XL National Congress of the Italian Society for the History of Physics and Astronomy

Tuesday 08 September 2020 - Thursday 10 September 2020

Book of Abstracts

Contents

SISFA / 55

Inaugurazione del Congresso

Apertura dei lavori
introduce Salvatore Esposito, Presidente SISFA

Duecento anni di elettromagnetismo / 34

Oersted e la scoperta dell'Elettromagnetismo

Author: Giuseppe Giuliani[1]

[1] *Università di Pavia*

La scoperta di Hans Christian Oersted (1777-1851) che un filo percorso da una corrente elettrica cambia la direzione di un ago magnetico orientato dal campo magnetico terrestre (1820) costituisce l'atto di nascita dell'Elettromagnetismo. La scoperta di Oersted non fu casuale: egli era, come altri, alla ricerca di una connessione tra elettricità e magnetismo. Questa connessione era per Oersted solo un aspetto di una concezione unitaria delle forze della Natura: chimiche, termiche, elettriche e magnetiche. Oersted, diversamente dagli altri, fece l'esperimento adatto alla scoperta.
Senza sapere cosa fosse una corrente, i fisici incominciarono a studiare le interazioni tra correnti e tra correnti e magneti. Tra questi, André Marie Ampère (1775-1836), sulla base di accurati esperimenti formulò una teoria matematica di queste interazioni (Elettrodinamica), sulla base di due postulati. Il primo consisteva nell'assunzione che la forza esercitata da un elemento di circuito su un altro fosse diretta, come le forze newtoniane e coulombiane, lungo il segmento di retta congiungente i due elementi. Il secondo assumeva che le proprietà dei magneti permanenti o dei materiali magnetizzabili fossero dovute a correnti molecolari native.
Dopo la scoperta di Oersted, l'induzione elettromagnetica era presente in molti esperimenti svolti nei laboratori. In particolare, nell'esperimento con il disco di Arago e nello studio di una possibile induzione di una corrente in un anello conduttore sospeso all'interno di una spira circolare percorsa da corrente (Ampère): ma la sua presenza non fu rilevata. Nel caso di Arago (1786–1853) perché il fenomeno era troppo complesso; nel caso di Ampère, perché il fenomeno, sebbene superficialmente osservato, non fu adeguatamente studiato ed interpretato.
L'induzione elettromagnetica fu invece scoperta nel 1831 da Michael Faraday (1791-1867).
Ernest Rutherford definì "decennio straordinario" quello intercorrente tra il 1895 ed il 1905. Alla stessa stregua, possiamo definire "decennio straordinario" anche quello che ha dato origine all'Elettromagnetismo.

Duecento anni di elettromagnetismo / 5

Oersted, Ampere, Faraday e i "moti" rivoluzionari del 1820-21

Author: Salvatore Esposito[1]

[1] *INFN Sezione di Napoli*

I celebri esperimenti di Oersted furono il punto di partenza per una frenetica campagna di ricerche che nel 1820-21, attraverso i successivi contributi fondamentali di Ampere, Faraday ed altri attori minori, portò a quella che convenzionalmente viene considerata la "nascita dell'elettromagnetismo". In occasione del bicentenario di tali eventi, viene qui presentata una proposta didattica e divulgativa che, mettendo al centro lo studio della Storia della Fisica, fornisce un esempio di come, senza far ricorso a linguaggi specialistici, si possa illustrare efficacemente a studenti e grande pubblico co-me si pervenne al concetto fisico di unificazione dei fenomeni elettrici e magnetici.

Duecento anni di elettromagnetismo / 35

Saverio Barlocci and the First Electromagnetic Experiments in Rome

Author: Roberto Mantovani[1]

[1] *University of Urbino Carlo Bo - Dept. of Pure and Applied Sciences*

The talk discusses the scientific work of Saverio Barlocci (1774-1845) and some of his remarkable electromagnetic experiments. In the years 1814-1845 Barlocci was the first lay professor to hold the chair of Experimental Physics at the La Sapienza University in Rome. Among his numerous scientific activities stand out, for importance, the electromagnetic experiments he "instituted" in the years 1821-1822 at the Physics Cabinet of Rome University. After Oersted's famous announcement in 1820, Barlocci was the first physicist in Rome to spread, comment and replicate the Danish physicist's original experiment. He also replicated other experiments that, after the discovery, had been presented in Paris by Arago, Ampère and other French scientists. In 1826 Barlocci published an interesting essay on Electromagnetism where he collected the most significant electromagnetic experiences that could be performed in a Physics Laboratory. For this purpose, he reduced most of the proposed devices into a simpler and more suitable form for educational use. This essay was among the very first attempts in Italy to offer a complete set of experiments capable of effectively illustrating the new and emerging science of Electromagnetism.

Short bibliography

Barlocci S. (1821a). Sopra alcune esperienze elettriche, lettera del Professor Saverio Barlocci al chiarissimo signor professor Domenico Morichini. Giornale Arcadico, IX, pp. 350-355.
Barlocci S. (1821b). Rapporto del professor Saverio Barlocci sopra alcune sperienze elettro-magnetiche istituite nel gabinetto fisico dell'Università di Roma. Giornale Arcadico, X, pp. 426-435.
Barlocci S. (1822). Continuazione del rapporto sulle sperienze elettro-magnetiche istituite nel gabinetto fisico dell'Università di Roma dal professor Saverio Barlocci. Giornale Arcadico, XIII, pp. 37-57.
Barlocci S. (1826). Saggio di Elettro-Magnetismo dedotto dagli esperimenti istituiti nel Gabinetto Fisico della Università di Roma da Saverio Barlocci professore di Fisica Sperimentale in detta Università e membro del Collegio Filosofico. Roma: Nella stamperia di Filippo e Nicola De Romanis.

Erone e Leonardo / 21

The mechanics of Heron and his copies Missing sheets or multiplicity of interests?

Author: Giuseppina Ferriello[1]

[1] *sisfa*

The transmission of Hero's Mechanics through Persian manuscripts is a recent line of studies that was opened in the nineties by the random discovery of a manuscript brought from Isfahan to Paris by Francois Pétis de la Croix , emissary of Louis XIV.
The copies attest to the continuity of the diffusion of the text, that has application as well as cognitive purposes; however, a reading of the work in historical key is still neglected and the text is crystallized and subjected to episodic interpretations .
The intervention concerns the some results of a methodological experimentation that uses lexical and iconic language, allows to identify the chronology and allows to formulate hypotheses on possible interests of the users.

Erone e Leonardo / **23**

La conservazione della quantità di moto in Leonardo da Vinci

Author: Erasmo Recami[1]

[1] *Università degli studi di Bergamo*

Viene esaminato il contributo di Leonardo da Vinci al metodo sperimentale delle scienze fisiche attraverso due rilevanti esempi di meccanica. Si mostra che Leonardo ebbe piena coscienza della legge della conservazione della quantità di moto.

Astronomia e dintorni / **20**

L'affermazione selenografica di Giovan Battista Riccioli, tra nomenclature celesti e cartografie planetarie / The selenographic statement of Giovan Battista Riccioli, between celestial nomenclatures and planetary cartographies

Authors: Valeria Zanini[1]; Mauro Gargano[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

La nomenclatura adunque è per se stessa indubitatamente una parte importante della scienza siccome quella che c'impedisce di essere smarriti in una immensità di particolari ed involti in una confusione inestricabile (J. Herschel, 1840)

Sin dall'antichità, le stelle visibili all'occhio umano furono raggruppate in costellazioni; tra esse si muovevano i pianeti, e sia le une sia gli altri ricevettero, per essere contraddistinti, un nome poi consolidatosi attraverso i popoli e i secoli. Ma da quando Galileo Galilei rivolse il suo telescopio al cielo, nell'autunno del 1609, divenne subito chiaro che gli oggetti celesti erano molto più numerosi e complessi di quanto ci si potesse mai aspettare, e che nuovi nomi e nuove mappature si sarebbero ben presto rese necessarie.
Il primo dei corpi celesti che rivelò la sua natura complessa fu la Luna, e alla selenografia si dedicarono moltissimi astronomi del XVII secolo, come Michel Florent van Langren (1600-1675) o Johannes Hevelius (1611-1687), ciascuno dei quali mise a punto una sua propria nomenclatura. Tuttavia quella proposta da Giambattista Riccioli (1598-1671), che aveva associato alle "macchie", ossia ai crateri, i nomi di celebri astronomi e sapienti dell'antichità o a lui contemporanei, si dimostrò vincente rispetto alle altre, tanto che nel 1932 fu scelta dall'Unione astronomica internazionale come base di partenza della nomenclatura lunare moderna.

Nomenclature, then, is, in itself, undoubtedly an important part of science, as it prevents our being lost in a wilderness of particulars, and involved in inextricable confusion (J. Herschel 1831)

Since ancient times, the stars visible to the naked eye were grouped into constellations. The constellations and the planets, moving among them, received a name to be distinguished. This nomenclature was then consolidated among peoples and over the centuries.
When Galileo Galilei turned his telescope to the sky in the fall of 1609, it became immediately clear that celestial objects were more numerous and complex than could ever have been expected, and that new names and new maps would soon be needed.
The Moon was the first celestial body that revealed its complex nature. Many 17th century astronomers devoted themselves to selenography, such as Michel Florent van Langren (1600-1675) or Johannes Hevelius (1611-1687), who developed their own nomenclature. However, the one proposed by Giambattista Riccioli (1598-1671) in the Almagestum novum proved successful compared to the others. He associated the various lunar spots with the names of famous astronomers and

savants of ancient and contemporary times. In 1932 the International Astronomical Union chose Riccioli's hypothesis as the starting point for the modern nomenclature of the Moon.

Bibliografia / References
MAFFEI P., Carte lunari di ieri e di oggi, Firenze, coi Tipi dell'Istituto Geografico militare, 1963.
RICCIOLI G. B., Almagestum novum astronomiam veterem novamque, Bononiae, ex typographia haeredis Victorij Benatij, 1651.
WHITAKER E. A., Mapping and Naming the Moon: A History of Lunar Cartography and Nomenclature Cambridge University Press, 1999.

Astronomia e dintorni / 32

Archaeoastronomy in Sicily: a report on past studies, present research and future projects.

Author: Andrea Orlando[1]

[1] *Istituto di Archeoastronomia Siciliana*

This contribution presents a report of the main cultural astronomy studies conducted in Sicily from the second half of the 19th century to the present day.
Sicily has an ancient tradition of observations and studies related to archeoastronomy. Among the pioneers of this discipline, it is important to remember the German historian Heinrich Nissen, who in the second half of the nineteenth century studied the orientations of several churches and some Greek temples in Sicily (Nissen, 1869). At the end of the 19th century other archaeoastronomical studies were carried out in Sicily, conducted by two famous German archaeologists, Robert Koldewey (1855-1925) and Otto Puchstein (1856-1911), and by a British architect, Francis Cranmer Penrose (1817-1903).
At the end of the twentieth century, two Sicilian scholars conducted new and interesting archaeoastronomy studies on some prehistoric monuments, such as the Sesi of Pantelleria and some rock-cut tombs built between the IV-II millennium BC (Tusa et al., 1992; Foderà Serio and Tusa, 2001).
More recently, following the foundation of the Institute of Sicilian Archaeoastronomy in 2014, cultural astronomy studies have multiplied, in about 6 years new research has been started, often in collaboration with foreign universities, in numerous archaeological sites and Sicilian areas, as for example: Alcantara Valley, Aeolian Islands, Thapsos, Argimusco, Rocca Novara, Balze Soprane, Rocca di Cefalù, Muculufa (e.g: Orlando 2017).

References
Foderà Serio G. and S. Tusa, Rapporti tra morfologia ed orientamento nelle architetture rituali siciliane dal IV al II millennio a.C., in Atti dei convegni lincei 171, pp. 297-323, 2001.
Koldewey R. and O. Puchstein, Die griechischen Tempel in Unteritalien und Sicilien, A. Asher & Co, Berlin, 1899.
Nissen H., Das Templum. Antiquarische Untersuchungen, Berlin, 1869.
Orlando A. (ed), The Light, the Stones and the Sacred, in Astrophysics and Space Science Proceedings 48, Springer, 2017.
Penrose F.C., On the Orientation of Greek Temples, Being the Results of Some Observations Taken in Greece and Sicily in the Month Orientations of Greek Temples of May, 1898, Proceedings of the Royal Society of London, 65, pp. 370–375, 1899.
Tusa S., Foderà Serio G. and M. Hoskin, Orientations of the Sesi of Pantelleria, Journal for the History of Astronomy 17, S15-S20, 1992.

Astronomia e dintorni / **7**

Tempo e “fantasia di sparizione”: la nascita dell’astronomia

Author: Tommaso Sorrentino[1]

[1] *Pisa university*

An increasing number of Paleolithic rock depictions and artifacts is suggesting the presence of an ancient astronomical knowledge but little is known about the reasons behind the development of a complex astronomical thought. By using modern theories of human mind, especially the “Human Birth theory ” proposed by the psychiatrist Massimo Fagioli, we could explore a novel possibility for the birth of astronomy as symbolization of time.

Bibliography

Brague R (2003) The wisdom of the world. Cambridge University Press, Cambridge
Henshilwood Christopher, d’Errico Francesco, Yates Royden, Jacobs Zenobia, Tribolo Chantal, Duller Geoff, Mercier Norbert, Sealy Judith, Valladas Helene, Watts Ian, Wintle Ann (2002)
Emergence of Modern Human Behavior: Middle Stone Age Engravings from South Africa Science (New York, N.Y.)
Massimo Fagioli (2010) Istinto di morte e conoscenza. L’asino d’oro edizioni.
Michael A. Rappenglück (1997) The Pleiades in the “Salle des Taureaux”, grotte de Lascaux. Does a rock picture in the cave of Lascaux show the open star cluster of the Pleiades at the Magdalénien era (ca 15.300 BC)?”
Michael A. Rappenglück (2015) Possible Astronomical Depictions in Franco-Cantabrian Paleolithic Rock Art
Michael A. Rappenglück (2015) Possible Calendrical Inscriptions on Paleolithic Artifacts
Stanislaw Iwaniszewski (2015) Concepts of Space, Time, and the Cosmos.

SISFA / **56**

Premio di Laurea SISFA 2020

Premio finanziato dal Socio Leonardo Gariboldi in memoria dei genitori

Cerimonia di Premiazione
Presenziano Salvatore Esposito, presidente SISFA e la commissione giudicatrice: Fabio Bevilacqua, Leonardo Gariboldi, Valeria Zanini.

Comunicazione del vincitore
Marco Giganti
L’esplosione della Supernova 1987A: una prospettiva storica sulla ricerca delle onde gravitazionali a Roma

Storie: nel ’900 in giro per il mondo / **27**

Beppo Occhialini in Brazil between Physics and Politics

Authors: Leonardo Gariboldi[1]; Mattia Verzeroli[2]

[1] *Università degli Studi di Milano, Dipartimento di Fisica ”Aldo Pontremoli”*

[2] *Università degli Studi di Pavia*

The aim of this work is to offer an analysis of the documents kept in Italian and Brazilian archives on Occhialini’s activity in Brazil in the late 1930’s. Occhialini went to São Paulo to help Gleb Wataghin

in creating a new Physics team. Due to Brazil's geomagnetic location and the scarcity of funds, they chose cosmic ray physics as the main subject of research. We shall analyse Occhialini's main activities of research and his contribution to the international conference on cosmic rays held in Rio de Janeiro. As for the political context of the time, we shall show Occhialini's activity in helping people living under European regimes, in particular the role he played in the Houtermans affair.

Bibliografia

Amaldi E. *The adventurous life of Friedrich Georg Houtermans, physicist (1903-1966)* in Battimelli G. et al. (eds.) *A Selection of Historical Writings by Edoardo Amaldi* (World Scientific Publishing, 1998): 592-695.
Amato N. et alii. *Cesar Lattes 70 Anos: A Nova Física Brasileira* (CBPF, 1994).
Belloni L. *Un fisico europeo: Houtermans*, Quaderni di Storia della Fisica 9 (2001): 17-38.
Freire Jr. O, Silva I. *Diplomacia e ciência no contexto da Segunda Guerra Mundial: a viagem de Arthur Compton ao Brasil em 1941*, Revista Brasileira de História, 34, 67 (2014): 181-201.
Gariboldi L. *Occhialini's scientific production between the two English periods* in Redondi P. et alii (eds.) *The Scientific Legacy of Beppo Occhialini* (Springer, 2006): 71-77.
Ribeiro de Andrade A.M. *Occhialini's trajectory in Latin America* in Redondi P. et alii (eds.) *The Scientific Legacy of Beppo Occhialini* (Springer, 2006): 51-69.
Shifman M. *Standing together in troubled times: unpublished letters by Pauli, Einstein, Franck and others* (World Scientific Publishing, 2017).
Silva L.V.S. *A missão italiana da Faculdade de Filosofia, Ciências e Letras da Universidade de São Paulo: ciência, educação e fascismo (1934-1924)* (tesi di master in filosofia, Universidade de São Paulo, 2015).

Storie: nel '900 in giro per il mondo / 8

Tales from Dubna's oakwood: Bogoliubov, Pontecorvo, and the JINR seminars

Authors: Giulia Carini[1]; Stefano Furlan[1]; Rocco Gaudenzi[1]

[1] *Max Planck Institute for the History of Science*

If much ink has been spilt on Bruno Pontecorvo's emigration to the USSR (1950), on the other hand, much less has been said about the scientific milieu in which he found himself: the Joint Institute for Nuclear Research (JINR) in Dubna. In this paper, we begin to fill this gap by focusing on the distinguished scientists with whom Pontecorvo interacted beyond direct collaborations; paying particular attention to Nikolai Bogoliubov, both a friend and a colleague of the Italian physicist. In the story, a fruitful arena for exchanges was provided by the tradition of seminars held at JINR; however, as it often happens with the more elusive (but no less interesting) aspects of "oral communities", what we have at disposal to reconstruct that atmosphere is little more than accounts or reminiscences of participants. On the basis of the latter—some of which are new—as well as of published works, we underline, across not-so-obviously-related branches of physics, an analogical resonance between Bogoliubov's notion of quasiparticle and Pontecorvo's first idea of neutrino-antineutrino oscillation and mixed particle. In doing this we also bring to the fore an historiographical question. While the probative character of analogies is easy to contest in absence of explicit recorded declarations —even when their plausibility is increased by a shared milieu and bond between two scientists—is it legitimate, we ask ourselves, to omit or neglect that whole oral-associative dimension, rather than to specify, with some due caveat, those possible links? Without sacrificing the peculiar character of the JINR seminars, we hope this instance will suggest to pay more attention to the other seminars and their possible role in shaping people and ideas of XX-century physics.

Storie: nel ’900 in giro per il mondo / 28

Thinking Big. How large-scale detectors set the stage for the emergence of astro-particle physics

Author: Luisa Bonolis[1]

[1] *Max Planck Institute for the History of Science*

The evolution of the astrophysical dimension of cosmic-ray studies as a bridge between high-energy particle physics and experimental astrophysics has not been explored as it deserves, considering its explosive developments during the 1970s/1980s also contributing to the emergence of astro-particle physics, a field whose identity was shaped by the growing symbiotic relationship between elementary-particle physics, high-energy astrophysics and cosmology.
Since the advent of the modern era of cosmic ray studies at the end of the 1920s, detectors have ranged from small Geiger-Müller counters up to giant arrays distributed over areas measured in square kilometers, in order to understand which are the sources and mechanisms of acceleration of the most energetic particles in the Universe. At ultra-high-energy regimes of incoming particles, the low probability of such events is compensated by the huge exposure on the ground. Different techniques have been developed to observe the Extensive Air Showers, initiated both by charged particles or gamma-ray photons, all having in common the same well established practice for studying rare events: large-scale detectors.
The same concept has been transferred to the search for solar neutrinos, to last generation arrays for gamma-ray astronomy and to huge detectors hunting high-energy cosmic neutrinos, dark matter candidates and other relics of the early Universe, or searching for proton decay.
Also the long baseline kilometer-scale interferometers catching gravitational waves originated from cosmic catastrophes are part of this network of detectors addressing fundamental physical and astrophysical questions.
At the intersection of different research areas, detection approaches and communities of practitioners, astro-particle physics provided an umbrella merging different observational, theoretical and material cultures, creating a new unconventional breed of “astronomers”, more and more combining forces in the new field of multimessenger astrophysics.

Pensieri differenti nella fisica del ’900 / 9

Far From The Particle Crowd: Shugyosha Nambu And Michizane-Wheeler

Authors: Stefano Furlan[1]; Rocco Gaudenzi[2]

[1] *Max Planck Institute for the History of Science*

[2] *Max Planck for the History of Science*

Pi meson, 1947: the rise of what came to be known, with an edge of contempt, as “the pion industry”; and, in turn, represents the real beginning of “the particle zoo”: a wealth of new experimental data and the proliferation of purported elementary particles encoded in it. Saluted enthusiastically by most, this situation of abundance does raise—it might seem bizarre today—also recalcitrant reactions among distinguished scientists who were far from being of the “reactionary” kind. One such example is represented by Yoichiro Nambu who, initially involved with the result from accelerators, challenges though the search for models whose results are compatible with experimental data, but without questioning whether the way these results are drawn is legitimate from the standpoint of meson field theory. A geopolitical contextualization right after WWII could suggest that in countries such as Japan, cut out from cutting-edge experimental research in those areas, the pride of previous successes of a national scientific tradition led to compensate that exclusion with an emphasis on deeper levels of theorising, embedded within some grand narrative stressing the national glory. That is an interesting key of interpretation, but it does not really befit Nambu, imbued with that tradition but without nationalistic overtones; nor is it capable of explaining how come the reaction was shared by people such as J.A. Wheeler, at the peak of his career as a nuclear physicist in

Princeton. In this paper we examine, in reference to that period, some unexpected affinities (accompanied by proper distinctions) between Nambu in Japan and Wheeler in the US. Far from being a missed opportunity, their "reactions" played a crucial role in shaping their heuristic methodologies and their styles of doing physics, thus preparing the new paths that, in the following decades, they were going to open.

Pensieri differenti nella fisica del '900 / 3

Feynman's Frameworks on the Nanotechnology in a Current Historiographical Debate

Authors: Raffaele PISANO[1]; Andrea DURLO[2]

[1] *IEMN, Lille University, Lille, France; CPNSS, LSE, UK*

[2] *IEMN, Lille University–CNRS, France*

The nanostructures research has been exploring new modelling and techniques in the fields of Sciences and Applied Sciences & Technology. Outstanding results have been enriching the scientific knowledge from Physics to Biology, from Engineering to Medicine continuously achieving new milestones. In in the end 1959, Richard Phillips Feynman (1918–1988) gave a talk to the American Physical Society in Pasadena, which explored the immense possibilities afforded by miniaturization research. This talk was transcribed in famous "There's Plenty of Room at the Bottom" (1964, March 13th). It appears to be, according to the current historiographical––and scientific narrative, the inspiring cornerstone for scientists in Nanotechnology research. Self-assembling machines, atom manipulation, nano–carriers in medicine, new materials like graphene and fullerene, innovations in electronic microscopy are just a few of the new discoveries whose origins are commonly said to lie on Feynman's work. In the following decades, Feynman's heritage has been. The argument on "Plenty of Room" 's framework opened new historiographical debate: Is Feynman's framework the ispiring source for nano research? In literature, interesting examples of different points of view about this work can be found in several sources. As part of my current doctoral research at Lille University (supervised by prof. Raffaele Pisano), our talk aims at discuss the influence of the Feynman's "There's Plenty of Room at the Bottom" on the theoretical and experimental developments of nanotechnology, including the epistemic and controversial historiographical debates on the subject.

Selected References

Bayda S, Adeel M, Tuccinardi T, Cordani M, Rizzolio F (2020) The History of Nanoscience and Nanotechnology: From Chemical-Physical Applications to Nanomedicine. Molecules 25/112
Bussotti P, Pisano R (2020) Historical and Foundational Details on the Method of Infinite Descent: Every Prime Number of the Form 4n+1 is the Sum of Two Squares. Foundations of Science 1:1-32
Drexler KE (1988) Engines of Creation: The Coming Era of Nanotechnology. New York, Doubleday-Anchor Books.
Feynman RP (1960) There's Plenty of Room at the Bottom. Engineering and Science 23/5:22-36
Feynman RP (1984) Tiny machines: a lecture on nanotechnology.
Madhuri S (2019) History of Nanotechnology. From Prehistoric to Modern Times. Beverly, Scrivener Publishing, Wiley
Mansoori GA (2017) An Introduction to Nanoscience & Nanotechnology. In Ghorbanpour M., Manika K., Varma A (Editors) Nanoscience and Plant-Soil Systems. Cham, Springer, pp. 1-20.
Myers TG, MacDevette MM, Font F, Cregan V (2014) Continuum mathematics at the nanoscale. Journal of Mathematics in industry 4:11.
Pisano R, Sozzo S (2020) A Unified Theory of Human Judgements and Decision-making under Uncertainty. Submitted to Entropy Special Issue Andrei Khrennikov A, Bagarello F (eds). Quantum Models of Cognition and Decision-Making.
Pisano R, Anakkar A, Pellegrino EM, Nagels M (2019) Thermodynamic Foundations of Physical Chemistry Reversible Processes and Thermal Equilibrium into History. Foundations of Chemistry 21:297–323
Toumey C (2008) Reading Feynman Into Nanotechnology: A Text for a New Science. Techné: Research in Philosophy and Technology 12/3:133-168

Pensieri differenti nella fisica del ’900 / 16

Einstein’s Wonder

Author: Enrico Gasco[1]

[1] *Zirak s.r.l*

In his Autobiographical Notes [1] Einstein recognizes the importance of wonder in the cognitive process by stating that it occurs when an experience comes into conflict with a sufficiently stable world of concepts. It is through this emotion that our intellectual world reacts and seeks a solution to the contradiction found; it is as if conceptual development is a continuous escape from wonder. Already in classical philosophy, wonder is considered the starting point of philosophizing as Plato highlights in Theetetus [2] and Aristotle in Metaphysics [3]. The Stagirite himself states that wonder corresponds to the state of not knowing (e.g. amazement at the immeasurability of the diagonal on the side of the square), that is, that aporetic condition which is the task of philosophizing to overcome. The emotion Aristotle speaks of is recognized as an ‘interrogating wonder’ [4, 5, 6] - to distinguish it from the ‘contemplating’ one with more aesthetic characteristics - and is the basis of scientific research (also known as epistemic wonder). To describe what the interrogating wonder consists of we will make use of the Dynamic Frames proposed by Barsalou [8] and used profitably in the philosophy of science to explain conceptual changes [11] and to represent knowledge in general [9, 10]. In this communication we will also focus on the role of wonder in the years of Einstein’s formation [7] and in particular we will examine the famous mental experiment in which he tries to chase a light beam [12, 13], showing its aporetic conditions with respect to classical physics.

Bibliography

1. Einstein A.,(1951), “*Autobiographical Notes*“ in “*Albert Einstein: Philosopher-Scientist*“.
2. Plato, (2015), “*Thaetetus and Sophist*“, Cambridge University Press.
3. Aristotle, (1991), “*The complete works of Aristotle: The revised Oxford Translation*“, Princeton University Press.
4. Candiotto L, (2019), “*Epistemic Emotions: the case of wonder*“, Journal of Philosophy Aurora, Vol 31, No 54.
5. Metthews G.B, (1997), “*Perplexity in Plato, Aristotle, Tarsky*“, Philosophical Studies, Vol 85, No. 2/3
6. Tobia K.P., (2015), “*Wonder and Value*“, Res Philosophica, 92(4).
7. Gregory F., (2000), “*The mysteries and wonders of natural science: Aaron Bernstein’s Naturwissensschaftliche Volksbucher and the adolescent Einstein*“, in “*Einstein the formative years, 1879-1909*“, Birkhauser, 23-41
8. Barsalou L.W., Halle C.R., (1993), “*Components of conceptual representation: from Feature lists to recursive frame*“ in “*Categories and Concepts: Theoretical Views and inductive data analysis*“, Academic Press, 97-144.
9. Kornmesser S., (2018), “*Frames and Concepts in the Philosophy of Science*“, European Journal for Philosophy of Science, Vol. 8, 225, 251.
10. Kornmesser S., Shurz G., (2018), “*Analyzing Theories in the Frame Model*“, Erkenntnis.
11. Andersen H., Barker P., Chen X., (2006), “*The cognitive structure of Scientific Revolution*“, Cambridge University Press.
12. Norton J.D., (2013), “*Chasing the light*“ in “T*hought Experiments in Philosophy, Science and Arts*“, Routledge, 123-140
13. Kaku M., (2004), “*Einstein’s cosmos; how Einstein’s vision transformed our understending of space and time*“, W.W. Norton/Atlas Book.

Pensieri differenti nella fisica del ’900 / 11

Reduction of two theories by means of a mathematical limit: a historical review of past debate

Authors: Marco Di Mauro[1]; Antonino Drago[2]; Adele Naddeo[3]

[1] *Dipartimento di fisica ”E.R. Caianiello”, Università di Salerno*

[2] *Dipartimento di Fisica, Università di Napoli "Federico II"*

[3] *INFN, Sezione di Napoli*

In the past century programs of research for unifying science (Hilbert, neo-positivists, physicalists) were born. Many scholars pursue the goal of a "Theory of Everything". They have to prove the reduction of theories insisting on the same field of phenomena. On the other hand, historians and philosophers of science introduced the notion of a mutual incommensurability of two theories when their basic notions have radical variations in meanings and hence their relations are difficult to be established. A great debate was born about this notion of reduction, questioning even whether in the history of physics it ever occurred.
A specific notion of reduction is the physicist's one: two theories are reduced by a mathematical limit process on a parameter. E.g. a common opinion is that classical mechanics on the one hand and special relativity and quantum theory on the other are reduced by taking such a limit respectively for c and h. However, some scholars (Berry, Batterman), owing to the singularity of this limit in many cases, obtained several impossibility results (e.g. the reduction of ray optics to wave optics). This fact supports Rohrlich's suggestion of an essential pluralism of physical theories.
The communication offers a review of the past contributions on mathematical reduction. The debate on the results is summarized.

Bibliography

Batterman R.W., 2002, The Devil in the Details: Asymptotic Reasoning in Explanation, Reduction, and Emergence. Oxford UP.
Berry M.V., 2001, "Chaos and the Semiclassical Limit of Quantum Mechanics", in Quantum Mechanics: Scientific perspectives on divine action, R.J. Russell et al (eds), Vatican Observatory CTNS publications, pp. 41–54.
Nagel E., 1961, The Structure of Science, London: Routledge and Kegan Paul.
Nickles T., 1973, "Two concepts of intertheoretic reduction", The Journal of Philosophy, 70: 181.
Rohrlich F., 1988, "Pluralistic ontology and theory reduction in the physical sciences", The British Journal for the Philosophy of Science, 39: 295.

Pensieri differenti nella fisica del '900 / 31

Historical review of the algebriac foundations of quantum mechanics

Author: Antonino Drago[1]

[1] *Formerly at University "Federico II" Naples*

I review the algebraic foundations of quantum mechanics. They have been suggested since the birth of this theory till up to present year. They are the following ones: Heisenberg-Born-Jordan's (1925), Weyl's (1927), von Neumann's (1936), Segal's (1947), T.F. Jordan's (1986), Morchio and Strocchi's (2009) and Bucholz and Fregenhagen's (2020).
They are illustrated according to an increasing degree of formalism, from the mere introduction of matrices till up to group theory and C*-algebras. Two particular cases are presented in details: Von Neumann's 'conversion' from Hilbert space to the operators algebra and the foundation of quantum mechanics (as well as Feynman's path integrals) upon the algebra of interaction Lagrangians.
Moreover, these foundations will be inspected whether they may be rationally re-formulating as problem-based theories which make use of no more than constructive mathematics.

Bibliography

Born M., Heisenberg W., and Jordan P. (1925), "Zur Quantenmechanik II", Zeitschrift für Physik, 35, 557-615, 1925 (B. L. van der Waerden (ed.) (1968), Sources of Quantum Mechanics, New York: Dover).
Bucholz D. and Fredenhagen K. (2020), "Classical dynamics, arrow of time, and genesis of Heisenberg commutation relations.
Bucholz D. and Fredenhagen K. (2020), "From path integrals to dynamic algebras: A macroscopic view of quantum physics", Foundations of Physics, 50 (7), pp. 727-734
Jordan T.F. (1986), Quantum Mechanics in Simple Matrix Form. New York: Wiley & Sons.

Murray F.J., Von Neumann J. (1936), "On rings of operators", Ann. of Math., 37, pp. 116–229.
Segal I.E. (1947), "Postulates for general quantum mechanics", Ann. Math., 48, pp. 930-948.
Strocchi F. (2018), A Primer of Analytical Mechanics, Berlin: Springer, Chp. 7.
Weyl H. (1928), Group Theory and Quantum Mechanics, New York: Dover.

In ricordo di Salvo D'Agostino / **57**

Introduzione alla sessione

Author: Fabio Bevilacqua[1]

[1] *Università di Bologna*

In ricordo di Salvo D'Agostino / **24**

Salvo D'Agostino e la storia della fisica

Author: Enrico Giannetto[1]

[1] *Università di Bergamo*

Sarebbe impossibile ricordare e discutere in maniera adeguata tutti i contributi di Salvo D'Agostino alla Storia della Fisica. Qui, vorrei invece discutere la prospettiva di Storia della Fisica che ha elaborato, che ha perseguito nei suoi scritti e che ci ha lasciato come eredità culturale. Attraverso la memoria di varie conversazioni personali e l'analisi di alcuni suoi scritti, cercherò di far emergere il valore culturale fondamentale che attribuiva alla Storia della Fisica.

In ricordo di Salvo D'Agostino / **38**

Salvo D'Agostino's History of Physics in context

Author: Stefano Bordoni[None]

D'Agostino's history of physics belongs to the cultural tradition of physicists who have undertaken wide-range researches in the history and foundations of their discipline. More specifically, he inquired into different aspects of scientific practice: technological devices, mathematical languages, theoretical models, and more or less tacit philosophical assumptions.
At first, I would like to sketch some meaningful steps of D'Agostino's research in the history of physics; then I would like to put his research in context.
In the chronological context of the late twentieth century, and in the cultural context of the history of science over time, two main issues are at stake: the synchronic comparison between D'Agostino and other historians of physics in the last decades of the twentieth century, and the diachronic search for the international and Italian traditions that D'Agostino joined.
In the 1960s, in English-speaking countries, the tradition of historical-critical studies that had emerged in the last decades of the nineteenth century was revived by a new generation of historians-philosophers of science. In the same years, even in Italian scientific and cultural context, D'Agostino's early researches represented both a fresh start and the re-emergence of an already existing tradition. Afterwards, in Italy, the history of physics would have undergone a remarkable professionalization. Nowadays the discipline is not a definite career any more, and the cultural and social cleavage between our time and the last decades of the twentieth century allows us to appreciate the essential features of that context.

In ricordo di Salvo D'Agostino / **46**

Pensieri personali

interventi liberi

Da Newton a Maxwell / **1**

Epistemology of music in d'Alembert's Élémens de musique

Author: Danilo Capecchi[None]

The involvement of d'Alembert in musical issues has its roots in 1749, when Jean Philippe Rameau submitted to the Académie des sciences de Paris, for approval, a manuscript containing the elements of his musical theory. Even though d'Alembert praised Rameau's theory he did not appreciate his prose, and for this reason he felt impelled to write a more readable treatise which originated the Élémens de musique of 1752, written anonymously as a form of respect, followed in 1762 by a second edition, this time with the name d'Alembert in the cover. To start with he declared music a physical mathematical science, like hydraulics and astronomy and unlike mechanics which is purely rational like mathematics. Thus for music too, as for the other physical mathematical sciences, one should not seek a striking evidence, which is the characteristic of the works of mathematics alone and which is found so rarely in those of physics. The Élémens de musique was not simply a didactical work; it was rather a propagandistic pamphlet for spreading d'Alembert's rational epistemology. By reformulating Rameau's brilliant but ineptly articulated theory into a rigorous writing, d'Alembert was able to provide both a vindication as well as an advertisement for his own peculiar scientific epistemology. A treatise on music was a perfect means to illustrate the merits of his professed empirical-rational methodology of physical sciences because more simple of his Traité de dynamique, for instance.

Da Newton a Maxwell / **14**

Details on Lagrange's Method as Described by Maxwell in his Electromagnetic Theory

Authors: Raffaele Pisano[1]; Donatella Marmottini[2]

[1] *IEMN, Lille University, Lille, France; CPNSS, LSE, UK*

[2] *Campus dei Licei, Cisterna di Latina, Italy*

Both in A treatise on electricity and magnetism (1873, 2 vols.) and A dynamical theory of the electromagnetic field (1864) Maxwell converted in a mathematical language the main content of the Experimental Researchers in Electricity by Michael Faraday. He went beyond the Newtonian approach reaching a new physics mathematics based on the concept of energy instead of that of force. First, he mathematically stressed the three – as he called – Lagrange's methods and then used Lagrangian formulating through the idea of connected mechanical system described by means of Lagrange's [...] equations of motion of a connected system. In our talk, the first part of the Lagrangian and its specific formulation adopted by Maxwell are discussed.

Selected References

Faraday M (1839–1855) Experimental Researches in Electricity. 3 vols. Taylor, London
Gillispie CC, Pisano R (2014) Lazare and Sadi Carnot. A Scientific and Filial Relationship. 2nd ed. Springer, Dordrecht
Lagrange JL (1788) Méchanique analitique. Desaint, Paris
Maxwell JC (1873) A Treatise on Electricity and Magnetism. 2 vols. CP, Oxford

Pisano R (2013) On Lagrangian in Maxwell's electromagnetic theory. Scientiatum VI. The University of Federate. Rio de Janeiro Press, Brazil, pp. 44-59
Pisano R, Bussotti P (2020) Historical and Foundational Details on the Method of Infinite Descent: Every Prime Number of the Form 4n+1 is the Sum of Two Squares. Foundations of Science 1:1-32
Pisano R, Marmottini D (2017) Nature of Science Teaching: Notes on the Lagrangian Methods in Maxwell's Electromagnetic Theory. SISFA Proceedings. Pavia. PUV, pp. 263-268

Da Newton a Maxwell / 26

On the Proposition LXVI, Book I, Principia Newton Geneva Edition

Author: Paolo Bussotti[1]

[1] *DIUM, Udine University, Italy*

The Proposition LXVI (Book I, Newton's Principia) with its 22 corollaries is the longest proposition of Newton's masterpiece. It faces the three bodies-problem. This problem cannot be solved in general terms; Newton by few qualitative indications solved it in specific cases. Based on previous and current research on Newton's Geneva Edition ([1739-1742]1822), we remark that Geneva Edition's editors, Le Seur and Jacquier, explained Newton's approach to this famous problem. They added an interesting series of footnotes to clarify Newton's procedures. In our talk we will 1) explain the meaning and the most important features of this Prop./corollaries; 2) analyse the structures of their footnotes in the range of this Prop., and as a case study.

References

Bussotti P, Pisano R (2014) Newton's Philosophiae Naturalis Principia Mathematica "Jesuit" Edition. Accademia Nazionale Lincei–Matematica e Applicazioni 25/4:413–444
Bussotti P, Pisano R (2017) Historical and Philosophical Details on Leibniz's Planetary Movements as Physical-Structural Model. In: Pisano R, Fichant M, Bussotti P, Oliveira ARE (eds). College Publications, London, pp. 49-92.
Newton I ([1726] [1739-1742] 1822) Philosophiae Naturalis Principia Mathematica, auctore Isaaco Newtono, Eq. Aurato. [...] Thomae le Seur et Francisci Jacquier [...]. A. et J. Duncan, Glasgow.
Pisano R, Bussotti P (2016a) A Newtonian Tale Details on Notes and Proofs in Geneva Edition of Newton's Principia. Journal of the British Society for the History of Mathematics 31/3:160-178
Pisano R, Bussotti P (2016b) The Fiction of the Infinitesimals in Newton's Works: A note on the Metaphoric use of Infinitesimals in Newton. Isonomia 9:141-160

Strumentaria / 19

The introduction of the decimal metric system in the Este Duchy

Author: Elena Corradini[1]

[1] *Università di Modena e Reggio Emilia*

The report presents, through documents and tools still preserved, the complex process that led, in the mid-1800s, to the adoption of the decimal metric system in the territories of the Este Duchy, characterized by a remarkable metrological multiplicity. The process had been started by a law of the Italian Republic in 1803 but, despite the publication of comparison tables between the new and existing measures and weights, the old measures continued to coexist alongside the new ones.
Several years after the Restoration of the ancient rulers the archiduc Francesco V of Austria Este who in 1849 sanctioned, starting from 1852, the introduction of the decimal metric system and appointed a Commission on weights and measures chaired by Stefano Marianini and Giuseppe Bianchi who were in charge of going to Paris to conduct the experiences of measure with the new archetypes that

had been ordered there.
In Paris, they had made, through Jean Baptiste Biot and Victor Regnault,one kilogram sample and a precision balance from Louis Joseph Deleuil a sample meter, a dial gauge for linear measurements and a machine for dividing in a straight line by Guillaume Perreaux.
When all the equipment was received in Modena, in 1851 work began on the Metrology Cabinet, located in a room in the Palazzo Ducale adjacent to the Astronomical Observatory.
In August 1852. after the Tables of comparison were published, the Metric Workshop completed the construction of the archetypes but the entry into force of the decimal metric system was postponed to 1/1/1857 after the production of 72 samples of the new measures for each of the 72 administrations of the Estense State in the new restored rooms of the Metric Workshop, obtained seventeenth-century ducal stables.
In 1858, the Commission on Weights and Measures was dissolved and the closed metric workshop was closed: in the same year a copy of the archetypes for the measurements to be performed in the Observatory of the Roman College had been sent to Rome.

Strumentaria / 39

Iconografie e strumenti astronomici del Museo archeologico A. Salinas di Palermo

Author: Maria Luisa Tuscano[1]

[1] *SISFA*

Intitolato ad Antonio Salinas (1841-1914), che ne fu il direttore dal 1873 avviando il metodo scientifico nello studio dei suoi reperti, il Museo accoglie prestigiose collezioni, in parte derivanti da preesistenti musei di Palermo, in parte dagli scavi realizzati in Sicilia e in parte da ulteriori acquisizioni e donazioni. Nel grande patrimonio esposto, alcuni reperti presentano riferimenti iconografici al cielo dell'antichità. Ad essi si aggiungono degli orologi solari del I secolo d. C. ed altri presenti nell'antico edificio dei Padri Filippini che ospita il Museo. Come memoria storica si menziona anche la prestigiosa raccolta di astrolabi che però non fa più parte della collezione museale.

Strumentaria / 22

Il ruolo del "foliot", regolatore inerziale del tempo, in un modellino di orologio medievale

Author: Pietro Cerreta[1]

[1] *Associazione ScienzaViva, Centro della Scienza, Calitri (Av)i*

Chiunque abbia cercato di comprendere il funzionamento di un orologio medievale, sulla base delle sole descrizioni e delle immagini schematiche trovate in un libro o in un articolo scientifico, si è scontrato con la difficoltà di rappresentarselo in azione. Infatti, risulta piuttosto complicato capire, senza vederne il movimento, il ruolo svolto nella scansione del tempo dalla coppia *verga-foliot*, che in tale congegno compare per la prima volta. Per ovviare al problema, sono ricorso ad un modellino che, azionato da un peso trainante, mostra l'interazione di questa coppia con la corona dentata dell'orologio, realizzato coi materiali di un kit, proprio a ciò predisposto.
Parlando dell'orologio medioevale Antonio Simoni, storico dell'orologeria, si esprimeva in questo modo: *«È uno spettacolo che non ci si stanca di stare a guardare: infinitamente più suggestivo che non l'oscillare di un pendolo o il veloce vibrare dei bilancieri moderni. Il mondo umanistico ne fu estasiato e percosso di meraviglia»*.
Si tratta, infatti, di mettere in scena uno spettacolo, che combina in maniera incantevole le antiche conoscenze umane sulle macchine semplici con quelle più recenti sull'inerzia rotazionale, intuite dagli artigiani del Duecento, ben prima della formulazione delle leggi della dinamica newtoniana. Caratteristica della coppia *verga-foliot* era la sua forma a T, costituita da un'asta verticale, la *verga*,

e da una sbarretta orizzontale detta *foliot*, la quale recava ai suoi estremi due masse mobili uguali. Il nome *foliot* proveniva dal francese *folier*, folleggiare, cioè andare da una parte e dall'altra "come un folle". Dunque il *foliot* è qualcosa che ogni tanto si ferma e riparte girando all'indietro, con una velocità legata, appunto, all'inerzia rotazionale delle sue masse. Sono proprio queste ultime che, spostate anche di poco lungo la sbarretta, ne modificano il tempo d'oscillazione. Userò alcuni video, realizzati ad hoc, per evidenziare lo stupefacente andirivieni del *foliot*.
emphasized text

Teorie nel '900 / 12

The ancestors of the two-component theories of neutrino

Author: Giulia Carini[1]

[1] *MPIWG*

The two-component theories of neutrino were developed in 1957, right after the discovery of parity violation in weak interactions, which had taken place the previous year thanks to the theoretical studies of Tsung-Dao Lee and Yang Chen-Ning. The choice of the plural in the word "theories" is due to the fact that, in that year, three papers - all containing the same theoretical idea - were published. Although this theory found fertile ground only in that moment, it was actually rooted in the 1929 work of Hermann Weyl, who, in an attempt to get rid of the negative-energy solutions to the Dirac equation, had coined the term "Zweikomponententheorie". However, Weyl's suggestion was not the only road leading to a two-component approach. Another attempt in this direction, although driven by different motivations, was made in 1937 by Ettore Majorana, who also shared the will to drop the negative-energy solutions. This would have allowed him to construct a theory of neutral particles, such as neutrinos, that could be equivalent to their own antiparticles. Therefore, Majorana came up with another type of two-component theory. Even though Lee & Yang's theory was based on Weyl's reformulation of the Dirac's equation, Majorana also played a role in there, because not the whole physics community was ready to accept an interpretation of neutrinos as "Dirac particles". Therefore, some physicists started to describe how the two-component theory of neutrino and Majorana's theory could be reformulated so to be equivalent for the free-particle, massless case.
In this contribution, I will reconstruct a version of this story that differs from the traditionally accepted one, because it sacrifices the "pedagogical" simplified linearity of textbooks for a more complex approach, that takes into account different perspectives.

Bibliography
"Pauli-Fierz correspondence", Pauli Archives, CERN;
Unpublished interviews with C.N.Yang (credit Jinyan Liu).

Teorie nel '900 / 4

Some insight into Feynman's approach to electrodynamics

Authors: Marco Di Mauro[1]; Salvatore Esposito[2]; Adele Naddeo[2]

[1] *University of salerno*

[2] *INFN Sezione di Napoli*

An unpublished formulation of electromagnetism, motivated by Feynman's involvement in undergraduate teaching, was sketched by him in handwritten notes, and subsequently completed in unpublished lectures given at the Hughes Aircraft Company in the late sixties.
Starting from the relativity principle, Lorentz invariance of electric charge and the principle of least action, Feynman derives the Lorentz force, the homogeneous Maxwell equations and the expressions

of the fields in terms of the potentials, including gauge invariance. Adding a couple of empirical assumptions, i.e. the Coulomb law and the superposition principle, he includes the inhomogeneous Maxwell equations.
We compare Feynman's approach with analogous treatments which appeared in the literature starting from 1912. Unlike any of the latter, Feynman's approach gives priority to the potentials, reflecting his ideas about the quantum foundations of electromagnetism and of fundamental interactions, as expressed in several of his writings.
Some considerations about the history and foundations of special relativity, which are naturally suggested by this approach, are given. In fact, if electromagnetism is to be developed as an ab initio relativistic theory, special relativity must be approached independently of detailed electromagnetic considerations, as was first done in 1911.

Bibliography
M.Di Mauro, R.De Luca, S.Esposito, A.Naddeo, Some insight into Feynman's approach to electromagnetism.
R.P. Feynman, Alternate way to handle electrodynamics, (1963).
R.P. Feynman, Electrostatics, Electrodynamics, Matter-Waves Interacting, Relativity. Lectures at the Hughes Aircraft Company; notes taken and transcribed by J.T. Neer, (1967-8).
L. Page, Am. J. Sci. 34, 57 (1912).
P. Frank, H. Rothe, Annalen der Physik 339, 825 (1911).

'900 in Italia / 2

The diffusion of quantum mechanics in Italy (1900-1940)

Authors: Paolo Rossi[1]; Adele La Rana[2]

[1] *Dipartimento di Fisica Università di Pisa*

[2] *University of California - Riverside*

We examine the limited reception of quantum theory in Italy until 1925 and the evolution determined by the rise of quantum mechanics (1925) and by the establishment of the first (1926) and second (1937) university chairs of theoretical physics. A detailed analysis of the introduction of theoretical physics in all Italian universities between 1927 and 1938 is presented, specifying the teachers and the content of the courses.

'900 in Italia / 30

Giovanni Gentile jr. and the new quantum mechanics in Rome

Author: Antonio Bianconi[1]

Co-author: Alessandra Vittorini-Orgeas [1]

[1] *Rome Int. Centre Materials Science Superstripes (RICMASS), Rome, Italy*

We discuss here the key role of Giovanni Gentile Jr in Rome for the first developments in Italy of the New Quantum Mechanics developed by Born, Jordan. Heisenberg, and Dirac and London [1-5]. We will focus on his works made in the first year after his thesis in Pisa. Giovanni Gentile Jr called Giovannino by his friends, moved to Rome University as assistant professor of prof. Corbino in 1927. In January1928 he gave a talk on the new results obtained by Ruterford on the nuclear emission of alfa particles pointing out the paradoxes of the proposed model and the need to apply the new quantum mechanics to shed light on these quantum phenomena, This idea was the starting point for the thesis of Ettore Majorana. In the spring 1928 Giovanni Gentile Jr with new student of Fermi, Ettore

Majorana, verified that the new Dirac theory proposing the correction of the Schrödinger equation to include relativistic spin-orbit interaction was in agreement with the experimental splitting of the X-ray atomic lines due to spin-orbit interaction which is today a fundametal step in the fields of modern spintronics and of quantum processes of configuration interaction between open and closed scattering channels [6].

Bibliography
1. Gentile, G. (1928). Reale Accademia Nazionale dei Lincei, AM, 7,
346-349.
2. Gentile, G., & Majorana, E. (1928). Rend. Accad. Lincei, 8, 229-233.
3. Gentile, G. (1930). Zeitschrift für Physik, 63(11-12), 795-802.
4. Bloch, F., & Gentile, G. (1931). Zeitschrift für Physik, 70(5-6), 395-408.
5. Gentile j, G. (1940). Il Nuovo Cimento (1924-1942), 17, 493-497.
6. Vittorini-Orgeas, A., & Bianconi, A. (2009). Journal of superconductivity and novel magnetism, 22(3), 215-221.

'900 in Italia / **33**

Women scientists in the early italian synchrotron radiation research

Author: Vanda Bouché[1]

Co-author: Antonio Bianconi [1]

[1] *)Rome Int. Centre Materials Science Superstripes (RICMASS), Rome, Italy*

Women scientists gave relevant contributions in the italian syncrotron radiation research, since the early days. The first european synchrotron radiation experiment was performed at the 1GeV Frascati electro-synchrotron in 1963 by an international collaboration directed by Yvette Cauchois [1]. Marta Cremonese, director of the X-ray laboratory of ISS, directed the synchrotron radiation group "Sanità Luce" [2] in 1967-1969 and Cucolo of Naples universty, was the first student at the group "Solidi Roma" in Frascati. The number of women scientists in synchrotron radiation research was growing during the second half of the seventies and many contributed to key experiments [3-6] of the 'PULS' project, (1975-1987) during the gold era of Frascati synchrotron research when Frascati rised to the level of a world leader of X ray spectroscopy using the 1.5 GeV Adone storage ring.

Bibliography
1. Cauchois Y., Bonnelle C., et al, Compt. Rend. Acad. Sci. 257, 409 (1963).
2. Barchewitz, M Cremonese-Visicato et al - J. Phys. C: Solid Stale Phys.. 11, 4439 (1978).
3. Belli, M.); Scafati, A.; et al. - Solid State Communications 35, 355 (1980),
4. F. Sette, P. Perfetti, F. Patella, C. Quaresima, C. Capasso, et al.- Phys.Rev.B 28,4882, ,(1983)
5. Durham, P., Bianconi, A., Congiu-Castellano, A., Giovannelli, A., Hasnain, S. S., Incoccia, L., Morante S., Pendry, J. B. -The EMBO journal, 2, 1441 (1983).
6. Balerna A., E.Bernieri, P.Picozzi, A.Reale, S.Santucci, E.Burattini, S.Mobilio Phys. Rev.B, 31, 3038 (1985)

SISFA - Board: 13 / **58**

Assemblea dei Soci

Augusto Righi (1850-1920) / **41**

Augusto Righi (1850-1920): A new Survey on his scientific works, at a Century of his Death

Author: Giorgio Dragoni[1]

[1] *University of Bologna, Dept. of Physics and Astronomy & INFN, Bologna Section*

Thanks to Istitutional Archives' and Righi's Family materials (documents, manuscripts, letters, photos...) and a new deep look to several Righi's published original papers, it will be possible to run over again his scientific production, so to offer to the attention of the Readers a better comprehension of the original and fundamental role developed by Righi in Physics, in comparison with that of the leading physicists of his time.
For instance, it is intention of the A. to attract briefly the attention of the audience to some of Righi's typical subjects in physics and life episodes like the following:
- Righi's invention of an original loudspeaker
- Righi and the Photoelectric Effect's laws
- Righi and the Discovery of Zeeman Effect
- Righi's relationships with Lorentz and Zeeman
- Righi appreciation of Einstein scientific works and physical method
- Righi's as a Nominee Member of the scientific Solvay Commission.

References
1. G. Dragoni, Augusto Righi: Fisico e Matematico. Una rilettura biografica, in " Quaderni di storia della fisica ", 19, 2017, pp. 47-71.
2. G. Dragoni, Augusto Righi (1850-1920). Una vita tra fisica e matematica. Teorie fisiche, scoperte scientifiche, innovazioni tecniche, in print (2020).

Augusto Righi (1850-1920) / **25**

Lo studio di Augusto Righi sull'interferometro di Michelson

Author: Angelo Pagano[1]

[1] *INFN and Dipartimento di Fisica "E.Majorana" Catania*

Con l'affermarsi della teoria della relativita', il supposto risultato "nullo" dell'esperimento di Michelson e Morley (MM) [1] veniva preso come prova in favore di tale teoria e non si badò più alle critiche espresse da Sutherland[2] e Hicks [3]. Critiche che venivano erroneamente accomunate, genericamente, a quelle, spesso senza fondamento razionale, che venivano mosse alla teoria di Einstein. La questione fu ripresa da Augusto Righi in quattro successive memorie [4]. Più in generale l'esperimento MM ha aperto una serie di esperimenti di "ether drift" che sono stati oggetto di differenti studi anche molto recenti [5,6]. Senza entrare nel dettaglio di questi studi più recenti è sembrato opportuno, nel centenario della morte del Righi, riproporre [7] con qualche aggiornamento, una rianalisi delle principali conclusioni del suo lavoro[4].

References
1. A. A. Michelson, E. W. Morley, Phil.Mag., 24, 449(1887).
2. W. Sutherland, Phil. Mag., 45, 23(1898).
3. W. M. Hicks, Phil. Mag., 3, 9(1902).
4. A. Righi, Nuovo Cimento, XVI, 213(1918); XVIII, 91,(1919); XIX, 141(1920); XXI, 187(1921).
5. R. Lalli, tesi di PhD (FIS/08-M-STO/05) università di Milano A.A. 2009/2010.
6. M. Consoli-A.Pluchino, Michelson-Morley Experiments, World Sc. Pub. Co. Pte. Ltd. (2019).
7. P. Di Mauro, S. Notarrigo and A.Pagano , Quaderni di Storia della Fisica, 2, 101 (1997).

Augusto Righi (1850-1920) / **42**

Augusto Righi and "the intuition of the experiment": looking at the physicist's work through his original instruments

Author: Eugenio Bertozzi[1]

[1] *Department of Physics and Astronomy. University of Bologna.*

According to Righi's university colleague and friend Giacomo Ciamician who spoke at the commemoration held at the Senate few days after Righi's death (8th of June 1920), "the intuition of the experiment" was Righi's most characterizing feature. Ciamician underlined Righi's long-life commitment to repeat the major experiments of the late 19th and early 20th Century by pointing out, at the same time, his inextinguishable tension to carry out a personal adaptation of them.
In fact, Righi's major works such as "L'ottica delle oscillazioni elettriche" published in 1897 or "La materia radiante e i raggi magnetici" published in 1909 are largely based on experiments performed with devices designed and built by Righi himself (some of them existing as unique exemplars).
A recent restoration of Righi's principal instruments conserved at the Department of Physics and Astronomy in Bologna (and carried out in view of a permanent exhibition opening in October 2020) allowed to root Ciamician's words into the historical objects.
The presentation will provide an insight into Righi's experimental intuition by focussing in particular on devices and experiments for the study of electromagnetic waves and matter physics.

References
1. G. Dragoni, Augusto Righi: Fisico e Matematico. Una rilettura biografica, Quaderni di storia del-la fisica 19, 2017, pp. 47-71.
2. B. Carazza; H. Kragh, Augusto Righi's Magnetic Rays: A Failed Research Program in Early 20th-Century Physics, Historical Studies in the Physical and Biological Sciences 21 (1): 1–28 (1990).
3. A. Righi, L'ottica delle oscillazioni elettriche. Studio sperimentale sulla produzione di fenomeni analoghi ai principali fenomeni ottici per mezzo delle onde elettromagnetiche (Bologna, Zanichelli, 1897)
4. A. Righi, La materia radiante e i raggi magnetici (Bologna, Zanichelli, 1909)

Augusto Righi (1850-1920) / **10**

Augusto Righi and the theory of capacitors

Author: Lucia De Frenza[1]

[1] *SISFA*

In 1872, Augusto Righi was appointed assistant to Emilio Villari in Bologna; the following year he became a professor of physics at the Technical Institute, replacing his teacher, Antonio Pacinotti. In these early years, Righi was mainly concerned with the theory of capacitors and electrostatic research. His first work described a new induction electrometer, which served to measure weak charges. In a decade Righi carried out numerous experimental investigations to demonstrate that insulating materials under the influence of a charge did not polarize, i.e. there was no charge shifting within the materials. The charge detected on the opposite side of the insulators, electrified by induction, resulted from penetration by conductors in contact or by electrical particles from the atmosphere. On this hypothesis Righi collided with Giovanni Cantoni. In his essay of 1875 he examined the induction machines made in the second half of the Nineteenth Century, starting with those of Toepler and Holtz, and proposed a classification. In dealing with the technical aspects, Righi was looking for an alternative theory to the classical one of the action at a distance between the charges.

References
Dragoni G. (1998). Augusto Righi. Sperimentatore ed epistemologo. Physis, 35 (2), pp. 419-428.

Dragoni G. (2017). Augusto Righi. Fisico e matematico. Una rilettura biografica. Quaderni di Storia della Fisica, 19, pp. 47-71.
Magrini S. (1927). Augusto Righi di fronte al concetto delle azioni a distanza. Il Nuovo Cimento, 4, pp. 16-23.
Riess P.T. (1870). Sulla teoria delle nuove macchine elettroforiche. Il Nuovo Cimento, pp. 359-368.
Righi A. (1872). Descrizione di un elettrometro ad induzione. Il Nuovo Cimento, 7-8, pp. 123-134.
Righi A. (1875). Sulla penetrazione delle cariche elettriche nei coibenti fissi ed in movimento con applicazione alla teoria dei condensatori, dell'elettroforo e delle macchine ad induzione. Memorie dell'Accademia delle Scienze R. Istituto di Bologna, 6, pp. 87-157.
Righi A. (1881-1882), Le ombre elettriche. Memorie dell'Accademia delle Scienze dell'Istituto di Bologna, 4 (3), pp. 130-133; 4 (4), pp. 99-102.
Villari E., Righi A. (1882). Sulla carica dei coibenti. Il Nuovo Cimento, 11, pp. 42-44.

Laura Bassi: un esempio di donne nella scienza / 59

Una cattedra per Laura Bassi. Bologna 1732

Proiezione del film-documentario
Regia di Alessandro Scillitani
Idea e progetto di Miriam Focaccia e Raffaella Simili

Laura Bassi: un esempio di donne nella scienza / 60

Tavola rotonda

Partecipano: Luisa Cifarelli, Miriam Focaccia, Sandra Linguerri, Alessandro Scillitani

Laura Bassi: un esempio di donne nella scienza / 61

Conclusioni della Tavola rotonda

Didattica e divulgazione in Fisica / 40

Formazione dei docenti e dimensione storica delle discipline scientifiche: per un dialogo tra le due culture.

Author: Ivana Gambaro[1]

[1] *DAFIST, Università di Genova*

Within teacher training programmes devoted to philosophy teachers and physics teachers it is undoubtedly imperative to move beyond the "two cultures" dichotomy: Naturwissenschaften vs Geisteswissenschaften,. Between 1999 and 2015, working as a lecturer and teacher trainer at the SSIS Liguria (Scuola di Specializzazione per l'Insegnamento Secondario), and later at the TFA (Tirocinio Formativo Attivo) 1^ and 2^ cycle of the University of Genova, I have frequently proposed themes from history and philosophy of physics and science within the framework of the activities of Area2 (didactic and discipline in-depth studies) and Area3 (didactic laboratories, tools and methods). Here

I present a short overview of some Syllabi proposed to student teachers of both fields. The first one, "The New Astronomy and the New Science", provides a synthetic historical-critical analysis of the Scientific Revolution, and of the new philosophical themes and physical concepts emerged, through a selection of texts from 16th and 17th century astronomers and natural philosophers, and from 20th century philosophers and historians of science. Similarly "Physics and Philosophy of the 20th century", develops a path from the deterministic framework of the early 19th century to the Copenhagen Interpretation and later advancements, by means of selected texts from popular scientific works by physicists and philosophers. Finally I shortly refer to an on-line tutoring experience where student teachers in physics, philosophy, history and Italian literature have been supported in cooperatively planning didactic activities centred on the figure of Galileo.

Didattica e divulgazione in Fisica / 15

Reporting Experimental Results of a Galilean Teaching Case study

Author: Vincenzo Cioci[1]

[1] *CIREL, University of Lille, France*

Based on previous works such part of doctoral studies of one of us (VC) at the Lille University, France, a mixed with open-ended and closed-ended inquiring concerning *Force Concept Inventory* was arranged at *Liceo scientifico "F. Sbordone"* in Naples. Therefore, an analysis of understanding of physics topics starting from the students' difficulties and from their common sense knowledge was experimentally implemented, as well. Then a feedback on the effectiveness of the historical educational path about Galileo and motion (Pisano and Cioci 2020a, 2020b) – and more generally of the Nature of Science Teaching in history of physics – was produced. Particularly, the experimentations was conducted for three years with more than one hundred students participating. The results were also compared with a control group of about seventy pupils that followed a traditional path. The post–analysis of the misconceptions of students learning will be set into different learning–historically categories giving a related score (non––parametric statistical analysis methods were chosen).

Selected References

Hestenes D., Wells M., Swackhamer G. (1992). "Force Concept Inventory". *The Physics Teacher*, 30, pp. 141-158.
Pisano R., Cioci V. (2020a). *Galileo's Free fall into History Physics & Nature of Science Teaching.* In: Esposito S., Fregonese L., Mantovani R. (eds.) *Proceedings of 38th SISFA Congress.* Pavia: Pavia University Press, pp. 271-278.
Pisano R., Cioci V. (2020b). *Nature of Science Experiments: Exploring Galilean Physics of Motion.* In: La Rana A, Rossi P. (eds.) *Proceedings of 39th SISFA Congress.* Pisa: Pisa University Press, in press.
Wilcoxon F. (1945). "Individual comparisons by ranking methods". *Biometric Bulletin*, 1 (6), pp 80–83.

Didattica e divulgazione in Fisica / 18

"In the beginning": physic and cosmology in the XX and XXI centuries art.

Author: Eleonora Loiodice[1]

[1] *ce*

From the early time humans have always expressed the desire to explain the origin of cosmos through narrations. The representations of this desire were also tangible signs of the connection with the

universe. They brought awareness of a world beyond their reach and often functioned as scientific observation tools and as three-dimensional calendars.
In the mid-20th century there was a change in cosmological understanding that arose from the dissemination of ideas from new physics developed in the first half of the century. Artists who wished to represent the newly understood nature suggested by these ideas had to find new ways of doing so and, among visual artists, abstracted forms of representation were one outcome.
The aim of this talk is to show how physics, the scientific concepts of the 20th century have influenced not only culture, but also contemporary art. It also wants to show how contemporary art has tried to represent the birth of the universe. In particular, we will focus on the analysis of Grosse fatigue (2013) by the artist Camille Henrot, a work in which different languages and disciplines are intertwined: comparative mythology, physics, anthropology, etc. All this also allows us to have an interesting suggestion on an effective communication of scientific concepts in the new millennium.

Bibliography

Bertol D., *Framing the land and sky: art meets cosmology in a sustainable environment*, «Leonardo», vol. 39, n. 2, Cambridge, MIT Press, 2006.
De Paoli M., *L'infinito. Il vuoto*, Bari, Schena editore, 1988.
De Rosa M., Fowler. C., *Creating Entangled Histories of Museum Collections*, Milano, Mimesis, 2019.
De Santillana G., von Dechend H., *Hamlet's mill*, Boston, Gambit, 1969.
Novello M., *Qualcosa anziché il nulla. La rivoluzione del pensiero cosmologico*, Torino, Einaudi, 2011.
Rycroft S., *Art and micro-cosmos: kinetic art and mid-20th century cosmology*, «cultural geographies» vol.19, n. 4, 2012.

Didattica e divulgazione in Fisica / 13

The historical transition from the Young's double slit experiment to the Davisson – Germer experiment, as taught to undergraduate educators. The educational outcomes and implications.

Authors: Aristotelis Gkiolmas[1]; Artemisia Stoumpa[1]; Constantine Skordoulis[1]; Panagiotis Lazos[1]; Anthimos Chalkidis[1]

[1] *Department of Primary Education, National and Kapodistrian University of Athens, Greece*

n the present work a teaching method is presented, concerning the way that a sample of undergraduate students is instructed about two basic experiments in the history of Physics: The Young's double-slit (interference) experiment and the Davisson - Germer experiment, which essentially proved that particles (electrons) do behave like waves(de Broglie hypothesis). The research question behind this research project is whether it is possible to teach students about the very important aspects of wave interference and wave properties of matter (Vokos et al., 2000) , by avoiding mathematical formalism and difficult Physics' concepts as much as possible. There have been similar efforts in the past, in the area of educational research (Baily and Filkenstein, 2010; Krijtenburg-Lewerissa et al., 2017), but these efforts usually refer to students with a good physics and Mathematics' background. The novelty here is that future educators - with weaknesses in Physics and with not an interest in Physics taken for granted - are addressed.
The students watch both the experiments in front of them, they have some level of interaction with what is happening and are interviewed, in semi-structured research interviews about: (i) what they predict that will happen, (ii) what they see happening and (iii) what they learned about it (meta-knowledge). The first experiment is executed both in its original form with water waves with laser light, but also in the alternative form with laser light. The second experiment is executed through computer simulations (phet colorado and others) (McKagan et al,. 2008) and animations.
Prior to the interviews with the N=6 students, N′ = 2 were pilotically interviewed, in order to improve the interviews. Also the N=6 students were given a pre-test and a post-test questionnaire, so as to measure what they learned from this teaching and experimental sequence.
The results concerning the educational outcomes – given the limitations o the sample – are encouraging.

References

Baily, C., and Finkelstein, N., D. (2010). Teaching and understanding of quantum interpretations in modern physics courses. Physics Education Research, 6(1), 1-11.
Krijtenburg-Lewerissa, K., Pol, H., J., Brinkman, A., and van Joolingen, W., R. (2017). Insights into teaching quantum mechanics in secondary and lower undergraduate education. Physical Review, Physics Education Research, 13(1), 1-21.
McKagan, S., B., Perkins, K., K., Dubson, M., Malley,C., Reid, S., LeMaster, R., and Wieman, C., E. (2008). Developing and Researching PhET simulations for Teaching Quantum Mechanics. American Journal of Physics, 76 (4), 406-418.
Vokos, S., Shaffer, P., S., Ambrose, B., S., and McDermott, L., C. (2000). Student understanding of the wave nature of matter: Diffraction and interference of particles. Physics Education Research, American Journal of Physics, Suppl. 68 (7), S42-S51.

Didattica e divulgazione in Fisica / 37

La Collezione degli Antichi Strumenti di Fisica del Dipartimento di Fisica e Astronomia di UniCT: esperienza didattica e di divulgazione scientifica

Author: Josette Immè[1]

Co-author: Roberta Raciti

[1] *Università di Catania - Dipartimento di Fisica e Astronomia "Ettore Majorana"*

Il Dipartimento di Fisica e Astronomia "Ettore Majorana" dell'Università di Catania è depositario di un prezioso patrimonio di "beni culturali scientifici", che ha un grande valore storico oltre che scientifico.
La ricca collezione, che attualmente fa parte del Sistema Museale di Ateneo (SiMUA) da poco costituito, comprendendo al momento quasi 250 strumenti antichi restaurati, testimonia che quanto oggi è stato realizzato dai fisici catanesi trova le sue radici nell'impegno faticoso e lungimirante delle precedenti generazioni di scienziati. Non a caso la prima cattedra di Fisica istituita nel 1779 nella Regia Università di Catania fu proprio di Fisica sperimentale, anche se all'interno dell'insegnamento di Filosofia.
Anche se ancora la collezione non gode di una location adeguata all'importanza e alla ricchezza della strumentazione, tuttavia la visita dell'esposizione degli strumenti antichi viene inserita in tutte le iniziative che vedono coinvolto il pubblico esterno, soprattutto studenti delle scuole medie di I e II grado, in particolare nelle iniziative organizzate nell'ambito del Piano MIUR Lauree Scientifiche, volto alla promozione della cultura scientifica (Open Day, Settimana della Cultura scientifica e tecnologica, Notte dei Ricercatori, Olimpiadi di Fisica, visite guidate ai laboratori del DFA,...).
Più recentemente, un progetto di Alternanza Scuola-Lavoro, oltre che indirizzato a sensibilizzare gli studenti verso i temi della valorizzazione e promozione dei beni culturali e degli strumenti scientifici antichi in particolare, è stato occasione per coinvolgere gli studenti nell'avvio di una nuova catalogazione della strumentazione, attraverso la ricerca di informazioni utili alla sua identificazione e caratterizzazione. In un'occasione gli studenti sono stati altresì protagonisti della fruizione della collezione, presentando e "raccontando" gli strumenti a loro coetanei, testimoniando la grande potenzialità di divulgazione scientifica che una collezione di strumenti antichi possiede.

English version

The collection of the ancient physics instruments of the Department of Physics and Astronomy of UniCT: Teaching experience and scientific dissemination

The Department of Physics and Astronomy "Ettore Majorana" of the University of Catania is repository of a precious "scientific cultural heritage", which has a great historical as well as scientific value. The rich collection, which is currently part of the Museum System of Ateneo (SiMUA) recently constituted, including at the moment almost 250 restored ancient instruments, testifies that what the physicists of Catania have achieved today has its origin in the hard and far-sighted commitment of the previous generations of scientists. It is no coincidence that the first chair of Physics in 1779 in the Royal University of Catania was just Experimental Physics, within the teaching of Philosophy.

Although the collection does not yet have a location suitable to its importance and richness, however, the visit of the exhibition of ancient instruments is included in all the initiatives that involve the external public, especially school students, in particular in the initiatives organized in the framework of the Plan MIUR "Lauree Scientifiche", aimed at the promotion of scientific culture (Open Day, Week of Scientific and Technological Culture, Researchers' Night, Physics Olympiad, guided visits to the DFA laboratories, ...).
More recently, a project of "Alternanza Scuola-Lavoro", as well as aimed at raising awareness among students on the promotion of cultural heritage and ancient scientific instruments in particular, was an opportunity to involve students in the start of a new cataloging of the instruments, through the search for information useful to their identification and characterization. Once the students were also protagonists of the fruition of the collection, presenting and "telling" the instruments to their peers, testifying to the great potential of scientific dissemination that a collection of ancient instruments possesses.

Didattica e divulgazione in Fisica / **17**

The electromagnetic field photographed by Berenice Abbott

Author: Benedetta Campanile[1]

[1] *Università degli Studi di Bari Aldo Moro*

In the 1960s the American photographer Berenice Abbott (1898-1991) took photos of the electromagnetic field for the Physical Science Study Committee project developed at the Massachusetts Institute of Technology. The project became a reform program in the teaching of physics that influenced the teaching of the subject all over the world, also reaching Italy thanks to Giampietro Puppi.
Abbott was famous for her black and white photos of New York City architecture documenting the change in the city according to the New Deal, while her passion for scientific photography was a key chapter in her art since 1939. In fact, she brought her vision of unity between science and photography to MIT. She invented experiments and built her tools to photograph invisible and difficult to capture phenomena. With her originality Abbott managed to express the poetry of science and its contents. In particular, she captured the essence of the movement in the form of the wave and managed to merge the undulatory and corpuscular nature of light in a single photo.

References

MIT Institute Archives and Special Collections, MIT Oral History Program, Oral History Interviews on the Physical Science Study Committee, MC 602, Box X.
NY Public Library, Manuscript and Archives Division, Berenice Abbott's Papers, Box 10, Folder 6, "Photography and Science", New York City, April 24, 1939.
Abbott B., Documenting Science, ed. R. Kurtz, Steidl, Göttingen 2012.
Campanile B., Fermate il tempo! La fotografia ad alta velocità, in F.P. de Ceglia, L. Dibattista (a cura di), Il bello della scienza. Intersezioni tra storia, scienza e arte, FrancoAngeli, Milano 2013, pp. 189-204.
Comitato per lo studio della scienza fisica (PSSC) (a cura di), Fisica, voll. 1 e 2, Zanichelli, Bologna 1963.
Daston L., Galison P., Objectivity, Zone Books, New York 2010.
Haaften J. (van), Berenice Abbott: A Life in Photography, W. W. Norton & Company 2018.

SISFA - Board: 17 / **62**

Quarant'anni di congressi SISFA

interventi liberi

SISFA - Board: 18 / **63**

Chiusura del Congresso