Who were Fabry and Pérot?

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In 1897 Charles Fabry and Alfred Pérot published their most important article on what we now call the Fabry–Pérot interferometer. Despite the great importance of this instrument for present-day research in physics and astrophysics, its inventors are almost completely unknown to most physicists. This article presents brief accounts of the life and work of Fabry and Pérot, who at the beginning of the twentieth century were highly regarded by physicists throughout the world for their contributions to optics and spectroscopy. Later they also made many important contributions to astrophysics, including Fabry's 1913 discovery (with Henri Buisson) of the ozone layer in the Earth's atmosphere. © *1998 American Association of Physics Teachers.*

I. INTRODUCTION

The Fabry–Pérot interferometer is a more widely used research instrument today than at any other time in its 100-year history. Its origin derives from the theory of multibeam interference developed by Charles Fabry in 1890–1892, and incorporated into the design of the first interferometer constructed by Fabry and his colleague, Alfred Pérot, in 1897.

In the form first developed by Fabry and Pérot, their F–P interferometer consisted of two perfectly flat glass plates coated on their parallel facing surfaces with thin silver films. In the first interferometer these metal films reflected over 90% of the light incident on them. The portion of a light beam incident on the outer surface of one of the plates, and passing through the silver coating, was then trapped between the silvered plates and reflected back and forth a very large number of times. At each reflection, however, a small fraction (1/10 or less) of the incident beam escaped through the outer surface of the second plate. As a result a very large number of parallel beams of light emerged at the same angle at which they had entered the interferometer and could then be focused to an image by a converging lens. The constructive interference of these many parallel beams of light produced very bright and remarkably sharp interference fringes.[1]

By increasing the reflectivity of the plates, and their separation, the resolution of the F–P interferometer can be increased until it is finally limited only by the natural linewidth of the spectral lines emitted by the source. Modern F–P interferometers used at wavelengths near 500 nm, with a fixed separation of 1 cm between the coated (silver or aluminum) surfaces, and reflectivities for their coated surfaces of 95%, have resolving powers $R = \lambda/\Delta\lambda_{min} = 1.2 \times 10^6$. In special cases, resolving powers of about 2.5×10^7 have been obtained. These values exceed those for prism and grating spectrometers by one or two orders of magnitude. This is one of the great advantages F–P interferometers have over other kinds of optical instruments for precision wavelength measurements, analysis of hyperfine structure of atoms, the cali-

bration of the standard meter in terms of wavelengths of light, and other more specialized applications.[2]

The compensating disadvantages of the F–P interferometer are the elegant but somewhat complex methods that must be applied to obtain the desired precision wavelengths from measurements on the F–P interference patterns. A discussion of these methods is outside the scope of this paper, but good treatments are available in the literature.[3]

Despite the extraordinary usefulness of the F–P interferometer, however, its inventors are much less well known to present-day physicists than is the instrument they developed. Because they used their interferometer to make many important contributions to astrophysics, the names of Fabry and Pérot are more likely to be familiar to astronomers than to physicists, even though both were trained as physicists and served as professors of physics at important French universities throughout their careers.

It is even hard to find reference books on optics or the history of physics that make any serious attempt to answer the question: Who were Fabry and Pérot?[4] This brief article attempts to rectify this sad state of affairs, and to demonstrate why Fabry and Pérot deserve to be better known and more widely appreciated by the present generation of physicists, astronomers, and historians of science.

Fig. 1. Charles Fabry (1867–1945). [Photo courtesy of AIP Emilio Segrè Visual Archives, E. Scott Barr Collection.]

II. CHARLES FABRY

Charles Fabry (1867–1945) was born on June 11, 1867 in Marseille, the seaport city on the Mediterranean in southeast France.[5] When he was 18, he entered the Ecole Polytechnique in Paris and, after graduating two years later, returned to his native Marseille for his *Agrégé de physique* (1889). After his *agrégation*, which gave him the license to teach at any State secondary school, Fabry taught at Lycées in Pau, Nevers, Bordeaux, and Marseille, and finally at the Lycée Saint Louis in Paris. During this time he was preparing his doctoral dissertation on the theory of multibeam interference phenomena, a topic that had been treated as early as 1831 by George Biddell Airy (1801–1892), but not with the depth and sophistication Fabry brought to the subject. In the years 1890–1892 Fabry published two papers on the visibility and orientation of interference fringes, the first of which was a joint paper with his mentor, Professor Jules Macé de Lepinay, and the second, which was accepted by the Faculty of Science at the University of Paris for his *Docteur ès sciences* degree.[6] These papers and the large number that soon followed gradually established Fabry as an authority in the field of optics and spectroscopy.

In 1894 Fabry replaced Alfred Pérot (1863–1925) as Maître de Conférences (Lecturer) at the University of Marseille, where he spent the next 26 years, starting as an assistant in de Lepinay's laboratory. In 1904, when de Lepinay retired, Fabry was appointed to fill his post as Professor of Physics at Marseille (see Fig. 1).

Soon after his arrival in Marseille in 1894, Fabry entered into a close collaboration with Pérot on the design and construction of a multibeam interferometer, based on the theory Fabry had developed. Fabry has described in his own words how the work began on the instrument that later was named after him and Pérot:

> The subject on which we began to work had occurred to me, partly by chance, following an observation in an electrical problem. A young physicist who was working with me wished to study the spark discharges passing between metallic surfaces separated by the very small space of a micron or less; he consulted me as to the method which he could employ to measure such small distances. I was already familiar with the phenomena of interference; and I thought at once that the interference methods would be the only ones capable of giving the required precision. The idea came to me that it would be easy to solve the problem if it were possible to observe the interferences produced across the metal, and I thought that would be possible by using a lightly silvered glass plate. A trial at once showed that this could be done; I was immediately struck by the singular appearance of the fringes, which were visible as very fine lines, and showed, toward the five hundredth fringe, the doubling of the sodium line instead of the disappearance which was ordinarily observed. ... the high reflecting power of the silvered surface was evidently the cause of the phenomenon.
>
> I immediately commenced with Pérot the study of fringes of silvered films, and numerous applications followed.[7]

The actual development of the Fabry–Pérot interferometer occurred during the period 1896 to 1898, with their most important paper describing this instrument being published in 1897.[8] During the six years between 1896 and 1902 Fabry and Pérot published 15 joint articles on their interferometer and its uses in metrology, spectroscopy, and astrophysics.[9] After Pérot left Marseille for Paris in 1901, Fabry continued his work with Henri Buisson (1873–1944) on further applications of this new interferometer, including the establishment of a system of spectroscopic standards (1908), the verification of Doppler broadening in the emission lines of He, Ne, and K (1912), the comparison of spectral wavelengths with the standard meter (1913),[10] and the laboratory obser-
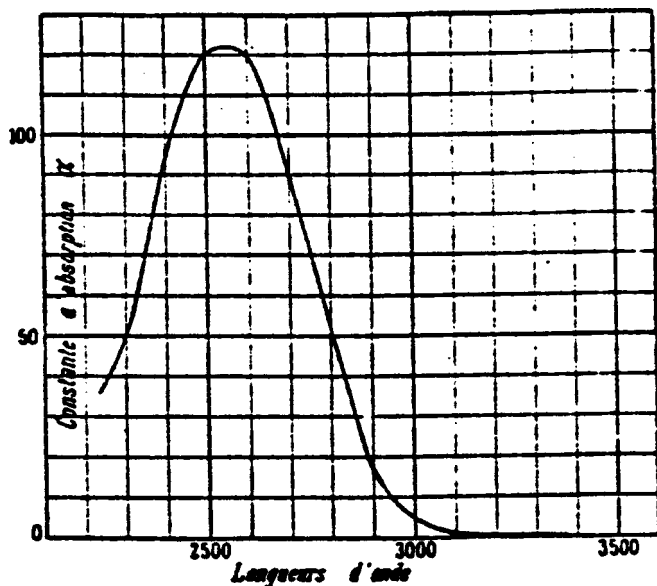
Fig. 2. Graph of the absorption coefficient α as a function of wavelength λ in the ultraviolet [from C. Fabry and H. Buisson (Ref. 13), p. 202]. The strong absorption region centered at about 255 nm is caused by the absorption of solar radiation by ozone in the Earth's upper atmosphere, as demonstrated by Fabry and Buisson.

vation for light waves of the Doppler effect (1914), which had previously been observed only for stellar sources.

Fabry's great interest in astronomy, acquired as a student while observing the night sky with his two brothers, led him to apply the F–P interferometer to the study of the spectra of the sun and stars. For work in astrophysics Fabry and Pérot found their interferometer especially well suited for obtaining very high spectral resolution for sources of small angular size (like the other planets or stars), or for achieving medium to high resolution for sources of low surface brightness (like nebulae or galaxies).[11] As part of this ongoing project, in 1911 Fabry and Buisson discovered the ''nebulium'' lines in the Orion nebula,[12] and in 1913 they were the first to demonstrate that the ultraviolet absorption in the Earth's upper atmosphere was due to ozone[13] (see Fig. 2). Fabry retained his interest in this problem, and in 1929 hosted in Paris the first international meeting on atmospheric ozone (a meeting not attended by a single scientist from the United States!). He also devoted a great deal of his time to developing better photometers for measuring the intensity of spectral lines emitted by both laboratory and astrophysical sources. These instruments were crucial in his explanation of the cutoff of solar radiation in the ultraviolet by the Earth's atmosphere.

His 27 years in Marseille were the happiest and most productive of Fabry's career, despite the primitive laboratories and slim budgets he had to endure. In 1921 Fabry was appointed Professor of General Physics at the Sorbonne and the first director of the new Institute of Optics.[14] In 1926 he also became professor at the Ecole Polytechnique, as the replacement for his old friend and colleague, Alfred Pérot, who had died the previous year. During his career Fabry published 197 scientific papers, 14 books, and over 100 notes, obituaries, and popular articles. For his important scientific achievements he received the Rumford Medal from the Royal Society of London in 1918. In the United States his work was recognized by the Henry Draper Medal[15] from the National Academy of Sciences (1919) and the Benjamin Franklin Medal from the Franklin Institute (1921). In 1927 the honor

most coveted by French scientists was bestowed on him: He was elected to the French Academy of Sciences.

Fabry's sound judgment, personal charm, lucidity of expression, and sense of humor made him the popular choice of colleagues, both in France and throughout the world, for service on important scientific committees. This committee work, added to his greatly increased administrative responsibilities at the Institute of Optics, gradually consumed most of his time and energy, and he soon longed for the chance to devote himself once again to his beloved research.

Throughout his life Fabry was very interested in the teaching and popularization of science. He wrote both textbooks and popular books on science, and for many years taught an introductory course on electrotechnology every Wednesday evening. The course was scheduled for 9 p.m., but the doors of the large lecture room had to be closed at 8:30 p.m., because no more people could squeeze in. His ability to capture a diverse audience of science students, engineers, and working men by his clear, witty words and his skillful use of demonstrations prompted Louis Duc de Broglie to suggest that Fabry would have been an ideal director for the Royal Institution in London, the position Michael Faraday (1791–1867) had filled so ably from 1825 to 1862. De Broglie's reason was simply that Fabry, like Faraday, was both an outstanding research physicist and a spellbinding lecturer.

During World War II Fabry left Paris for a village in Provence not far from Marseille and there continued to carry out secret optics research related to the war effort. At the end of the war he returned to Paris, but his health was failing and he died on December 11, 1945, after having added much luster to the established French tradition in optics, reaching back to Etienne Malus (1775–1812) and Augustin Fresnel (1788–1827). His own words may be quoted to summarize his brilliant career: ''My whole existence has been devoted to science and to teaching, and these two intense passions have brought me very great joy.''

III. ALFRED PÉROT

Alfred Pérot (1863–1925) has always been less well known outside France than Fabry,[16] and remarkably little published information on his career exists, even in the French literature (see Fig. 3). He was born in Metz, France, on November 3, 1863 and educated at the Lycée in nearby Nancy and then at the Ecole Polytechnique in Paris.[17] After completing his course of studies at the Polytechnique in 1884, he returned to Nancy to do research in physics under René-Prosper Blondlot (1849–1930), who is best known for his claimed discovery of N rays in the early years of the twentieth century. About these N rays (named after Nancy, where Blondlot was born and spent most of his career), J. J. Thomson once quipped ''no English, German or American physicist succeeded in finding them, while in France they seemed to be universal.'' In 1888 Pérot received his *Docteur ès sciences* degree from the University of Paris, with a dissertation devoted to a precise determination of thermodynamic constants, which he then used to calculate a value for the mechanical equivalent of heat. His result, which agreed extremely well with the best direct measurements by Joule and Rowland, provided an elegant confirmation of the basic laws of thermodynamics.

After receiving his degree, Pérot was appointed Maître de Conférences (Lecturer) at the University of Marseille. He began work in the rapidly developing field of industrial electricity, publishing some research on the electromagnetic

Fig. 3. Alfred Pérot (1863–1925). [Photo from *The Astrophysical Journal*, Vol. 64 (November, 1926), p. 208; courtesy of University of Chicago Press.]

waves that Heinrich Hertz had discovered in Karlsruhe in 1888. Soon he became a consultant to the burgeoning electrical industry, and in 1894 he received a special appointment as Professor of Industrial Electricity at Marseille. It was at this time that his fruitful collaboration with Fabry began, their first research together being the development of the interferometer that brought them lasting fame. On this project, as in most of their subsequent collaborations in the years 1894–1902, Fabry handled most of the theoretical planning, optical measurements, and calculations, while Pérot contributed his great mechanical skill to the design and construction of the instruments needed for their research. Pérot liked to gather a group of talented technicians around him for the construction of needed research apparatus, but for developing new instruments Fabry always considered Pérot by far the most talented of those working in their laboratory. The first Fabry–Pérot interferometer was undoubtedly so successful because of Pérot's great talent for designing and building equipment (see Fig. 4). In his book on the F–P interferometer, J. M. Vaughan has written:
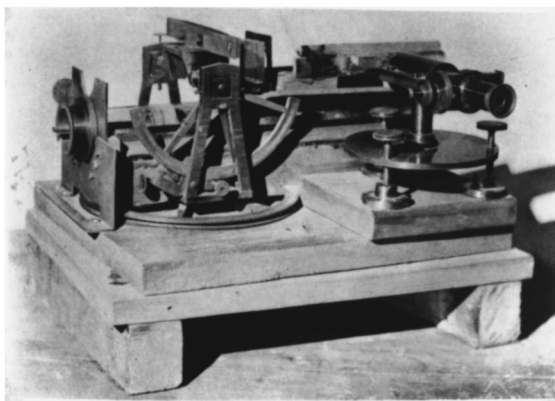

Fig. 4. The original (1898) model of the Fabry–Pérot interferometer. [Photo from C. Fabry and A. Pérot, *Les Annales de Chimie et Physique*, Vol. 16 (January, 1899), p. 122; courtesy of Masson Editeur and Gauthier-Villars, Paris.]

To the modern instrumentalist the startling aspects of this, the first 'Fabry-Perot interferometer,' must be the ability to scan the fringes over several orders, the coarse and fine control of plate separation, the provision for rapid and variable change of plate separation while maintaining near parallelism, and the protection against vibration.[18]

Fabry and Pérot constantly improved their interferometer, and began to apply it more and more to astrophysical problems. They soon discovered small systematic errors in the earlier work of Kayser and Runge (1888) and that of Rowland (1901) on the solar spectrum—researches that both had employed large Rowland gratings ruled in Rowland's laboratory in Baltimore.[19] The more accurate F–P interferometer measurements showed convincingly that the solar wavelengths obtained from the grating spectra were too high by a factor ranging from 1.000 030 to 1.000 037 throughout the spectrum. A graph of this error against wavelength was provided by Fabry and Pérot and could then be used, together with Rowland's remarkably complete solar spectrum, to provide accurately known wavelength standards throughout the visible spectrum.[20] This beautiful piece of research was greeted enthusiastically and quickly put to use by physicists and astrophysicists all over the world.

An outgrowth of this work was a paper by Fabry, Pérot, and Buisson proposing precise values for the wavelengths of a series of important spectral lines, which eventually led to the international system of wavelength standards.[21] By this research it finally became clear that the F–P interferometer provided more accurate results than either diffraction gratings or the Michelson interferometer, and the F–P soon became the preferred instrument for highly accurate wavelength measurements on spectra, whether obtained from sources in the laboratory or in the universe of stars and galaxies.

In 1901 Pérot was asked to organize and direct the new *Laboratoire d'essais* of the *Conservatoire des arts et métiers* in Paris. He did an excellent job, but soon grew weary of the heavy administrative load that fell upon him. He resigned this position in 1908 to become Professor at the Ecole Polytechnique as successor to Henri Becquerel (1852–1908), while doing most of his research at the Meudon Observatory near Versailles. There Pérot devoted himself more and more to solar physics, and especially to the use of the F–P interferometer for the measurement of Doppler displacements of solar spectral lines. For the remaining years of his career, a deep interest in the relationship between laboratory physics and astrophysics motivated his research. But he also continued some work on electricity, making contributions to the development of the triode vacuum tube, and to telegraphy. In the years 1920–1921 Pérot attempted to verify the gravitational redshift predicted by the general theory of relativity, but failed in this overly ambitious endeavor. He served as a member of the French Bureau of Weights and Measures, and in 1915 published (in English) an interesting booklet on the decimal metric system.[22]

Alfred Pérot died on November 28, 1925, at the age of 62. His colleague and close collaborator, Fabry, outlived him by 20 years. Pérot was not well known by physicists outside of France, in great part because he preferred to remain with his family rather than travel abroad for conferences and meetings.[23] This may partially explain why Alfred Pérot is not better remembered today.

IV. CONCLUSION

The above brief accounts of the lives of Fabry and Pérot should make clear that both these French physicists fully deserve more prestigious places in the annals of science than they now occupy. Their importance in the history of science is based not only on their design and construction of the F–P interferometer, but on their many other contributions to physics and astrophysics, only a few of which have been included in this brief account. At a deeper level, surely their most significant contribution was their conviction that laboratory physics carried out on tiny planet Earth cannot be separated from the physics that governs the rest of our vast universe—a conviction now fully shared by today's elementary-particle physicists, astrophysicists, and cosmologists. This idea was well expressed in 1936 by Fabry himself: ''Everything in the universe is thus linked. There is no separation between terrestrial physics and astronomy. There is no border between earth and sky.'' [24]

[1] For a good discussion of the physical principles behind the F–P interferometer, see Francis A. Jenkins and Harvey E. White, *Fundamentals of Optics* (McGraw–Hill, New York, 1976), 4th ed. pp. 301–311; and Frank L. Pedrotti, S. J., and Leno S. Pedrotti, *Introduction to Optics* (Prentice–Hall, Englewood Cliffs, NJ, 1987), pp. 291–300.

[2] The bibliography found in G. Hernandez, *Fabry–Perot Interferometers* (Cambridge U.P., New York, 1986) contains over 400 references to papers from the years 1897–1985 on the design, adjustment, and use of F–P interferometers, and this is quite a selective list, which only includes the original papers by Fabry and Pérot, and more recent references deemed important by Hernandez. A good account of the historical development of the F–P interferometer may be found in the first chapter of J. M. Vaughan, *The Fabry–Pérot Interferometer* (Hilger, Bristol, 1989). An account of some interesting recent applications may be found in William S. Fornall, ''The World of Fabry–Pérots,'' 47–52 Lasers Applicat. (July, 1983).

[3] Methods of analysis of F–P data for the comparison of spectral wavelengths may be found in Max Born and Emil Wolf, *Principles of Optics* (Pergamon, New York, 1980), 6th ed., pp. 333–341, and for the determination of hyperfine structure in Karl Wilhelm Meissner, ''Interference Spectroscopy. Parts I and II,'' J. Opt. Soc. Am. **31**, 405–427 (1941); **32**, 185–211 (1942). Meissner himself used a simple F–P fixed-separation etalon, crossed with a low-resolution spectroscope, to obtain orders of interference of 80 000 for large etalon separations, and theoretical resolving powers of over 2.5×10^7. For a good description of an up-to-date laboratory experiment employing a F–P interferometer, see Paul Nachman and Aaron C. Bernstein, ''Scanning spherical-mirror Fabry–Pérot interferometer: An upper-division optics laboratory experiment,'' Am. J. Phys. **65**, 202–213 (1997). See also S. Tolansky, *An Introduction to Interferometry* (Wiley, New York, 1973), 2nd ed., pp. 117–154.

[4] For example, the *Dictionary of the History of Science*, edited by W. F. Bynum, E. J. Browne, and Roy Porter (Princeton U.P., Princeton, 1981) contains references neither to Fabry, Pérot, nor their interferometer. *Asimov's Biographical Encyclopedia of Science and Technology* (Doubleday, Garden City, NY, 1982), Second Revised Edition contains a brief account of Fabry's life (but nothing on Pérot), and lists Fabry's discovery of ozone in the Earth's atmosphere in 1913 as his most important contribution to science. Azimov fails even to mention their interferometer!

[5] This account of Fabry's life and work is based on the article by Sigalia Dostrovsky in the *Dictionary of Scientific Biography*; on Charles Fabry, *Oeuvres Choisies* (Gauthier-Villars, Paris, 1938), which contains a 20-page list of Fabry's publications (pp. 669–689); on the obituary of Fabry by Louis Duc de Broglie in *Obituary Notices of Members of the Royal Society (London)* (1945–1948), vol. 5, pp. 444–450 (in French); on F. Twyman, ''The Scientific Work of Charles Fabry,'' Nature (London) **143**, 449–450 (1939); and on three speeches—by Jean Lecomte, Albert Arnulf, and E. Vassy—commemorating the centenary of the birth of Fabry and delivered at the opening session of the 1968 International Ozone Symposium in Monaco. These personal accounts of Fabry's life and work are reprinted in English translation in Appl. Opt. **12**, 1117–1129 (1973).

[6] Charles Fabry and Jules Macé de Lepinay, ''Théorie générale de la visibilité des franges d'interférence,'' J. Phys., 2nd Sér. **10**, 5–20 (1891); C.

Fabry, ''Théorie de la visibilité et de l'orientation des franges d'interférence,'' J. Phys., 3rd Sér. **1**, 313–332 (1892).

[7] Charles Fabry, ''Alfred Pérot,'' Astrophys. J. **64**, 208–214 (1926), on 210–211.

[8] Charles Fabry and Alfred Pérot, ''Sur les franges des lames minces argentées et leur application à la mesure de petites épaisseurs d'air,'' Ann. Chim. Phys. **12**, 459–501 (1897), reprinted in Charles Fabry, *Oeuvres Choisies* (Ref. 5), pp. 62–71. This was the earliest article by Fabry and Pérot chosen by Fabry for inclusion in his *Selected Works*.

[9] J. M. Vaughan has written enthusiastically of these 15 papers written jointly by Fabry and Pérot:

> Perhaps, as importantly, in their blend of theoretical analysis, physical insight, description of equipment and practical exploration, the papers themselves provide a masterly guide to scientific investigation [J. M. Vaughan (Ref. 2), p. 2].

[10] In 1913 Benoit, Fabry, and Pérot improved greatly on Michelson's results for such a comparison. On this see Born and Wolf (Ref. 3), pp. 367–369, which explains how the comparison was actually carried out using five F–P etalons of fixed separations 6.25, 12.5, 25, 50, and 100 cm.

[11] For the use of F–P interferometers in astrophysics, see Daniel J. Schroeder, *Astronomical Optics* (Academic, New York, 1987), pp. 251–254; and J. Ring, ''The Fabry–Pérot Interferometer in Astronomy,'' in *Astronomical Optics and Related Subjects*, edited by Zdenêk Kopal (Interscience, New York, 1956), pp. 381–388.

[12] C. Fabry and H. Bulsson, ''Application of the Interference Method to the Study of Nebulae,'' Astrophys. J. **33**, 406–409 (1911). ''Nebulium'' was for years considered a new element whose spectrum only appeared in the light emitted by gaseous nebulae. In 1928 it was shown by the American astronomer Ira S. Bowen (1898–1973) that the green emission lines attributed to ''nebulium'' were actually produced by forbidden transitions in singly and doubly ionized oxygen, and singly ionized nitrogen atoms.

[13] C. Fabry and H. Bulsson, ''L'absorption de l'ultraviolet par l'ozone et la limite du spectre solaire,'' J. Phys., 5th Ser. **3**, 196–206 (1913).

[14] On the occasion of the opening of the new buildings for the Institute of Optics in 1927, Fabry stated his ideas about the type of workers required for its staff and the kind of students it should educate:

> Three types of scientific and technical activity must converge for the solution of every problem in optics: that of the theoretician, who brings out new ideas and makes calculations, that of the physicist, who makes experiments and measurements, and that of the instrument maker, who builds the final instrument.'' [Quoted by Albert Arnulf in Ref. 5: *Appl. Opt.* **12**, 1124 (1973).]

In accordance with this philosophy of research, Fabry made one component of his institute a special school for the training of optical technicians and instrument makers.

[15] The Henry Draper Medal was (and still is) the most prestigious prize in astrophysics awarded in the United States, and was established as an award to a scientist, irrespective of nationality, who had made truly outstanding contributions to astrophysics. On the politics surrounding the award of this medal, especially during the First World War, see Donald E. Osterbrock, *Pauper and Prince: Ritchey, Hale and Big American Telescopes* (University of Arizona Press, Tucson, 1993), pp. 147–149.

[16] This account of Pérot's life and work is based largely on Fabry's obituary of Pérot (Ref. 7) and on Sigalia Dostrovsky's article on Pérot in the *Dictionary of Scientific Biography*.

[17] Pérot graduated from the Ecole Polytechnique in 1884, the year before Fabry began his studies there. There are interesting photographs of each of them in their Polytechnique cadet uniforms in *Les objets scientifiques: un siècle d'enseignement et de recherche à l'Ecole Polytechnique* (Ecole Polytechnique, Palaiseau, 1997), p. 136. [The author is grateful to the Archivist of the Library at the Ecole Polytechnique, Mme. Jacqueline Brenot, for providing him with a copy of this interesting account of the many great scientists produced by the Ecole Polytechnique, and of the scientific instruments they developed during their research careers.]

[18] J. M. Vaughan (Ref. 2), p. 10. The interferometer Vaughan is describing here is the one pictured in Fig. 4, which allowed the separation between the interferometer plates to be changed by the movement of one plate along a precisely machined channel normal to the other plate, which was fixed in position.

[19] Rowland claimed that the absolute values of his wavelengths were correct only to one part in 10^5, which is at least one order of magnitude less than what a F–P interferometer could achieve because of its higher resolution. Also all gratings, especially those ruled around the turn of the century,

were marred by systematic errors in the ruling process which led to inaccurate results even in the comparison of wavelengths.

[20]C. Fabry and A. Pérot, ''Measures of Absolute Wavelengths in the Solar Spectrum and in the Spectrum of Iron,'' Astrophys. J. **15**, 73–96, 261–273 (1902). Also reprinted in Fabry's *Oeuvres Choisies* (Ref. 5), pp. 157–181.

[21]For an excellent account of the precision achieved in interferometric wavelength measurements using the F–P interferometer, see C. Fabry and H. Buisson, ''Wavelength Measurements for the Establishing of a System of Spectroscopic Standards,'' Astrophys. J. **28**, 169–196 (1908). [Fabry and Pérot were both for many years collaborators with the editors, George E. Hale and Edwin B. Frost, in publishing the *Astrophysical Journal*.]

[22]Alfred Pérot, *The Decimal Metric System* (Typographie Plon-Nourrit, Paris, 1915).

[23]One exception was the second meeting of the International Union for Cooperation in Solar Research, held at Oxford University in 1905. Both Fabry and Pérot appear in a photograph taken at this meeting. This is reprinted as Fig. 4 in Joseph F. Mulligan, ''The personal and professional interactions of J. J. Thomson and Arthur Schuster,'' Am. J. Phys. **65**, 954–963 (1997); on p. 961.

[24]Charles Fabry, ''Sur les Confins de la Terre et du Ciel,'' Address on 24 October 1936 to the formal assembly of the five French Academies; reprinted in Fabry's *Oeuvres Choisies* (Ref. 5), pp. 625–632; on p. 632. Fabry delivered this address the year after the publication of his book: *Physique et Astrophysique* (Ernest Flammarion, Editeur, Paris, 1935). This is a popular book containing many perceptive insights into the relationship between physics and astrophysics. The third section of this book Fabry entitled ''Physique Céleste et Physique Terrestre,'' a reflection of his view that both of these deserve to be included on equal terms in what we normally refer to as ''physics.''