

**ȘTEFAN PROCOPIU – THE UNIVERSAL SCIENTIFIC
HERITAGE OF A ROMANIAN SCIENTIST**

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*This paper is dedicated to the memory
of academician ȘTEFAN PROCOPIU (1890–1972)*

The scientific heritage of Ștefan Procopiu (1890–1972), reputed physicist, educator and member of Romanian Academy has an international dimension. His scientific works, reflected in a series of discoveries, opened new directions of research in physics, such as: depolarization of light through the suspension of crystalline particles (Procopiu’s phenomenon), the circular effect of demagnetization discontinuity manifested when an alternative electric current flows through a ferromagnetic wire (Procopiu’ effect – inverse Wiedemann effect), calculation of the magnetic moment of the electron (Bohr-Procopiu magneton), the first systematic measurement of terrestrial magnetism in Eastern Europe.

Keywords: life, scientific work, patrimony museum, correspondence, heritage

LIFE

Even if not sufficiently well-known and appreciated at European and international level, because he lived during the period of the Iron Curtain that separated Europe in two distinct parts, Ștefan Procopiu remains a reputed Romanian physicist, keen researcher, academician, illustrious educator and professor whose heritage has enriched the Romanian science.

Born on January 19th 1890 in Bârlad, a small town in the South East part of the historical region Moldova, he graduated in 1908, head of promotion, the “Roșca Codreanu” high school in his native town [2]. In the same year, he enrolled in the Faculty of Sciences – “Alexandru Ioan Cuza” University of Iași (1908–1912).



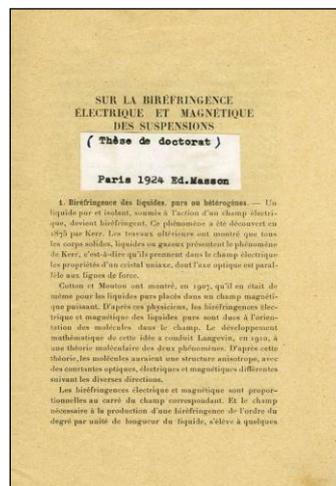
Between 1919 and 1924, he continued his doctoral studies at Sorbonne University in Paris, where he attended the courses of renowned scholars: Gabriel Lippmann (1845–1921), Marie Curie (1867–1934), Paul Langevin (1872–1946), Aimé Auguste Cotton (1869–1951), Charles Fabry (1867–1945). His doctoral thesis, initially coordinated by Professor Gabriel Lippmann until 1921 and, after his death, by Professor Aimé Cotton [1–3], was prepared in the Laboratoire de Recherches Physiques, Sorbonne University.

On 5 March 1924, Procopiu obtains the title of Doctor in Physical Sciences, publicly defending the thesis entitled *Sur la biréfringence électrique et magnétique des suspensions*, rewarded with the mention *très honorable*. His work was published by the Masson Publishing House, Paris, and was sent by the author to the famous physicists of the time, from Romania and abroad, to his friends and collaborators [3,4].

Beginning with 1925, once returned to Romania, Procopiu built up his academic and professional career at the University of Iași. In January 1925 he was appointed, by Ministerial Order, professor in the Department of Gravitation, Heat and Electricity, Faculty of Science of the University of Iași, a position he held until 1962, when he retired, yet he continued to collaborate with the faculty until his death in 1972 [4].

Between 1925–1937, he was also head of the Electrotechnical Institute founded at the Faculty of Sciences – University of Iași. Later on, the institute was integrated as an independent faculty of the “Gheorghe Asachi” Polytechnic School (in the year 1948, the institution was renamed the “Gheorghe Asachi” Polytechnic Institute and, on May 1993 – the “Gheorghe Asachi” Technical University of Iași). In 1955, he was elected member of the Romanian Academy, and invited to coordinate the Physics Section of the Iași Branch of the Academy. In February 1967, he was awarded the title of *Doctor Honoris Causa* of the Polytechnic Institute of Iași. The last years of his life were dedicated, as actually his whole life, to scientific research and teaching at the Faculty of Physics of the “Alexandru Ioan Cuza University” of Iași [2,3].

During his long and prestigious scientific activity, professor Procopiu published three extensive



The first page of the doctoral dissertation (“St. Procopiu” Science and Technicque Museum Iasi patrimony).

books for students and assistants, 162 scientific articles, issued in both Romanian and international journals, 47 papers and dozens of other short interventions in various publications. After a life crowning a prestigious scientific, educational, and cultural activity, Ștefan Procopiu passed away on August 22, 1972, in Iași [4].

THE SCIENTIFIC WORK OF ȘTEFAN PROCOPIU, REFLECTED IN HIS SCIENTIFIC WORKS AND CORRESPONDENCE

The most important part of the scientific activity of the scholar was carried out until 1948, the year when the communist regime took over the power in Romania, after which any connection with the international scientific community was drastically restricted; equally, from then on, professor Procopiu had to face numerous obstacles and difficulties, because of his constant refusal of becoming a member of the communist party.

THE THEORETICAL VALUE OF THE MAGNETON

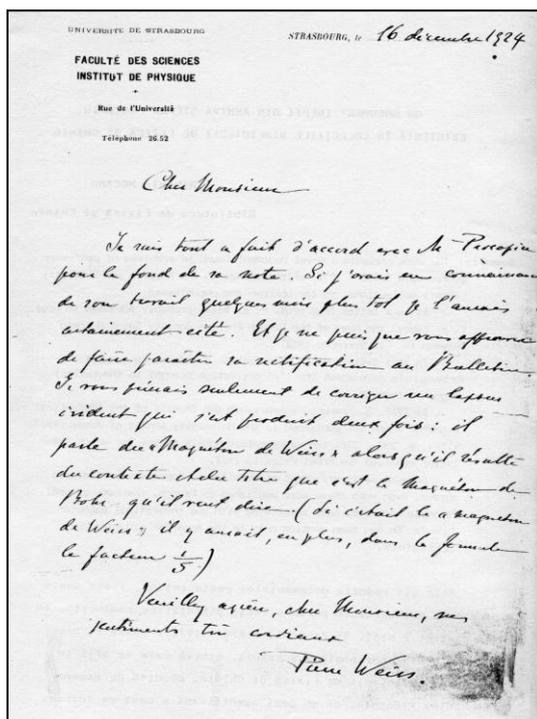
The scientific consecration of Ștefan Procopiu began in 1913, when he published the paper entitled *Sur les éléments d'énergie* [5], in which he established – for the first time in the world – the value of the molecular magnetic moment, acknowledged and known today as Bohr-Procopiu's magneton. He calculated the value of the magneton one year before the Danish physicist Niels Bohr [6,7].

In the paper entitled *Determination of the momentum magnetique moléculaire par la théorie de M. Planck* [8], starting from a series of studies of the French physicist Paul Langevin (1872–1946) on the magnetism of substances, and applying the quantum theory of Max Planck (1858–1947), Procopiu was the first scientist to establish a relationship between the moment of the magnetic orbital of the electron and Planck's constant, and to determine the elemental magnetic quantum, which he called *THEORETICAL MAGNETON* [1,7,30].

The research continued, so that, in the year 1957, together with his collaborator, Constantin Papușoi, Procopiu published the work entitled *Magnétisme. Détermination de la valeur du magneton de Bohr par une méthode de résonance dans l'air ionisé* [9]. In 1963, he published the last paper in this topic, entitled *Determining the value of Bohr-Procopiu magneton from measurements made by a resonance method upon a beam of free electrons in motion: 1) in ionized air, and 2) in vacuum, under the action of a constant longitudinal magnetic field and of a transversal one to radiofrequency* [10].

The prowess of the Romanian physicist Ștefan Procopiu regarding the calculation of the elementary magnetic moment was a scientific topic avoided by the international community, because of the existence of the political Iron Curtain

and also of Western world's conviction on the supremacy of the capitalist system over communism. Certainly, both communities were wrong as to the recognition of scientists' works all over the world. In the end, it is the international community of scientists, and only this community that can attempt at and, sometimes, even succeed in doing justice and establishing the truth. Few examples of scientists' opinions will be presented in the following:



“Strasbourg, le 16 décembre 1924

Cher Monsieur,

Je suis tout à fait d'accord avec M. Procopiu pour le fond de sa note. Si j'avais eu connaissance de son travail quelques mois plus tôt je l'aurais certainement cité. Et je ne puis que vous approuver de faire paraître la rectification au Bulletin. Je vous prierais seulement de corriger un lapsus évident qui s'est produit deux fois: il parle du “Magneton de Weiss” alors qu'il résulte du contexte et du titre que c'est le Magneton du Bohr qu'il veut dire (si c'est le “Magneton de Weiss” il y aurait, en plus, dans la formule le facteur $\frac{1}{5}$).

Veuillez agréer, cher Monsieur, mes sentiments très cordiaux, Pierre Weiss” [6].

Letter dated December 16, 1924, signed by P. Weiss, addressed to Prof. H. Fabry, in which he recognized that he had no information on Procopiu's work and on its priority about the quantified atom model (The letter is in possession of the “Ștefan Procopiu” Physics and Chemistry Library in Iasi).

- On the occasion of a scientific session organized by the French Physical Society (December 15–19, 1924, Paris), Procopiu delivered a lecture entitled “Sur le magneton de Bohr”, thus making known to the scientific world his priority in magneton calculation;
- Physicists Pierre Weiss (1865–1940) and Gabriel Foëx (1887–1963) asserted that “several independent authors (Einstein, Procopiu, Chalmers

Wereide) have established that quantum theory gives the elementary moment” [11].

- In the volume entitled *Development of the Basic Ideas of Physics*, the Soviet physicist D.D. Ivanenco (1904–1994), commenting on Bohr magneton, concluded that “it was introduced for the first time in physics by Șt. Procopiu” [12].
- The German physicist Otto von Auwers (1895–1949) mentions that “This magnitude is the elemental quantum of magnetism. For the first time it is calculated by Ștefan Procopiu” [13].

PROCOPIU’S PHENOMENON

While approaching a new optical phenomenon – namely, the longitudinal depolarization of light by the suspensions of crystalline particles – during his stage at Sorbonne University, Procopiu elaborated a paper titled *Dépolarisation de la lumière par les liquids tenant en suspension des particules cristallines*, communicated at the Paris Academy meeting of 8 August 1921. The paper was published in *Comptes Rendus de l’Academie des Sciences Paris* [14].

In August 1939, Augustin Boutaric (1885–1949) and Ms. Breton from the Faculty of Sciences at Dijon named this phenomenon *THE PROCOPIU PHENOMENON* [15]. The Romanian scientist continued to investigate the depolarization of light along many years, elaborating and publishing several studies in specialized journals in the country and abroad, such as: *Dépolarisation par les solution colloïdales, les précipités cristallins et les dépôts solides sur verre* (“Comptes rendus de l’Academie des Sciences”, Paris, 1935) and *Longitudinal Dépolarisation des Lichten durch Suspensionen von Kristallinen Partikeln und Kolloïdalen Suspensionen in Kolloid-Zeitschrift* (September Heft., Dresden, 1941) [7,25].

PROCOPIU’S EFFECT

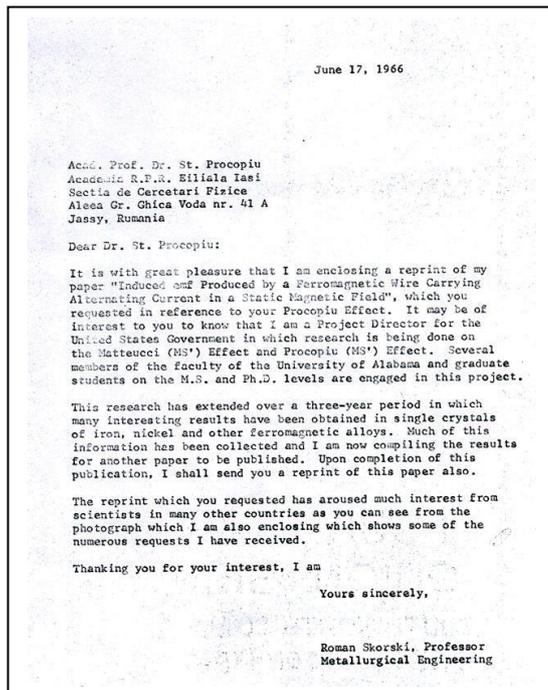
The Barkhausen phenomenon represented a priority research area of professor Procopiu. The results obtained by his research group and his PhD students drew the attention of the international academic community. In his first paper, published in 1930, entitled: *Influence d’un alternate circulaire sur les discontinuités d’aimantation du fer*, Procopiu referred to it as to the “Barkhausen circular effect” [16]. However, it is currently known as the *PROCOPIU EFFECT*, as the priority of his discovery was recognized by the scientific community of that time.

On this topic, Romanian scholars published series of articles treating the variation of Barkhausen's effect in different materials, under the influence of a circular alternative field [27,29].

The phenomenon was "rediscovered" in 1932 by Richard M. Bozorth and Joy F. Dillinger, and called "transverse effect", yet, in 1951, physicists T.A. Hofbauer and K.M. Koch defined it as PROCOPIU'S EFFECT, in recognition of his first work and important contribution in the field of ferromagnetism [17]. Procopiu's works in this field have been recognized by numerous scientists, among which mention should be made of:

- Roman Skórski (Metallurgical Engineering Department, University of Alabama) and Andrzej Duracz (Institut of Mechanics, Warsaw), authors of a study issued in 1965 discussing Procopiu's effect [18],
- M.A.R. Leblanc who, in the paper entitled *Analog of the Procopiu effect in type II superconducting wires carrying an alternating current* refers to the Procopiu effect studied by Skórski and Duracz and the analog effect observed during the replacement of a ferromagnetic wire with a non-conductive type II superconductor wire [19].
- Physicist Alvin B. Kaufman, who in 1965, demonstrated, that the Procopiu effect can be used to construct ferromagnetic wire memories, as shown by the experiments performed all along those years. The author states that: "The concept of memory is grounded in the recent discovery of a new electrodynamic phenomenon based on Procopiu's effect" (*I.E.E.E. Transactions on Electronic Computers*, vol. 16, no.1, p. 86–88, febr. 1967), outlining that, based on Procopiu's effect, a new type of non-destructive memory has been built, possessing important, both technical and economical characteristics [20].
- The German Professor Klauss Stierstadt, University of Munich, devoted a subchapter, entitled "Der Magnetische Barkhausen Effekt", to Procopiu's effect and cited 14 of his and his co-authors papers in the 40th volume of the Springer Series "Tracts in Modern Physics" [21].
- On January 10, 1968, several press agencies announced that the Applied Research Laboratory, Litton Systems Inc. (Woodland Hills, California, USA), created memories for computing machines, starting from the studies developed by the Romanian physicist, Professor Ștefan Procopiu, emeritus scientist of the University of Iasi [22].

During the 1960's, there was a substantial change of letters between Roman Skórski, professor at the University of Alabama and Ștefan Procopiu, two of their letters being reproduced in full below. These two letters, currently preserved by the "Șt. Procopiu" Physics and Chemistry Library of Iasi, reflect the state of research developed by the American University on Procopiu's Effect and Matteuci's Effect in ferromagnetic materials.



June 17, 1966

Dear Dr. Ștefan Procopiu,

It is with great pleasure that I am enclosing a reprint of my paper "Induced emf Produced by a Ferromagnetic Wire Carrying Alternating Current in a Static Magnetic Field", which you requested in reference to your Procopiu Effect. It may be of interest to you to know that I am a Project Director for the United States Government in which research is being done on the Matteucci (MS') Effect and Procopiu (MS') Effect. Several members of the faculty of the University of Alabama and graduate students on the M.S. and Ph.D. levels are engaged in this project.

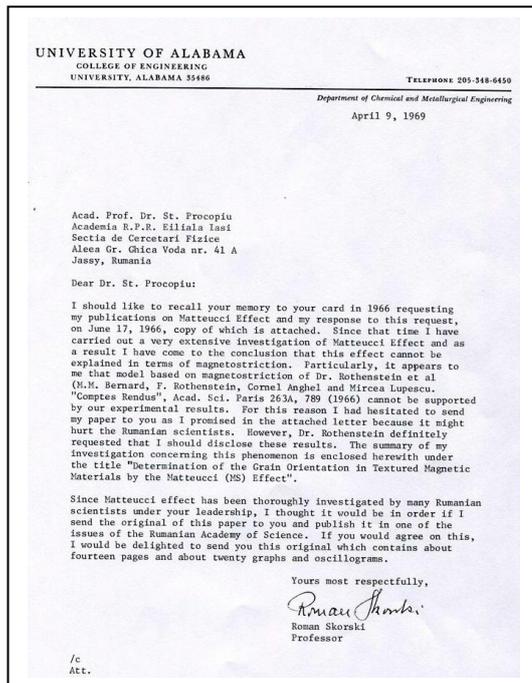
This research has extended over a three-year period in which many interesting results have been obtained in single crystals of iron, nickel and other ferromagnetic alloys. Much of this information has been collected and I am now compiling the results for another paper to be published. Upon completion of this publication, I shall send you a reprint of this paper also.

The reprint which you requested has aroused much interest from scientists in many other countries, as you can see from the photograph which I am also enclosing, which shows some of the numerous requests I have received.

Thanking for your interest, I am yours sincerely,

Roman Skorski

Professor of Metallurgical Engineering



April 9, 1969

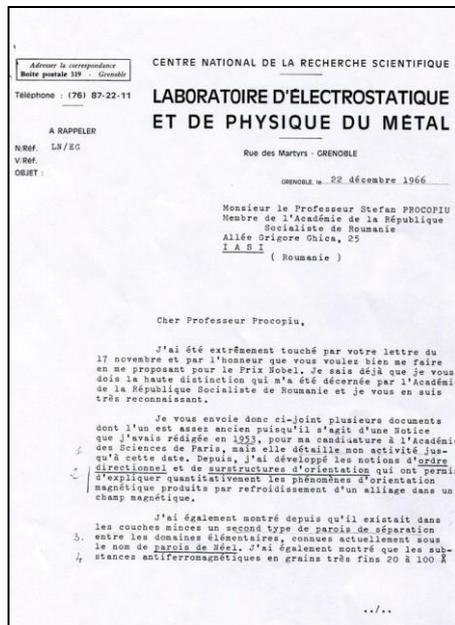
Dear Dr. Șt. Procopiu,

I should like to recall your memory to your card of 1966 requesting my publications on Matteucci Effect and my response to this request, on June 17, 1966, copy of which is attached. Since that time I have carried out a very extensive investigation of Matteucci Effect and as a result I have come to the conclusion that this effect cannot be explained in terms of magnetostriction. Particularly, it appears to me that model based on magnetostriction of Dr. Rothenstein *et al.* (M.M. Bernard, F. Rothenstein, Cornel Anghel and Mircea Lupescu, "Comptes Rendus", Acad. Sci. Paris 263 A,

789, 1966) cannot be supported by our experimental results. For this reason I had hesitated to send my paper to you as I promised in the attached letter because it might hurt the Rumanian scientists. However, Dr. Rothenstein definitely requested that I should disclose the results. The summary of my investigation concerning this phenomenon is enclosed herewith under the title "Determination of the Grain Orientation in Texture Magnetic Materials by the Matteucci (MS) Effect".

Since Matteucci effect has been thoroughly investigated by many Rumanian scientists under your leadership, I thought it would be in order if I send the original of this paper to you and publish it in one of the issues of the Rumanian Academy of Science. If you would agree on this, I would be delighted to send you this original which contains about fourteen pages and about twenty graphs and oscillograms.

Yours most respectfully,
Roman Skorski, Professor



Letter from “Șt. Procopiu” Physics and Chemistry Library Iași

If Ștefan Procopiu had lived in a liberal society and not in a communist country, most likely he would have been able to communicate freely with members of the international scientific community. His correspondence was censored and few of the letters asking for co-operation succeeded in avoiding the barriers raised by communist officials. An example is the letter sent by the notorious French physicist Louis Néel (1904–2000).

In this letter, Néel thanked Procopiu who nominated him for the Nobel Prize in Physics and explained some aspects of his work on antiferromagnetism (developed in 1932) and ferromagnetism (1948). The importance of his concepts has gained the attention of specialists since 1956, being approached in numerous studies of theoretical and practical importance.

TERRESTRIAL MAGNETISM

For nearly three decades, Procopiu has studied and made land measurements on *TERRESTRIAL MAGNETISM*. Initiated in Iași in 1930, his research has yielded valuable results for Romania. The first scientific work on this field was entitled *Elements of earth magnetism in Iași. Iași region of anomaly* [4,7,23].

The first paper on terrestrial magnetism, completed with field measurements, entitled *Les éléments du magnétisme terrestre à Jassy* was published abroad in 1931, in the renowned American magazine “Earth Magnetism and Atmospheric Electricity” [24].

In the paper *Le moment magnétique de la Terre a commencé croître* [25] Procopiu describes how, in the year 1947, while making measurements, he came to the conclusion that Earth’s magnetic moment began to rise since 1932.

The systematic observations and field investigations were materialized in 23 articles, published in both Romanian and foreign specialized journals, of which 12 as single author and 11 in collaboration with his assistants.

MISCELLANEOUS RESEARCH DOMAINS

Throughout all his life, besides the main research topics presented above, Procopiu approached other scientific domains, such as electricity, electromotive force, electrooptics, spectroscopy, double electrical refraction, magnetic permeability, dielectric constant, electrolyte diffusion [1].

REFORMER OF POLYTECHNIC EDUCATION

Throughout his work extended for several decades, Ștefan Procopiu has decisively contributed to the development of physics and polytechnic education in Iasi. Together with several professors (Cristea Niculescu-Otin, Nicolae Costăchescu, Alexandru Cișman, Radu Cernătescu, Gheorghe Alexa, Agricola Cardaș, etc.) from the University of Iași, in 1937 he founded the “Gh. Asachi” Polytechnic School in Iași, being elected the first dean of the Faculty of Electricity (1937–1941) [32].

An open-minded, profound and clear thinker, endowed with a rare capacity of analysis and lured by a progressive vision regarding engineering education in polytechnical schools, the Professor shared throughout his life, in short position papers, his idea in reframing courses and programmes. For example, an inaugural course, entitled: “WHAT ELECTRICITY IS?”, held at the solemn opening of the “Gh. Asachi” Polytechnic School in Iasi on October 14, 1939, a text of great relevance for all generations of engineering educators, was structured into two parts: the former dedicated to the progress of science and technology, the latter – to the role of electricity and to the necessity of its continuous development [32].

PhD supervisor, research group leader, pedagogue, scientist and inventor, a good theoretician and a phenomenal experimenter with a rich imagination and practical sense, Șt. Procopiu remains a landmark in Romanian science history. Considering that: “knowledge is acquired through study, but the facts discovered and the experiments performed are the levers that fix the knowledge”, Procopiu created in Romania a real school of experimental physics [30]. He was equally concerned with endowing the laboratories with modern experimental equipments, and with establishing and expanding the library for the use of students, assistants and teachers. He was very demanding with his students, assistant professors, and technical staff, considering that accuracy of the work done is essential for research and professional development. He supervised 10 doctoral theses in electromagnetism and material science, by which their authors influenced the scientific advancement in the field.

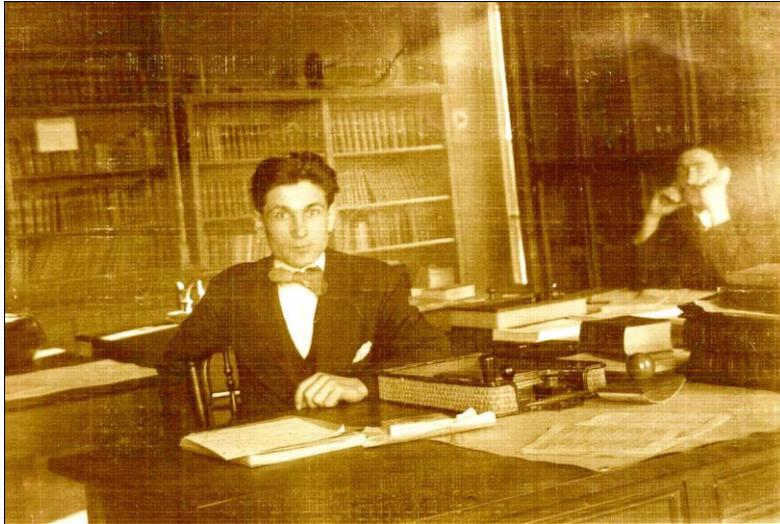
THE SCIENTIFIC AND CULTURAL HERITAGE OF PROFESSOR ȘTEFAN PROCOPIU

An all-comprising and refined spirit, Șt. Procopiu had various concerns about philosophy, religion, art, literature, sports and music. He published 47 articles focusing on the philosophy of science, history of physics and life of renowned physicists, in reputed cultural and scientific magazines issued in Romania, such as: *Viața Românească*, *Ethos*, *Vasile Adamachi*, *Însemnări ieșene* [1]. He has been permanently involved in the cultural life of the city, for many years being a member of the Steering Committee of the National Theater of Iasi. Equally, along all his life, he had a rich correspondence, exchanging numerous letters with the great scientists of his time: Nils Bohr, Aimé Cotton, Pierre Weiss, Léon Brillouin, Augustin Boutaric, Wolfgang Ostwald, Roman Skórski, Merle A. Tuve, Mario Bossolasco, etc.

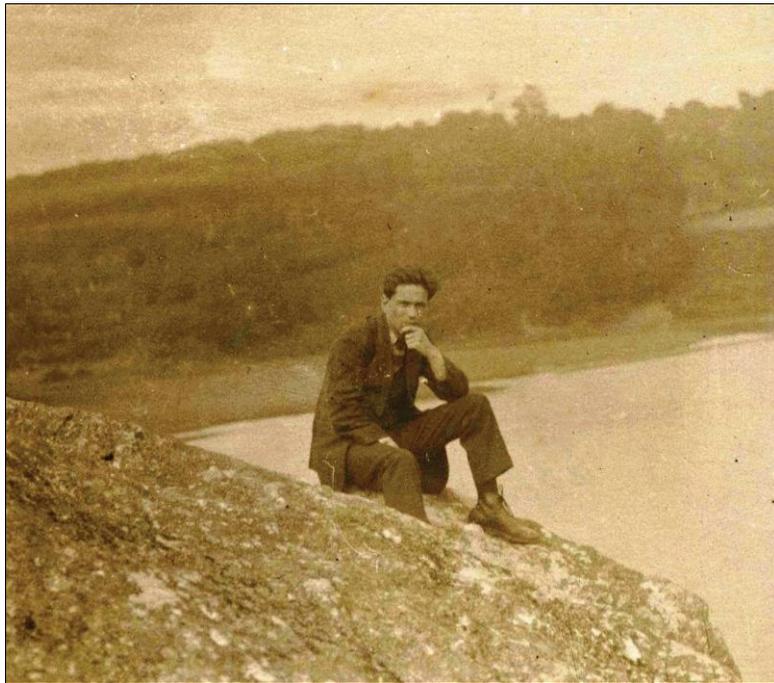
He contributed to the installation of the first radio station at the University of Iasi, which had its first broadcast on the occasion of the opening ceremony of the academic year 1938–1939 of the newly founded “Gh. Asachi” Polytechnical School [31].

Starting with the year 1994, the initiative of creating a memorial collection – currently preserved and capitalized at the “Ștefan Procopiu” Science and Technical Museum of Iași, Romania – containing personal objects, books, scientific papers, photographs, correspondence, diplomas, etc., contributed to a better knowledge of the scientific personality and activity of Ștefan Procopiu. Many items of the collection have been donated by his wife, Rodica Procopiu (1911–2012).

The Romanian Academy has established an annual prize in Physical Sciences, bearing the name of Ștefan Procopiu. At national level, a national physics contest for middle and high school students is also held every year. Many laboratories, schools, libraries and a museum bear his name. The scientific inheritance of one of the brightest Romanian physicists, his work on the reorganization of the experimental school of electricity at the University of Iași starting with 1925, the exceptional quality of the educational act he performed, the unanimous recognition received from the part of the international scientific community, represent Procopiu’s legacy for generations of scientists and engineers.



Bucharest, 1918. Ștefan Procopiu, head of works in the laboratory of Professor Hurmuzescu.



France, 1923. Ștefan Procopiu on vacation, in the province of Bretagne.



Iași, January, 1925. Ștefan Procopiu becomes full Professor in the Department of Electricity – Iași University.



Visit in Iași of Prof. Camille Gutton, Professor of Physics at the Faculty of Sciences, Nancy, for receiving the *Doctor Honoris Causa* award at the University of Iași (1938).
From left to right: Prof. Șt. Procopiu, Prof. C. Mihul, Prof. V. Ionescu and Prof. Camille Gutton.



Professor André Langevin (son of Professor Paul Langevin, physicist, Professor at École Supérieure de Physique et Chimie Industrielles de Paris) visits the Electricity Laboratory of the Faculty of Physics – University of Iași, 1959.



Iași, 1938–1939. Teaching staff of the “Gheorghe Asachi” Polytechnic School: Cristea N. Otin, Ștefan Procopiu, Haralamb Vasiliu, Gheorghe Huidovici, Cardaș Agricola, Ioan Plăcinteanu, Radu Cernătescu, C.V. Gheorghiu, Ilie Matei.



February 25, 1967. Ștefan Procopiu is awarded the title of *Doctor Honoris Causa* of the Polytechnic Institute of Iași. Acad. Cristofor Simionescu, Rector of the institution, reads the *Laudatio*.



Rodica and Ștefan Procopiu at Varatec, 1955.
Photos belong to the “Ștefan Procopiu” Museum patrimony.

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