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Lippmann: history, art and science in one photo

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Abstract: Gabriel Lippmann was awarded the Nobel Prize in Physics in 1908 for the invention of a method of colour photography exploiting the phenomenon of reflection interference, a rather unknown method today. The original Lippmann plates are very beautiful and extremely rare and, to our knowledge, only one exists in Italy at the Department of Physics and Astronomy in Florence. The history of the Italian plate is interesting and tortuous: in 1914 Gabriel Lippmann sent three interferometric plates to Augusto Occhialini, director of the physics department of Florence. Two were lost but one was found and saved by the Fondazione Scienza e Tecnica (FST), a scientific and cultural institution based in Florence. A meticulous search in the department's archives followed, which brought to light a correspondence between Lippmann and Occhialini. Lippmann's autograph letter made it possible to date the plate, learn its history, learn about the landscape portrayed, and certify its authenticity. This artistic, scientific, and technical jewel is permanently exhibited within the Enlighting Mind exhibition of the Department of Physics and Astronomy in Sesto Fiorentino. This contribution will report on the uncommon and brilliant Lippmann methods to produce interferometric photography (which is an *ante-litteram* nanophotonic approach), as well as the history, conservation, and preservation issues of our plate.

Keywords: Physics, Photography, Heritage

1. Introduction

Gabriel Lippmann (1845–1921) was a physicist awarded the Nobel Prize in Physics in 1908 for his method of reproducing colours photographically using the phenomenon of interference. Lippmann's photographic process was not only a groundbreaking and pioneering attempt to accurately capture colour images but also a significant validation of the wave theory of light, as it is based on standing light waves.

Despite receiving the Nobel Prize in Physics in 1908, Lippmann's method was quickly forgotten due to its complexity and the precise conditions required for successful results. It was soon overshadowed by the Lumière Autochrome technique, which was more practical for everyday use. Autochrome became the first widely accessible and commercially successful colour photography process, driving the growth of colour photography in the early 20th century. As a result, Lippmann's work was rapidly relegated to obscurity, and today it remains largely unknown, even within the physics community. This is a real loss and even a shame, given its strong connections to active research fields such as multilayer optics, nanophotonics, and artificial structural colours, as well as with artistic photography due to the beautiful, vivid colours emerging from the Lippmann plates.

In this contribution, we aim to highlight the history behind Lippmann's Nobel Prize and recount the fortunate series of rare events that led the Department of Physics and Astronomy at the University of Florence to get an original Lippmann plate dated 1914. We will also discuss the current state of the plate's preservation and the plans for its consolidation and restoration.

2. History of the Nobel Prize

Gabriel Lippmann was a physicist who made significant contributions across various branches of physics, including electricity, thermodynamics, optics, and photochemistry. In the late 1870s, Lippmann sought to design an experiment that would definitively demonstrate the wave nature of light by creating and detecting optical standing waves through his innovative interferometric colour photography process. Before briefly addressing the physics behind the method, we will first explore the history of Lippmann's achievement, placing it within the context of the evolving understanding of light and the development of colour photography in the second half of the 19th century.

In 1865, Maxwell published his renowned paper "A Dynamical Theory of the Electromagnetic Field", in which he demonstrated how electric and magnetic fields propagate through space as waves moving at the speed of light, proposing that light itself is an electromagnetic wave. Maxwell's prediction was a groundbreaking moment in science, but it also sparked considerable debate among scientists of his era and beyond. For instance, Maxwell's theory did not clarify the medium through which these waves travelled, leading to the hypothesis of the luminiferous aether and initiating a long-lasting debate that was only resolved by Einstein's theory of relativity in 1905. Of particular relevance to our discussion is the fact that, at the time, there was no experimental evidence to confirm the existence of electromagnetic waves; it was only between 1886 and 1889 that Hertz conducted his famous experiments, providing the first proof of their existence.

During the same period, direct colour photography - capturing the colours of an image in a single exposure - was a goal pursued by many researchers. Some progress was made in the second half of the 19th century, such as the experiments by Edmond Becquerel, but these results were largely accidental, and the nature of the colours observed was not well understood at the time. Another significant challenge with these early colour photographs was the difficulty in "fixing" the colours.

Therefore, Lippmann's work was both timely and significant for advancing the understanding of the nature of light and the development of colour photography. He first announced his invention on 2 February 1891, when he told the Acadèmie des Sciences: "I have succeeded in obtaining the image of the spectrum with its colours on a photographic plate, where the image remains fixed and can endure in daylight without deterioration" (Mitchell, 2010). It is important to note that Lippmann emphasized the stability of his results, highlighting that, unlike other colour photographic processes of the time, his method produced images that did not suffer from rapid chromatic degradation.

Despite his claim, Lippmann's results were not easy to reproduce, and the colour rendering was not optimal. While Lippmann had developed a solid physical and optical approach for capturing colour on an "ideal" emulsion, he did not yet possess the material science knowledge required to create a "real" emulsion suitable for his technique. One key requirement was that the silver salt particles needed to be smaller than 100 nm. Another challenge was creating a panchromatic emulsion, meaning one with consistent sensitivity across the entire visible spectrum. The issue arose because silver halide salts are only sensitive to blue and ultraviolet light. These challenges were eventually solved through the contributions of several researchers, many of whom achieved success through trial and error. For instance, extending the plate's sensitivity to all visible wavelengths was achieved by introducing specific dye sensitizers into the emulsion, based on the pioneering ideas of Hermann Wilhelm Vogel.

Reproducibility was another significant problem. Until 1892, Lippmann had achieved his most successful photographs using transparent collodion-based and albumen-based plates, but the results were still not satisfactory. Establishing the right ingredients and their quantities was a lengthy and time-consuming process. Lippmann's famous remark at his Nobel conference in 1908 reflects this: "Life is short and progress is slow". Soon after 1891, Lippmann recognized that the success of his method depended on industrial, systematic, and controlled plate-manufacturing processes. This realization led to his collaboration with the Lumière brothers, Auguste (1862–1954) and Louis (1864–1948), who made a crucial contribution by developing a gelatine-bromide plate with optical sensitizers, making it almost panchromatic and capable of achieving resolution of just a few tens of nanometres (Hannouch, 2022)

Using these new emulsion plates, Lippmann presented several photographs to the Académie des Sciences on 17 April 1893. The success was immense, as evidenced by the enthusiastic response from members of the (later Royal) Photographic Society of Great Britain in London:

> The pictures [...] show colours of unsurpassed beauty — beyond anything we are accustomed to see in the way of the reproduction of colours — somewhat metallic in appearance, but very bright and of very decided and definite colour [...] like real nature on a bright summer's day. Seeing these first photographs in natural colours we feel we are in the presence of one of the greatest inventions of the nineteenth century. (Mitchell, 2010)

It follows that the success and notoriety of Lippmann's invention was very relevant at the beginning of 20th century. By 1903 Lippmann began to be nominated frequently for the Nobel Prize in Physics by his French colleagues, since his photographic process was also an elegant demonstration of the wave theory of light. For several years, however, the Nobel committee did not consider this prizeworthy because many other epoch-making progresses in the physical sciences occurred at the beginning of 19th century. The situation finally changed, maybe also influenced by political factors related to the imbalance between nations in terms of the number of Nobel Prizes in Physics, with only one awarded to a French scientist in the first seven years. The 1908 prize decision is particularly notable because the Swedish Academy of Sciences overturned the committee's recommendation of Planck in favour of Lippmann. Planck's work was, at the time, considered insufficiently experimental, whereas Lippmann's achievement, in addition to its elegant demonstration of the wave theory of light and the political considerations, was also highlighted for its cultural and artistic significance. This is explicitly stated in the report on Lippmann's candidacy:

> Since no one can deny that this discovery, like the entire art of photography, represents one of the most important advances in human culture, it seems to us that honoring it with a Nobel Prize would be particularly in line with the founder's intentions. (Mitchell, 2010)

The primary reason for Lippmann's Nobel Prize in Physics in 1908 was "his method of reproducing colours photographically based on the phenomenon of interference." As emphasized throughout this manuscript, we fully agree that Lippmann deserved this recognition for the simplicity, beauty, and

(a) (b) (c)

Fig. 1: (a) The UNIFI Lippmann's plate recto/verso, properly illuminated and in reflection condition. (b) The UNIFI Lippmann's plate recto/verso, in diffusion condition. Note that with this angle of view and illumination the image on the plate is not visible. (c) Note also the poor condition of the bitumen on the retro of the plate.

brilliance of his optical and physical technique. At the same time, we conclude this historical account by underscoring the crucial role the Lumière brothers played in developing the appropriate emulsion for the practical implementation of the interferometric process, which was vital to Lippmann's success. Unfortunately, their contribution has been largely overlooked and completely ignored in the context of Lippmann's Nobel Prize in Physics.

3. Discovery of the UNIFI Lippmann's plate

The exhibition Enlighting Mind at the Department of Physics and Astronomy of the University of Florence hosts and shows the sole original Lippmann photograph present in Italy. To highlight the relevance of this presence it is worth pointing out that only a hundred interferometric photographs made by Lippmann himself are conserved around the world. The story of this plate is quite interesting, intricate, and therefore quite long.

Our plate has been discovered in 1990 at the Fondazione Scienza e Tecnica (FST) of Florence, which was founded in December 1987 to promote and spread scientific and technological culture, starting from the recovery, and enhancement of the historic and scientific heritage from the 19th-century Istituto Tecnico of Florence. This is a rich collection – unique in Italy – of thousands of items, divided up among naturalistic collections, scientific instruments, models of machinery, manufactured products, and collections of books of historical interest. FST manages a museum, where part of the collection, in the original rooms and furniture, are accessible to the public since 2007, and the Florence Planetarium (Lippi & Soldani, 2018).

The Physics Cabinet collection is one of the most significant nuclei of this historical heritage (Brenni, 2009; 2013), due to the exceptional quality of the scientific instruments present and the completeness of their ensemble. For this reason, it has from the very beginning been at the centre of the historical heritage recovery activities carried out by FST, which has favoured the formation of a staff specialised in the study and conservation of scientific and technological heritage. This specialisation was part of the objectives for which the FST was conceived, together with the role of linking research centres, the need for conservation and historical research, and dissemination and education activities for students and the general public, as stated in the programme documents of the time: "The basic idea of the project starts from the assessment that it is necessary, and that there is a possibility, to create a structure that is professionally and continuously dedicated to the dissemination of fundamental aspects of scientific culture and that acts as a link between research and innovation, historical tradition and scientific education". The specialisation of centres of this kind, and of the FST in particular, was part of the providential and brilliant vision of the Ministry of Universities and Scientific Research (MURST), which since the end of the 1980s has promoted a rediscovery of the high cultural value that resides in the material heritage of the scientific area, the keystone on which to base a project for the enhancement of scientific culture. In 1988, MURST established a National Committee for Scientific Culture to draw up a programme and guidelines. This outlined with speed and clarity the need for a series of actions including the establishment of specialised centres for the study, preservation, and enhancement of historical collections that had already been musealised, but also for the collection, selection, preservation, and restoration of more recent instrumentation when it became obsolete and left the research centres (Giatti, *in press*). It was in this climate that in 1990 the FST initiated the acquisition on loan of scientific instruments and equipment from the Physics Department of the University of Florence.

Among other items, a small box containing a Lippmann plate was transferred in 1990 from the Physics Department to the FST where, thanks to the expertise of Paolo Brenni, it was identified and where it has been properly preserved for many years.

In 2020, within several international initiatives marking the centenary of Lippmann's death, the Musée de l'Elysée in Lausanne launched the catalogue raisonné of preserved Lippmann plates. The initiative and the contacts that followed, provided the opportunity to start a process of study and conservation of the Florentine interferential photograph (Giatti, 2021). This also led to a historical investigation of archival sources to explain how the plate had arrived in Florence. Thanks to the help of Massimo Mazzoni, head and curator of the Department of Physics and Astronomy archive, who made all the material contained in the archive available online, important letters were eventually retrieved. Three documents kept in the Occhialini Archive and attributed to Gabriel Lippmann, Augusto Raffaele Occhialini (1878-1951), and Giuseppe Occhialini (1907-1993) were fundamental in tracing the historical acquisition of the plate.

Thanks to two of those documents, we know that in February 1914, Lippmann sent three interferential photographs to Occhialini to be shown to the Italian Physics Society (SIF), and that the agreement was to return the plates to Lippmann. The letters also state that the photograph we still have, was taken in 1914 and depicts a country house in Talloires, near Lake Annecy, France. Augusto Occhialini's response letter requests to postpone the return, in fact Occhialini had to wait the next meeting of the Society, in March[1] . No evidence could be found to date of Occhialini's intention to show the plates at one of the SIF meetings, but we can guess that something did not go as planned, as the plates were never returned to Lippmann.

Analyzing these two letters and comparing the handwriting with Lippmann's and Occhialini's (also thanks to the help of Agnese Mandrino), not all aspects become clear. Lippmann's letter also features a letterhead from the Chamber of Deputies, suggesting that a third person wrote both letters and that the letter signed by Lippmann is actually a transcription. The mystery of the letters could also pose doubts on the authenticity of the plate itself. Likely, this is not the case, since we discovered the Sorbonne University in Paris hosts an original and certified Lippmann photograph with the same framing of the same country house of our plate.

Let's go back to the history: in 1914 Augusto Occhialini was an assistant to Prof. Battelli, who was the founder of the SIF, in Pisa. Then, after the years of the First World War, he became assistant to Antonio Garbasso's Chair of Physics in Florence and, in 1918, the first Director of the new Laboratory of Optics and Precision Mechanics. However, he stayed only a few years before going to teach in Sassari in 1921. We think he took the plates with him when he moved from Pisa to the Institute of Physics in Florence where they have remained.

Also interesting is the third letter preserved in the Occhialini Archive, the one from Giuseppe Occhialini to his father, Augusto. There is no date given but, thanks to the reference to Laureto Tieri (1879-1952), we can place it between 1933 and 1949, the period in which Tieri was director of the Florentine Physics Institute (Casalbuoni, Dominici & Mazzoni, 2021). It is difficult today to understand all the references in the text but the letter testifies that there was more than one photograph at the time and that they were in Florence, in those years. As we said in the introduction, Lippmann's work was rapidly consigned to oblivion. In addition, Lippmann died in 1921, and his interferometric photographic method was already almost unknown before the Second World War. We believe that the difficulty in identifying the rare interferential photographs must be the reason why the plates were gradually forgotten until two of them were lost.

4. Conservation and consolidation

Just before the pandemic in 2020, the plate was proposed to Opificio delle Pietre Dure as a case study. On the occasion, the state of conservation was analyzed by conservators Anna Giatti and Barbara Cattaneo, and preliminary consolidation interventions were planned.

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[1] The meetings of the Tuscan section of SIF, established in 1912, were held in Florence or Pisa (Giuliani, 1996)

Although the research had to be postponed, the plate was exhibited at the Stibbert Museum, and after that, it was included in the Enlightening Mind exhibition at the Physics and Astronomy Department of the University of Florence. This last step was the right chance to perform a chemical and physical characterization of the plate's materiality as well as an *in situ* preservation treatment.

In fact, several factors threaten the photographic material's long-term preservation, envisaging further chemical, physical, and biological risks. The natural aging of the materials, as well as their storage in high or unbalanced thermo-hygrometric conditions, can provoke a silver oxidation and reduction, often involving sulfide formation, leading to image degradation (Lavédrine, 2019, p. 32). In common silver gelatin plates, this results in yellowing, discolouration, and 'silver mirroring.' In contrast, in Lippmann plates, any change in the silver structure can alter the geometry of the emulsion, leading to the loss of the interferential response and the irreversible disappearance of the color image. Glass corrosion, particularly from the interaction of acidic compounds, can weaken the substrate, and this can affect the silver grain. Moreover, the oxidation of the Canada balsam, which binds the prism to the emulsion, can cause yellowing, cracks, and delamination. Varnish oxidation, particularly of bitumen, can cause the varnish to become brittle, cracked, or discoloured. Finally, poor storage condition can induce mold growth or pest infestations (La Motte, 2014, pp. 61-70; Gold, 2022).

The Florentine plate is overall in good condition (see Fig. 1). The plate consists of a fine-grained (100-200nm) (La Motte, 2014) silver gelatin emulsion on a glass substrate, cemented, emulsion side, on a glass prism. A black sealing paper along the edges secures the presentation of the plate and the prism. To improve the appreciation of the interferential image, the back of the plate is coated with a black varnish. Loose microsamples of the cement and varnish were analysed through FTIR in transmittance and reflectance at the Institute of Applied Physics "Nello Carrara" belonging to the National Research Council (CNR IFAC) in Sesto Fiorentino. The adhesive used between the plate and the prism was confirmed to be Canada balsam, while the black varnish on the back was confirmed to be bitumen. XRF was also carried out to detect any additives in the black varnish and any peculiarities in the glass and emulsion. Unfortunately, due to the geometry of the object, it was not possible to take measurements directly on the surface of the emulsion, and attempts to measure beyond the glass layer did not lead to satisfactory results.

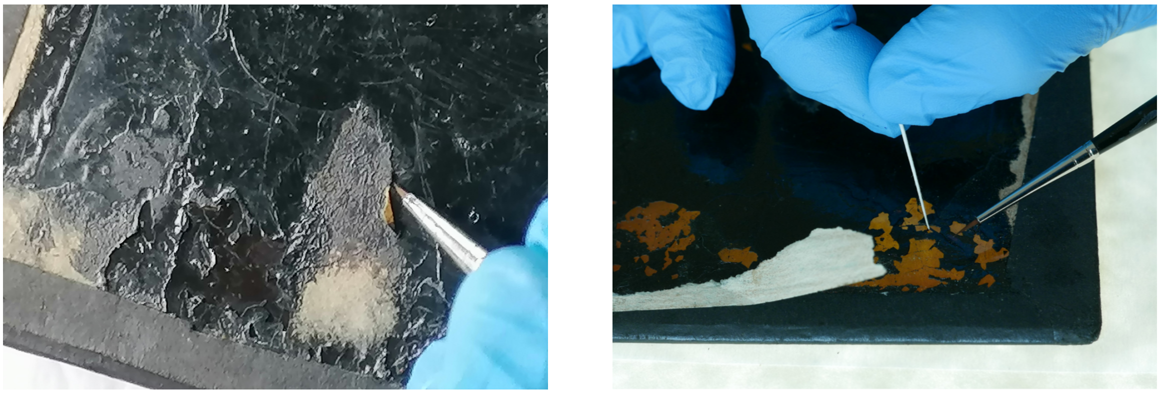
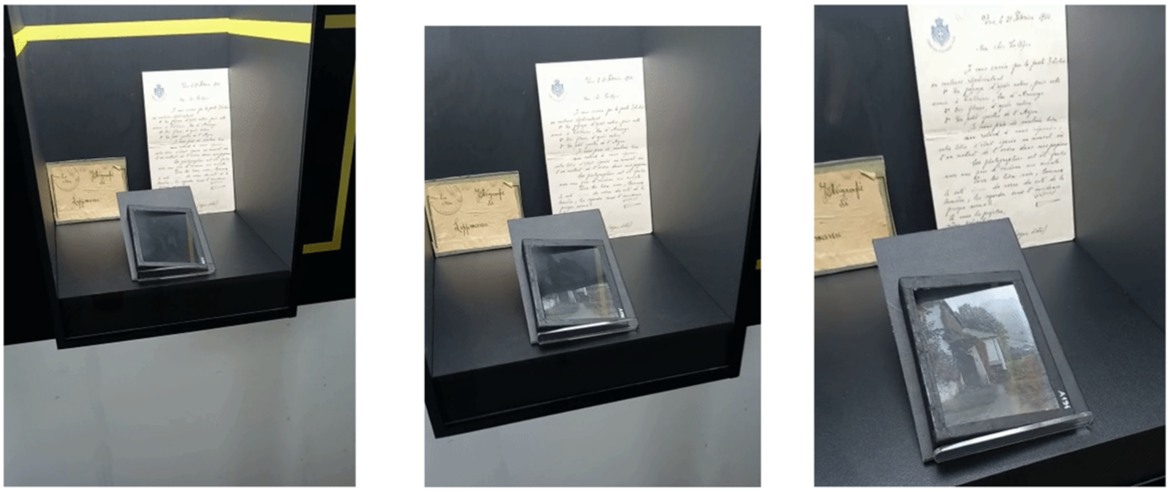


Fig. 2: Detail of the back of the plate during the *in situ* treatment

As stated before, the Florentine Lippmann plate is in overall good condition. In order to complete the *in situ* treatment, the plate was dry cleaned: dust and localized surface concretions were reduced using an air blower, soft brushes, dental paper points and a scalpel (Fig. 2). Localized solvent cleaning with a 1:1 demineralized water and ethyl alcohol solution was performed on the glass. The main deterioration concern was, and still is, the bitumen varnish, unfortunately very brittle, with cracks and losses, which cause also the appearance of orange stains, due to the different interference of light on the emulsion with or without the black backing. The varnish fragments were secured with a water solution at 5% of Aquazol 200, a polymer with thermoplastic properties, and a refractive index close to glass.

The plate is currently displayed in a protective case with appropriate illumination for both viewing and preserving the plate. Inside the case, we also exhibit Gabriel Lippmann's original letter to Augusto Occhialini, retrieved from the Department's archive.(Fig. 3).



(a) **(b)** **(c)**

Fig. 3: These three images of the plate in its protective case, taken from three different viewing angles, demonstrate the peculiarity of Lippmann's process: the colours can only be seen from a specific point of view. (a) the cone of view is taken outside and the plate is almost completely dark. (b) The panel shows that when approaching the correct point of view, suddenly part of the coloured image starts to appear. (c) It shows the view in the optimal condition. On the back of all photos, note the Lippmann letter to Augusto Occhialini dated 1914. Unfortunately, these photos fail to capture the full beauty of the plate.

5. Physics of Lippmann plate

The Lippmann method is unique in transcribing the shades of light, since each point of the Lippmann slide reproduces the exact spectrum of the recorded images, not only its perception via the standard RGB channels reproduction as in any other analog or digital photographic techniques. This comes out from a brilliant exploitation of the interference of light.

The basic idea of the Lippmann technique was to illuminate the photographic emulsion with a standing wave of light, which has a pattern of nodes (points of destructive interference) and antinodes (points of constructive interference). For any kind of waves, stationary waves can be formed by summing up two identical counterpropagating waves. The simplest way to do this is to use a wave reflector and for light, this is obviously a mirror. Note that the standing wave pattern is unique for any light spectrum; in other words, this interferometric pattern serves as a unique nanometric barcode for any possible color of light.

In the original Lippmann protocol, the plate was set inside a photo camera with a special device allowing the insertion of liquid mercury behind the plate, which acts as a mirror and creates a stationary wave in the emulsion. During the light exposure, the nanoscale size of the silver halide grains in the emulsion play their role in faithfully encoding the fine details of the standing wave pattern in a continuous distribution of silver nanoparticles, through the depth of the latent image registered in the emulsion. Once the plate is developed, fixed, and dried following the standard procedure, inside the depth of the emulsion there are planes of reduced silver whose nanoparticle density and their reciprocal distances depend in a unique way on the spectrum of the light that produced the image. The theory also demonstrates that, after proper illumination, a Lippmann photograph reveals to the observer the exact spectrum of the recorded light at each and every point on the plate.

Lippmann photographs, when correctly illuminated with white light and observed at the correct angle, is reflecting point by point the colours of the registered image, while the complementary colour is transmitted away, or rather absorbed by the layer of black pigments (usually bitumen) applied on the back of the plate. This dichroic effect is created by the presence of a periodic pattern of silver metallic nanoparticles within the depth of the plate. Each layer reflects all wavelengths of light, but the periodicity of the pattern enhances the interference, reflecting some colours while suppressing the reflection of the complementary ones. The pattern acts as a fine array of mirrors faithfully reflecting the chromaticity of each point of the recorded image. In modern words, we would name them “ante litteram” dichroic mirrors, which indeed were invented only in the middle 20th century when thin-film coating and multilayer technologies started to be exploited for manipulating light transmission and reflection. Therefore, Lippmann’s research into interference and colour set a milestone in the study for the study of thin film and multilayer interference as tools for a plethora of optical applications.

6. Conclusions

In this contribution, we had two aims. First, we aimed to inform that a fortunate series of rare events led the Department of Physics and Astronomy of the University of Florence to acquire an original Lippmann plate dated 1914.

The second aim was to preserve the memory of and highlight the almost unknown work of Lippmann. Despite its oblivion, we believe that it has an important legacy in science, technology, and art. The relevance for physics is implicit in the fact that the method was awarded the Nobel Prize in 1908, while its relevance for art and culture can be found in the previously cited sentence, quoting Lippmann’s discovery as “one of the most important advances in human culture”. In fact, a few contemporary artists are nowadays rediscovering the beauty and vividness of the interferometric colours emerging from these particular plates. From our side, on the occasion of the International Day of Light 2024 and with the support of SIF and SIOF, we organized the exhibition “The Rebirth of Lippmann Plate” where our historical plate was displayed side by side with contemporary ones.

In conclusion, we would like to report the following comment found in Giuseppe Occhialini’s letter to his father, which was previously discussed: it is "a tribute to a man whose photographs are jealously preserved in a museum and shown to young people," testifying that even for brilliant scientists fully dedicated to innovation and new physics, the relevance of preserving memory and disseminating knowledge was, and must remain, a significant vocation. This is the exact mission that we do have in presenting the plate inside the exhibition Enlighting Mind at the Department of Physics of the University of Florence: the plate is accessible to students and visitors free of charge and with a QR code explaining its history and physics.

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Bibliography

Brenni, P. (2009). *Il Gabinetto di fisica dell'Istituto tecnico toscano: guida alla visita*. Florence: Polistampa.

Brenni, P. (2013). "The Physics Cabinet of the Istituto Tecnico Toscano", in Bennett, J. & Talas, S. *Cabinets of Experimental Philosophy in Eighteenth-Century Europe*. Leiden: Brill, pp. 215-241.

Casalbuoni, R., Dominici, D. & Mazzoni, M. (2021). *Lo spirito di Arcetri. A cento anni dalla nascita dell'Istituto di Fisica dell'Università di Firenze*. Florence : Firenze University press, p. 177.

Giatti, A. (2021). "The Lippmann Plate at the Fondazione Scienza e Tecnica in Florence", in Cattaneo, B. *et al.* (eds.), *Proceedings of the Colour Photography and Film*, 29-30 March 2021, pp. 206-208.

Giatti, A. (in press). "Il patrimonio culturale di interesse storico-scientifico: tutela, conservazione e restauro", *Giornale di fisica*, 65.

Giuliani, G. (1996). *Il Nuovo Cimento. Novant'anni di fisica in Italia 1855-1944*. Pavia: La Goliardica pavese, pp. 25-40.

Gold, J. (2022). "Materiality, Identification, and Conservation of Lippmann Plates", in Hannouch H. (ed.), *Gabriel Lippmann's Colour Photography: Science, Media, Museums*. Amsterdam: University Press, pp. 213–50.

Hannouch, H. (2022). *Gabriel Lippmann's Colour Photography: Science, Media, Museum*. Amsterdam: University Press.

La Motte M. (2014). *Conservation et restauration d'un corpus de photochromies interferentielles obtenues par la méthode de Gabriel Lippmann provenant de la Société française de photographie et de l'Université Pierre et Marie Curie, Caractérisation de l'altération du baume du Canada* Paris: Institut National du Patrimoine.

Lavédrine, B. (2019). *Photographs of the Past. Process and Preservation*. Los Angeles: Getty Publication.

Lippi, D. & Soldani, S. (eds.) (2018). *Fondazione scienza e tecnica: guida al museo*. Florence: Giunti.

Mitchell, D.J. (2010). "Reflecting Nature: Chemistry and Comprehensibility in Gabriel Lippmann's Physical" Method of Photographing Colours", *Notes and Records of the Royal Society of London*, 64(4), pp. 319-324.