestigious school in France5. While Fresnel's name appeared officially in the programs, nearly thirty years after the Competition.

[1] A. Fresnel, Œuvres complètes, (1866).
[2] T. Young, Philosophical Transactions of the Royal Society of London, (1802).
[3] T. Young, Philosophical Transactions of the Royal Society of London, (1804).
[4] T. Young, A Course of Lectures on Natural Philosophy, Vol. 1, (1807).
[5] P. Dulong, Cours de Physique, École Polytechnique, (1824).

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