Substantia
An International Journal of the History of Chemistry

Firenze University Press
www.fupress.com/substantia

Citation: M. Fontani, M.V. Orna, M. Costa, S. Vater (2017) Science is not a Totally Transparent Structure: Ştefania Mărăcineanu and the Presumed Discovery of Artificial Radioactivity. *Substantia* 1(1): 77-96. doi: 10.13128/Substantia-14

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The authors declare no competing interests.

Historical Article

Science is Not a Totally Transparent Structure: Ştefania Mărăcineanu and the Presumed Discovery of Artificial Radioactivity

Marco Fontani[1]*, Mary Virginia Orna[2], Mariagrazia Costa[1] and Sabine Vater[1,3]

[1] *Dipartimento di Chimica "Ugo Schiff", Università degli Studi di Firenze, via della Lastruccia 13, Sesto Fiorentino (FI) Italy.* E-mail: marco.fontani@unifi.it
[2] *The College of New Rochelle, New York, USA.* E-mail: maryvirginiaorna@gmail.com
[3] *Freiberg University of Mining and Technology, Faculty of Chemistry and Physics, Leipziger Straße 29, Freiberg, Germany.* E-mail: sabinevater1993@googlemail.com

Abstract. A not very recent, but widely documented, event whose echo still resounds, the discovery of artificial radioactivity, might still cause some historians to lose a little sleep. The topic of this article recounts a noble attempt by historians of science to make known to the general public a woman who managed - in a backward country like România Mare[1] - to ascend the ranks of the university hierarchy and enter the hallowed halls of Academe. We could talk about a Romanian Madame Curie, similar to Lise Meitner (1878-1968), who embodied the same figure for the German world; but Romanian historians add other ideas.
Stephanie (Ştefania) Mărăcineanu (1882-1944) - the correct spelling of her name is in brackets - according to some would be nothing less than the discoverer of artificial radioactivity as well as the chemical transmutation of lead into gold and mercury, and of artificial rain. The discovery of induced or artificial radioactivity is universally attributed to the daughter and the son-in-law of Marie (1867-1934) and Pierre Curie (1859-1906). Furthermore, Irène Joliot-Curie (1897-1956) and her husband, Frédéric Joliot (1900-1958) were awarded the Nobel Prize in chemistry 1935 for this work. This study is divided into both an historic framing of the real and presumptive discoveries and in an analysis of the original data in light of our current knowledge of physics. An initial historic study, albeit partial, and with the aim of shedding light on the female personalities in the field of radioactivity, has already been done.[2] Other scholars have examined Ştefania Mărăcineanu's work focusing on its social, political, cultural and ideological aspects.[3] But no matter how much scientists try to be objective, they must always struggle between their beliefs and their human prejudices, including all of their habits of thought more or less imposed, and often inadvertently, by the society and the country in which they are formed.[4] It will therefore be our task to take account of the difficulties hitherto reported, and for that it will be absolutely necessary to exercise judicial restraint.

Keywords. Mărăcineanu, Artificial Radioactivity, History of Chemistry,

SCIENCE WHISPERED ABOUT IN THE HALLWAYS

At the beginning of the 1920s, when the phenomenon of radioactivity had finally been clarified as spontaneous nuclear fragmentation, a series of controversial publications - initially given to the press with the full support of respected professors - appeared in minor journals, as well as in prestigious ones such as *Comptes Rendus* of the French Academy of Sciences.

One example is the controversial case of Marie Curie's not-so-young student, Ştefania Mărăcineanu, who obtained a Ph.D. at the *Institut du Radium* at the age of 42, and within five years, she published some articles containing her scientific results. With a nonchalance at the limit of scientific orthodoxy, she announced four different (false or incomplete) findings: artificial radioactivity induced by alpha bombardment, the transmutation of lead into mercury and gold, the discovery of artificial rain, and an alleged link between earthquakes and radioactivity.[5] Only one of these discoveries, if true, could assure a Nobel Prize; they were of such magnitude that three of them would have placed her in the pantheon of scientists in all of history. On the contrary, if one, or more, of these presumed breakthroughs, so hastily announced, should prove a huge blunder, it would have severely compromised her career.We will set aside for the epilogue of this story a duplicate turn of events: two of the four announcements were immediately branded as examples of "pathological science,"[6] but at the same time Ştefania Mărăcineanu could be found in her home country with a university professorship and membership in the Romanian Academy of Sciences.[7] After her first article on artificial radioactivity, there was no talk of this except as a springboard for her subsequent discovery. Critics attacked her on this second far trickier topic: the transmutation of the elements.

On the one hand, Mărăcineanu did not seem to be aware of the possible scope of her first discovery, and would persist in dwelling on a subject much more intriguing as the transmutation of lead, but this was not acceptable to the scientific community.

Despite the fact that her work on chemical transmutation induced by solar radiation was immediately refuted, on the contrary, decades after her death, in her native Romania, a historiographic approach to her work on artificial radioactivity smacking of a lively, colorful, even aggressive, revisionism had reached a crescendo. Unfortunately many of these enthusiastic interpretations are not supported by the same scientific rigor and the data reported counting on a posthumous rehabilitation are either very weak or ontologically unacceptable because the authors seem to rewrite history for their own convenience. Furthermore, none of the authors were able to produce any new documentation[8] or got themselves lost in a useless speculative extrapolation of phrases taken out of context, passing over the most controversial and fallacious aspects.[9]

In a post-ideological period such as the first decade of the 21st century, freed from certain cultural constraints, greater objectivity is not only possible but required. This is a new task laid upon the shoulders of those who "do" history of science: to be vigilant and never regard certain discoveries as unassailable, and to uncritically accept a new revisionism that might be vaguely nationalistic.[10]

Regarding scientific knowledge: we do not know whether it can and whether it should be considered a cumulative cognitive process and, above all, axiomatic and immutable, but the events related to this episode have in themselves some aspects so conflicting, embedded in an aura of alchemy and xenophobia as to create doubts that "Science" can be advanced as a symbol of progress and civilization.

ARTIFICIAL RADIOACTIVITY

Ştefania Mărăcineanu had begun to work in Marie Curie's laboratory in the early 1920s when she was about 40 years old. In 1923, her Paris address was rue Cassette, 11. It is known that Nicolae Iorga[11] (1871-1940) had founded the „Şcoala Română din Paris"[12] in 1920 and probably Ştefania Mărăcineanu was one of the first scholarship recipients to go to the French capital. At that time, she was busy working on her PhD that she received two years later. In this case we can speak of scientific "maturity," in which a scientist, over the years, has probed and tilled different (scientific) fields and has come to full consciousness of himself/herself and has already given signs of his or her genius.

We have to start by saying that we are basically opposed to using the birth certificate as a yardstick, but it is undeniable that in scientific disciplines such as physics or physical chemistry - unlike love or literature - age is not simply a bourgeois convention, but an objective fact.

Her PhD research was supposed to focus on a more accurate measurement of polonium's decay constant. This element, highly radioactive but with a relatively short half life,[13] was concentrated as much as possible and electrolytically purified. It was the 10th anniversary of the outbreak of World War I: Marie Curie commissioned the no longer young Romanian PhD student to determine this element's decay constant with a level of precision and accuracy unimaginable in 1914, before Europe was falling to pieces.

Table 1. The Naturally Occurring Isotopes of Polonium.

Isotope	*Old Name*	*Z*	*N*	*Isotopic Mass (u)*	*Half Life*	*Type of Decay*	*Daughter Isotope*
^{210}Po	Radium F	84	126	209.9828737(13)	138.376(2) d	α	^{206}Pb
^{211}Po	Actinium C'	84	127	210.9866532(14)	0.516(3) s	α	^{207}Pb
^{212}Po	Thorium C'	84	128	211.9888680(13)	299(2) ns	α	^{208}Pb
^{214}Po	Radium C'	84	130	213.9952014(16)	164.3(20) ms	α	^{210}Pb
^{215}Po	Actinium A	84	131	214.9994200(27)	1.781(4) ms	α (99.99%) $β^-$ (2.3×10^{-4}%)	^{211}Pb ^{215}At

As is now well known, radioactivity may either be natural or induced (artificial), depending on whether nuclear decay is spontaneous or is caused by means of some other nuclear reaction.

In 1924, only natural radioactivity, discovered by Henri Becquerel (1852-1908) in 1896, was known. Marie Curie, the greatest expert in the world in the field of radioactivity, had discovered two naturally occurring radioactive elements (calling them radium and polonium). Certainly she could not have imagined that within a decade of these discoveries, the courage she had exhibited and the intellectual satisfaction she had derived from her life's work would bestow on her a gift with a two-edged sword. Contaminated by her radioactive substances and prematurely robbed of her health, Marie Curie would be brought to her grave in July 1934; in January of that same year, although worn out and suffering from a chronic fever, she witnessed the greatest discovery that ever took place at the *Institut Curie* through the work of her daughter and son-in-law: artificial radioactivity.

As mentioned previously, in 1922, Ştefania Mărăcineanu was trying to record the average half life of polonium in that same period. Polonium (Po) has 33 isotopes, all of them radioactive, the number of nucleons ranging between 186 and 227. The isotope ^{210}Po is a pure alpha-emitter and has a half life of 138.376 days, the longest of its five naturally occurring isotopes (Table 1).[14]

The subject of Mărăcineanu's doctoral research was to accurately and precisely determine the decay constant of element 84. This was, for Marie Curie, a fundamental topic and at the same time a great worry: in fact, the value of the half life varied from 135 to 143 days depending on the source from which the polonium was extracted: for many radiochemists, such a wide range was uncomfortable, and even unacceptable.[15]

At the French Academy's session of June 23, 1923, the newly appointed Academician, Georges Urbain (1872-1938), read Mărăcineanu's PhD thesis to the assembly. The polonium used came from ampules of *emanation* [*i.e.*, radium] which had been previously used for medical purposes. The electrolytic process for the obtaining of the polonium-free radium-D impurities [*e.g.*, Pb; see Table 2, below] had been developed in the chemistry laboratory of the *Institut du Radium*.

A drop of polonium chloride, $PoCl_2$, solution was deposited on a metallic or glass plate and left to evaporate. The plate was subsequently rinsed with distilled water to remove traces of acid. An ionization camera, complete with a piezoelectric quartz electrometer (as a current compensator), to detect alpha particles allowed for the determination of the activity of the radioelement - in the form of an electric current - over the course of time. Mărăcineanu was able to derive polonium's decay constant by measuring the logarithm of the current against time.

Ştefania Mărăcineanu conducted numerous experiments divided into two series: the first series of 38 measurements was carried out between March and May of 1922. She re-covered the polonium with slips of aluminum foil of varying thicknesses between 3/1000 and 7/1000 of a millimeter. In the second set of measurements, which began in May, she offset the aluminum sheet by 1 mm from the plate on which she had deposited the polonium.

Table 2. The Products of the Decay of Radium-226.

The products of 226Ra decay were initially called radium-A, radium-B, radium-C, etc. Later they were understood to be other chemical elements	Chemical Symbol of the Isotope
Emanation of radium (Em)	^{222}Rn
Radium A	^{218}Po
Radium B	^{214}Pb
Radium C	^{214}Bi
Radium C_1	^{214}Po
Radium C_2	^{210}Tl
Radium D	^{210}Pb
Radium E	^{210}Bi
Radium F	^{210}Po

Ştefania Mărăcineanu derived a half life equal to 139-140 days in all cases except when the measurements were recorded on a lead plate. In this case, the value was shorter: 135 days. Concerned with this unexplained variation of what was supposed to be a constant, she began to conduct a series of additional experiments to determine the reason for this anomaly. Thanks to previous work done by Marie Curie in 1920, she could exclude the presence of ^{210}Pb, radium-D, from the sample. She also examined the aluminum sheets and observed that they were not radioactive. A likely source of error could have been the effect of saturation for measurements conducted over a long period of time (greater than 136 days), but in this case as well, Ştefania Mărăcineanu had taken drastic precautions. The result left no doubt that no error had been committed, so much so that the Director of the *Institut* in person, Marie Curie, felt compelled to give an interpretation to the phenomenon observed: she said she witnessed a "penetration of polonium into the substance used to support it."

Marie Curie asked her to conduct a third set of measurements in support of this hypothesis, and this was completed in December, 1923. The diffusion phenomenon increased when the support was heated; the phenomenon was observed over a range of metal supports. If the support were glass, no penetration (diffusion) effect of polonium into the support was observed. However, the problem was not resolved: at first it was assumed that the disintegration of the polonium helped it to penetrate lead's crystal lattice. This conclusion was rather hard to accept. Later she resorted to the hypothesis of microcracks (or faults) in the metal support. This allowed her to shelve the problem for a short time. A practical arrangement made it possible to calculate the decay constant: diluted solutions were used,[16] no heat was applied, and glass was substituted for lead as the solid support.

INDUCED RADIOACTIVITY BY SOLAR RADIATION

Having finished her PhD with Marie Curie, Ştefania Mărăcineanu continued her research first in Romania (for a short time) and later at the Institute of Optics at the Meudon Observatory, near Paris, under the supervision of Henri Deslandres (1853-1948).

Mărăcineanu noticed that the decay constant of polonium, far from remaining immutable, varied depending on which metal was used as a support for the sample. She also noticed that the atoms of the substrate were "transformed" into radioactive isotopes. In all this, her superiors suspected nothing, but not for the reasons that the supporters of Ştefania Mărăcineanu eventually gave. If what she timidly asserted had really happened, this experiment would have shed light on the phenomenon of artificial radioactivity ten years in advance. It was not so, and, as we shall see, could not have been otherwise.

Continuing her doctoral work, in an article of November 25, 1925,[1] Ştefania Mărăcineanu suggested that sunlight could have an action on the radioactive decay of uranium and polonium.

After extended periods of exposing sheets of non-radioactive lead to direct sunlight, they would later be shown to be radioactive. Likewise, uranium oxide, if exposed to sunlight, began to show a change in the decay process, a variation that Mărăcineanu called "curious periodic variations." She tried many other things, but only Pb and Sb exhibited such behavior. After exposure to the sun these elements were able to:

- Expose photographic plates
- If placed in front of a zinc sulfide screen (detector), many scintillations were observed
- Lead or a Pb/Sb alloy exhibited a weak ionization current, detectable with an electroscope.

Over the years Marie Curie had also observed a change in the decay constant of uranium, with an order of magnitude of about 3%. Ştefania Mărăcineanu stated that by the action of sunlight, this change was amplified up to 50%.

On August 2 of the following year, Ştefania Mărăcineanu published a further note in which she pointed out the progress of her discoveries,[18] with reference to the observed solar effects on polonium. She placed a drop of a solution of highly purified polonium chloride on a somewhat thin lead sheet (1/10 mm). The polonium-210 she used was a pure alpha emitter. At the atomic level, 0.10 mm of lead is extremely thick and easily stops the alpha particles emitted by polonium, but inexplicably, she discovered an ionization current on the opposite side of the metal plate which was not exposed to the alpha source. She could think of only two reasons for this effect: induced radioactivity OR the following hypothesis.

Polonium is a very strong alpha emitter, but Ştefania Mărăcineanu dismissed this fact. As a side effect (which, for Ştefania Mărăcineanu, was the primary effect), she observed that if the lead sheet on which the polonium solution had been deposited were exposed to the sun or kept in the shade, the ionization current varied widely. At the conclusion of her work, Mărăcineanu reported: "One might have thought of a penetration of polonium from one side to the other of lead, but if this were the case, one would have had to have a loss of polonium inside the lead, which has not been observed".[19]

This sentence could have been the starting point to see if, indeed, the scientist had observed the phenomenon of artificial radioactivity, but how often does it happen that ideas ahead of their time are overlooked or dismissed? And she herself, first of all, put forward a very different explanation for the observed phenomenon.

By further work on polonium decay curves in bismuth, curves obtained from experimental observations after deposition of the polonium and before irradiation, Ştefania Mărăcineanu speculated that the facts "... seem to show that solar radiation can cause the reintegration of Radium-E [Bi] from Radium-F [Po], and thus can cause a reversal in the radiation series".[20]

This unorthodox hypothesis, based on an actual observation but certainly misunderstood, should have been immediately rejected, both by Marie Curie, her former director, as well as by Henri Deslandres. Things did not go well. Curie - maybe - was busy with wedding preparations for her daughter Irène, who was to marry the young and promising engineer, Frédéric Joliot (who would be assured a more flexible career by marrying the daughter of his employer). Henri Deslandres, on the other hand, was an astro-physicist who had done all of his scientific work before the mere mention of "radioactivity" was whispered by Marie Curie to her husband, Pierre, in the late 19th century. At the time, he was 73 years old, much older than Pierre Curie, and perhaps too sidelined at this point to contribute to the debate by siding in favor or not of this hypothesis. But this was not the case. As we will see in three notes, which appeared in the *Comptes Rendus*, he encouraged and praised the work and discoveries of Ştefania Mărăcineanu.

A further communication from Ştefania Mărăcineanu appeared in *Comptes Rendus* reporting on the session held on May 30, 1927.[21]

In this case as well, Marie Curie never said a word.[22] Perhaps she was occupied both within and outside of the laboratory walls with many other affairs: after her daughter's wedding on October 9, 1926, her new son-in-law was promoted, to the great chagrin of Marie Curie's long-standing collaborators, to the rank of "Prince Consort".[23] Irène, meanwhile, was "in a family way",[24] and Marie was "experimenting" with the idea of becoming a grandmother.

Following the advice of her colleague Lebel, Ştefania Mărăcineanu began to study the radioactivity of the lead sheets used as covering for French public buildings and therefore exposed to the sun's rays from time immemorial. It happened that the Paris Observatory's roof was covered with lead sheets. Ştefania Mărăcineanu, as she herself confessed a year later, climbed up to the top of the cupola and at high risk began to scrape off some of this roof covering in order to subject it to analysis. Since she found that the samples' radioactivity was so high as to be off the scale, she assumed that the lead - radioactive by solar induction - had an extremely rapid decay rate. As a matter of fact, Mărăcineanu carried out her measurements three times a day, after breakfast, lunch, and dinner. But not only that, said she: "at noon, when the sun hits the instrument, the lead appears to become twice as active...".[25]

To compare these results with ordinary lead, she also prepared daily a solution of "white" lead by treating commercial galena (PbS) with acid,[26] and observed: "Commercial lead, prepared every day with galena, is not, as is known, radioactive…".[27]

Henri Deslandres, her advisor and director of the observatory at Meudon, was so favorably impressed with Ştefania Mărăcineanu's research that he published a brief note[28] in the margin of the previous article where, in the euphoria of discovery, sent out an enthusiastic appeal to readers: "The people here have lead (that has lain) for a long time in the sun, and who do not have the necessary apparatus to do research on radioactivity, are asked to send a sample to the Observatory of Paris".[29]

The research was begun in earnest. Twenty days after the last communication a new work appeared[30] by Ştefania Mărăcineanu in *Comptes Rendus*. Following the advice of her director, she extended her research to other metals besides lead and polonium, such as copper and zinc. These last two elements were, like lead, used for the protection of the limestone ledges of the observatory. Ştefania Mărăcineanu collected specimens of them and observed that the surfaces hidden from the sun's rays exhibited no radioactivity.

She posed the dilemma of whether the radioactivity might be due to atmospheric radioactivity deposited over the years on coatings of copper and zinc, but in a short time disproved this hypothesis because there was no any trace of radioactivity in the blocks of limestone. This article, too, was followed by a laudatory note[31] by her superior - about as long as the article which preceded it:

"Mademoiselle Mărăcineanu's research on the old roofs of the Observatory of Paris is of increasing interest. Lead is not the only metal that acquires, under the influence of the sun's rays, a special radioactivity…".[32]

Dwelling on the more practical aspects of how to continue these experiments, Deslandres pointed out that the radioactivity - that we can define as induced - was not attributable to the diffusion of only radioactive bodies as happened for polonium, but it was an established fact that it was a special action of light on matter and could be said that it clarified the action of ultra-X rays, very penetrating X-rays, whose cosmic origin was demonstrated by Werner Kolhörster (1887- 1946),[33] Robert A. Millikan (1868-1953) and Russell M. Otis.[34]

Deslandres expressed a personal interest in the research of his Romanian assistant because it allowed him to reminisce over events that had occurred more than thirty years before when, in 1896, he had observed the emission of particles and X-rays from the sun, the other planets, and nebulae. These 19th century works were collected in a monograph[35] in precisely the year in which Ştefania Mărăcineanu began her collaboration with him.

Ştefania Mărăcineanu's third article[36] in 1927 appeared on July 11. In this case as well, at the suggestion of Henri Deslandres, she repeated the experiments of depositing polonium solutions on 0.1 mm thick lead plates. But this time, again at Deslandres' suggestion, she subjected the plates to a potential of 120,000 volts. For the occasion, they had to dismantle a large transformer that operated the observatory and dedicate it to this use.

After depositing the polonium solution, the experimental samples were divided into four groups:

1. plates not subjected to any potential
2. plates subjected to high voltage only
3. plates subjected to high voltage and solar radiation simultaneously
4. plates subjected only to solar radiation

In these cases, radioactivity was not observed on the surfaces of the lead plates not exposed to polonium; despite the fact that an extremely high voltage was applied, no nuclear rearrangement could be said to have taken place because there was no substantial difference between samples 1 and 2 . This was certainly a negative result. However, increased radioactivity continued to be observed in the samples exposed to the action of sunlight.

For the first time Ştefania Mărăcineanu reported the following phenomenon: "It has been observed that the ionization current exhibited on the opposite side (of the plate) is proportional to the initial amount of polonium deposited".[37]

But what is even more surprising is Ştefania Mărăcineanu's almost prophetic conclusion. Apparently, following the reasoning that she reported in the article, it seemed evident that Henri Deslandres, the teacher with his "forced suggestion" and counterproductive increase in the complexity of the experiments, derailed the entire project.

However Mărăcineanu remained stubbornly faithful to her earlier ideas; stripping the experiments bare from unnecessary complications derived from sunlight or high voltage, she seemed to really observe the phenomenon that less than ten years later would take the name of artificial radioactivity and so she closed the the article with the words:

If we consider the appearance of the curves, the ionization current, which increases daily by itself, passes through a maximum, then decreases according to an exponential law, as happens when a radioactive substance is formed, develops, and then decays. I think that a new radioactive substance is being formed in the body of the lead.[38]

Again Henri Deslandres wanted to comment with a note on the work of his student.[39] Outside of congratulating her and highlighting the enormous importance of the subject in the scientific landscape and recognizing its extreme complexity, he added almost nothing new.

Meanwhile the alleged discovery of radioactivity induced by solar radiation gave Ştefania Mărăcineanu an unexpected fame on a global level:[40] within a short time she became the most famous Romanian scientist in the world. The field of radioactivity lent itself to this sort of thing: it was a relatively new field of research; it was a kingdom ruled by a tiny little woman that she, Marie Curie, had created herself and the "world of little nations" wanted to have at home a "little Curie," to pamper and show off to exalt their own homegrown glories to their citizens. In a late positivist spirit, radium was viewed as an instrument of human progress, the weapon to fight cancer, which, in the years of industrialization, was defined by the late-19th century Pharmacopoeia as the most widespread and insidious disease, which nothing could oppose. All this, like a fairy tale, fascinated the public and newspapers competed to bring - often with sensationalist reportage - the most diverse and contrary reports, both scientific and pseudo-scientific, to the attention of the public. Among these they found wide-ranging opportunities in Ştefania Mărăcineanu. Already in 1925, during his official visit to Paris, King Ferdinand I of Romania (1865-1927) and his wife, Queen Marie of Edinburgh (1875-1938), invited Ştefania Mărăcineanu to demonstrate her scientific achievements to them. The queen, impressed by the work of her compatriot, took her personal prerogative to subsidize her research on chemical transmutation. In 1929, in Iasi, Ştefania Mărăcineanu received the award in memory of the recently-deceased King Ferdinand given by the Foundation of the same name.[41]

THE ANNOUNCEMENT OF THE DISCOVERY OF CHEMICAL TRANSMUTATION

1928 marked a year of more radical change. In March of that year, in fact, Ştefania Mărăcineanu published together with her director, Deslandres, a further development on the research on this phenomenon.[42]

From January 20 to February 17, Ştefania Mărăcineanu exposed to sunlight not only lead, but also old copper, aluminum, iron and zinc plates. She repeated, in parallel, experiments with other samples of the same elements, but obtained from commercial venues. Only lead showed radioactivity. With a complex reasoning resulting from a series of measurements, she excluded the idea that the specific activation of lead derived from a radioactive emanation from the atmosphere (external contamination). A careful study of the results led Ştefania Mărăcineanu to a suddenly change the ideas that she had espoused in the previous summer and she asserted instead: "In my experiments on lead, I have always found (decay) periods of this order of magnitude and at one point I thought of a reintegration of lead into polonium by solar energy".[43]

In other words, after an understandable hesitancy, Ştefania Mărăcineanu, announced that she had observed a chemical transmutation process by the action of sunlight. She reported that this phenomenon could be explained if associated with another inexplicable phenomenon, the presence of alpha particles, and the appearance of extremely penetrating rays (γ rays, perhaps, but these are not specifically named).

As a corollary to this controversial hypothesis, Ştefania Mărăcineanu speculated that the change in the decay constant of polonium was due precisely to this phenomenon. This would explain why, four years before, she had obtained such a variation in her data.

A year passed and Ştefania Mărăcineanu left France for her native Romania. We do not know the reason for this more or less voluntary removal from the observatory at Meudon. In her native country she gave to the press an article[44] having as its subject the effects of solar radiation on radioactive phenomena and transmutation. It was work conducted in France, described in summary in some communications in *Comptes Rendu*s, but quoted in full in Romania. If it had been national pride or an ill-concealed desire to reduce the effects of a likely fiasco that drove Ştefania Mărăcineanu to explicitly publish the phenomenon of transmutation of the elements in a Romanian journal is not known. The fact is that, in this work, values were observed in the spectroscope, *i.e.*, the appearance of spectral lines, attributable to elements that would be formed by the transmutation of lead explicitly appear. In confirmation of this hypothesis, the appearance of helium (alpha particles) and mercury lines were observed. In both publications, that of 1928 in the *Comptes Rendus* and that in the *Bulletin de la Section de l'Academie Scientifique Roumaine*, the word transmutation is not to be ascribed to an alchemical concept, but to the idea of radioactive decay (or its unlikely opposite: "radiative accretion"). If we must impute any kind of an error to Mărăcineanu, it would be to have formulated the concept of chemical reversibility in the process of radioactive decay, and to accept the fact that lead was not the end of the line for the thorium and uranium decay series (that includes radium):

$$Pb + \alpha \rightarrow Po$$
$$Pb \rightarrow Hg + \alpha$$

The extensive work of Ştefania Mărăcineanu consisted of numerous pages and photographs of samples taken from lead roofs that had been exposed for centuries to solar radiation. She took her time about her means of investigation, employing a few tricks to enhance the observed effect and in the end she added a note in italics that could not go unnoticed:

"The action of solar radiation could possibly cause a transmutation of 0.001% lead in gold".[45]

At the end of the article after the usual sentences relating to the circumstances of the work that scientists always expect, with a little bit discovered and much more to do, you can read in *ad hoc* italics, like a Wagnerian finale, the words:

> *But it is in solar radiation that one must recognize the philosopher's stone and the source of formidable radioactive energy, which will become needed more and more.*[46]

The year 1929 opened auspiciously for Ştefania Mărăcineanu. Her publications appeared both in Romania and in France and her work could be said to be truly cutting edge. Many scholars began to repeat her experiments, seeking to confirm her observations, but also to shed more light on an effect of nature that she had discovered and that she too easily had wished to define using such "hot button" words as "transmutation" and "philosopher's stone."

THE OLYMPIC CALM OF THE EUROPEAN COLLEAGUES COMES TO AN END

By return mail, Professor Nicolae Vasilesco Karpen (1870-1964), who a few days earlier had presented Ştefania Mărăcineanu's work to the Romanian Academy of Sciences, was forced to report a preliminary note under the signatures of Charles Fabry (1867-1945) and E. Dubreuil in which the two French physicists expressed their censure of tests carried out by the Romanian scientist that they repeated in their Paris laboratory: they were the experiments relating to the transmutation of lead into gold, mercury, and helium.[47]

They pointed out:

> *The experiments in question were conducted with results exactly contrary to those reported by Mlle. Mărăcineanu.*[48]

That was the first salvo that began to discredit the Romanian researcher's work. Shortly thereafter, she was the object of a great deal of criticism for her real or alleged discoveries. First the French, and then many other scientists, began to pour down condemnation on her like so many arrows.[49]

On February 22 of that same year, it was the Director of the *Institut du Radium* herself, Marie Curie, who pressed Mlle. Eliane Montel[50] (1898-1992) into service to investigate the embarrassing phenomenon of induced radioactivity discovered in the heart of her own laboratory.

Montel studied the evidence in great detail with the aid of a rigorous photographic analysis; the methodology followed was that of Ştefania Mărăcineanu, but she obtained very different results: as Mărăcineanu observed, a lead sheet on which was placed a solution of polonium hydrochloride exhibited radioactivity after the polonium had been removed. However, the radioactivity observed was not due to its induction by polonium in the lead as Elizabeth Róna (1890-1981) and E.-A. W. Schmidt demonstrated,[51] but to its penetration through microscopic cracks, between the lead crystals, and conveyed by the presence of a weakly acidic environment. This hypothesis was suggested to Eliane Montel by Fernand Holweck (1895-1941) and her laboratory subsequently tested it. Lead sheets were melted and then cooled so as to obtain crystals whose dimensions were visible to the naked eye. Then a solution of polonium hydrochloride was deposited on the sheets and their radioactivity was monitored photographically. What struck Eliane Montel was that on her photographic emulsions she saw the outlines of lead crystals, *i.e.*, the regions where the polonium had penetrated them. Eliane Montel asserted without a doubt that polonium passed through the lead only in the zones which she called "faults." It was a clear proof that damaged the hypothesis advanced by Ştefania Mărăcineanu on induced radioactivity.

A few months later, on May 25, 1929, the Dutch professor A. Smits and his assistant Mlle. Caroline Henriette MacGillavry[52] (1904-93) published an extensive piece of research[53] on another aspect of Mărăcineanu's work: the radioactivity of lead induced by solar radiation. Their work was conducted on sheets of lead from the roofing of the Observatory of Paris as well. The results were encouraging and gave confirmation of the comments previously made by Ştefania Mărăcineanu.[54]

Smits and Mac Gillavry reported the following:

> *... these results were perhaps of great importance because if the lead really is activated and emits α particles, it is likely that there is a transmutation of lead into mercury.*[55]

This was the first, albeit modest, confirmation Ştefania Mărăcineanu's work outside of French and Romanian borders, but it was short-lived. On February 9, 1930 she wrote from Paris, where she resided at 9 Rue Ernest Cresson, to her friend Alexandrina Fălcoianu.[56] It is an excerpt of a letter that foreshadows possible friction between her and her French colleagues:

> *I will fight, dear lady, for me, for justice, the honor of our country, and for women.*[57]

A few months later she will have come back to Romania for good. In fact, a deed of patent on artificial rain, dated June 10, 1930, gives her address as Boulevard Col. Mihai Ghica n. 57, Bucharest.

Six days before she drafted the letter to her friend, February 3, 1930, the French physicists Charles Fabry and E. Dubreuil officially opened hostilities against Ştefania Mărăcineanu and released a statement which seriously criticized her work and her heterodox theories. The two French colleagues also neglected to mention Mărăcineanu's earlier work that had appeared in the very same *Comptes Rendus*, as well as the encouraging articles of the famous astronomer, Deslandres, which had supported Ştefania Mărăcineanu. Even if they were correct, it was a petty attack on a "foreigner" as well as a chauvinistic attempt to make sure that a French institution was not tarnished.

The experimental work was conducted by E. Dubreuil at the *Institut d'Optique*. He had repeated the Romanian researcher's same experiments but ended up getting totally negative results, even in the case of lead.

Her reply was swift: seven days later, Ştefania Mărăcineanu transmitted her reply in the pages of *Comptes Rendus*.[58] It was, however, weak both in tone and in content. She realized she was a foreigner and could not reply to such aggressive criticism in the same tone with which she had been attacked. She hypothesized that her colleagues, Fabry and Dubreuil, had scraped lead from the observatory roof in the precise places where she had taken her samples and by so doing, they would have analyzed the underlying layer, which had not been exposed to sunlight for the centuries to which her own samples had been subjected. In addition, Ştefania Mărăcineanu openly reprimanded Dubreuil, saying that when she was at the Institute of Optics, he had provided the spectra and had offered to interpret them.

The Romanian researcher acknowledged the negative assessment of her work and tried to scientifically counter the accusations brought against her. If the cause of the radioactivity of the lead could be debated and could even change her hypothesis, she was firmly convinced that her observations were correct so much so that they were confirmed by Professor Smits, the Director of the Chemistry Department of the University of Amsterdam. As support, Ştefania Mărăcineanu reported some excerpts of a personal communication sent to her by Smits which confirmed the results that she had arrived at: in the arc spectra of lead, the spectral lines of mercury were readily apparent. This evidence could only lead to one conclusion: the transmutation of lead into mercury by the action of solar radiation. In support of her statement, Mărăcineanu emphasized that traces of mercury are always in lead and that scientists have always defined this fact as a "permanent impurity" without specifying any others. Now she, Ştefania Mărăcineanu, could explain this presence as the slow transformation of lead into mercury (with α particle emission) brought about by the prolonged action of solar radiation.

Ştefania Mărăcineanu cited the data of Professor Smits before their publication: the amount of observed alpha particles was equal to impingement of 1.6 α-particles per second on a surface area of with a diameter of 16 cm^2. At the conclusion of her article, Mărăcineanu summarized her convictions as a challenging hypothesis:

> *Wouldn't this be the result of a transmutation that has moved beyond lead in the periodic series of elements? And is radioactivity not a general property of matter?*[59]

But the attack had not been able to direct the French colleagues to the pages of a French newspaper that appeared with calculated coolness:

> *I can't understand how Messrs. M. Fabry and Dureuil haven't found [traces of gold, helium or mercury].*[60]

Ştefania Mărăcineanu had also given some samples of lead sheets used for the Meudon Observatory roof lining to some French colleagues: Augustine Boutaric[61] (1885-1949) and Mlle. Madeleine Roy[62] (1900-40) who conducted in turn their own personal investigation.[63] In addition to the samples supplied by the Romanian researcher, the two Dijon chemists analyzed lead sheets from old and recent roof coverings: the palace of Versailles, the tiles donated by the alchemist Mme Mary Dina-Shillito[64] (1876-1938), owner of the Avenières Castle (1050 meters above sea level) and even Vallot Observatory on Mont Blanc (4362 meters high).

In addition to the lead study they analyzed cladding sheets of zinc and copper which, exposed to sunlight, would be expected to become radioactive. The Boutaric and Roy results refuted the hypothesis advanced by Ştefania Mărăcineanu, according to which lead would not be the terminus of the atomic disintegration of all radioactive decay processes, but simply the next-to-last stop before its slow transmutation into Hg.

Boutaric and Roy put forth three hypotheses:

1. all the metals studied were undergoing a process of spontaneous disintegration (presumably emission of alpha particles, although these were not expressly mentioned in the article)
2. radioactive impurities were present in all their samples
3. radioactive products could accumulate over time in the atmosphere (water vapor, fog, rain, snow and ice)

The fact that only the face exposed to the elements exhibited radioactivity automatically excluded both the first and the second hypothesis. To confirm the third hypothesis, the chemists analyzed the stones in the walls of the buildings from which the lead was taken and did not observe any radioactivity, which they ascribed to the slow but continuous disintegration of the lithic material through weathering.

Although Ştefania Mărăcineanu's relationship with Smits and MacGillavry was most cordial and collaborative, in her latest work she quoted incorrectly and without permission some data extracted from a personal letter sent by them to her superior, the former Director of the Meudon Observatory. Smits and MacGillavry were forced to issue a note of reprimand in the *Comptes Rendus*[65] in which they expressed disappointment not only about the violation of communications protocol (citing publicly a work not intended for publication), but also certain doubts about Ştefania Mărăcineanu's conclusions. The two Dutch authors, although they had confirmed the radioactivity in the lead exposed to the sun, were not able to experimentally determine if that property was indeed of extraterrestrial origin or due to a radioactive deposit by atmospheric agents. Deslandres, the man to whom Smits had sent the letter containing the confidential data, the former director of the Observatory, and Ştefania Mărăcineanu's patron, replied by return mail in the pages of *Comptes Rendus*.[66]

Far from offering the slightest form of apology, she continued to cite Smits's work as a support for her hypothesis, or rather she kept on saying that although the action of the sun's rays were not yet regarded as established as the cause of the radioactivity of lead, to her way of thinking, it was indisputably the most likely. At this point, what we are witnessing in these more recent articles, is a fact both objective and sad at the same time: the experimental data had been supplanted by a flood of words and personal opinions.

To make the situation more problematic, Deslandres improperly cited the work of Reboul[67] and Pokrovsky[68] regarding the capacity of solar radiation to modify the radioactivity of uranium.

As befits any article which does not conclude with the certainty of solid experimental results, this intervention ended with a terse: "It is necessary to wait for further study of these facts".[69]

Ştefania Mărăcineanu also provided samples of lead to other French colleagues, Lepape Adolphe (1886-1977) and Marcel Geslin (1894-1962) who immediately carried out similar experiments.[70] Their investigation was extended to other coatings: not only to metals such as lead, copper and zinc, but to stone such as slate, as well as the deposits left from rainwater in gutters. Their conclusions were positive; Lepape and Geslin observed in all materials the emission of penetrating radiation. But the next step threw more light on the phenomenon: the dust in the air could have been the vehicle of radioactivity, with the help of rainwater.

Ştefania Mărăcineanu, as many often do when finding themselves in unpleasant situations, tried to get out of the line of fire by replying jointly to Smits, Boutaric and Lepape, with an article in the *Bulletin de la Section de l'Academie Scientifique Roumaine*.[71] There were only two reasonable ways out: admit error or place the blame on others, and she chose the second way.

She said that from 1895 on, astronomers like Sir Oliver Lodge (1851-1940) in England and Henri Deslandres in France had the intuition that the sun emitted "radioelectric" waves; but Deslandres had gone further and better in that regard: in 1898 he proposed the existence of an unspecified "penetrating corpuscular radiation" emitted by the sun. It was a way to shift many of the shortcomings of her research on her old colleague. But it should also be reasonably said that Ştefania Mărăcineanu firmly believed in her results and could not accept the simple idea that the roof samples she observed had been contaminated by radioactive atmospheric dust. Her article was a meticulously drawn up objection to her colleagues' data, though not always backed up by thorough research and reliable data. In fact, she cited in her favor the research of some of her colleagues: Nodon in Bordeaux, Fauvot of Courmelle, and Risler and Werner Kolhöster, without supplying any bibliographic references.

On June 11 of that year, Augustine Boutaric and Mlle. Madeleine Roy published an article[72] in which they confirmed the results of Lepape and Geslin: radioactivity accumulated on ancient rooftops was due to rainwater. It was a simple and effective work. An analysis of the sand and charcoal used for making rainwater potable was collected in a closed tank of an old building. They observed radioactivity of about the same amount and type found in samples exposed to sunlight.

It was the "coup de grace" to the complex theory put forth by Mărăcineanu and abundantly supported by old Deslandres.

For Ştefania Mărăcineanu it was the beginning of the end. After having departed France for good, she completely abandoned her research on the phenomenon of induced radioactivity for a very long period of time.

Eleven years later, smack dab in the middle of World War II, José Baltá Elías[73] (1893-1973) decided it was time to dust off the phenomenon of radioactivity induced by solar radiation. He began his research in 1935 but the worsening of the Spanish political situation, ensuing in civil war, had delayed the publication of his findings for six years, by which time international interest in this subject had waned considerably. The results however, deserve to be reported because they contradict both Ştefania Mărăcineanu, but also Augustine Boutaric and Mlle. Madeleine Roy. In his view, and supported by the highest precision instruments, the phenomenon of radioactivity induced by solar radiation was not observed for the simple reason that it did not exist.[74]

Heedless of the criticisms that rained down from all sides, Ştefania Mărăcineanu published her last work concerning radioactivity and the transmutation of lead. In this work, containing repetitive material and lacking even a minimal bibliography, she sought to take stock of all her previous work on balance:

- As the Joliot-Curie team had discovered artificial radioactivity for the light elements, so she had done for heavy elements (lead) and Otto Hahn (1879-1968) for uranium, although this finding is reported without any specific notation. She also speculated about how it would take place. To do this, she proposed a new mechanism, "chemical transmutation for integration." Alpha particles (positive) expelled by polonium would be able to overcome lead's Coulomb barrier since, before the impact with the nucleus, it would be subjected to great acceleration due to the attractive force of the outer electron cloud of the atom.
- And finally, Mărăcineanu suggested a second phenomenon independent of the induced radioactivity in the lead, but still a property of the same element: the lead, in itself, would encounter a very slow process of radioactive decay with the formation of mercury. She estimated a very long half life for the lead, of the order of 10^{27} years.

Current observations suggest that the age of the universe is about 13,799,000,000 years (1.3799×10^{10} years),[75] with an uncertainty of about 21 million years. The figures provided by Mărăcineanu are not accompanied by any supporting experimental data. Her estimate is totally unreliable and can only serve to put the researcher in an even worse light. Since this estimated time period was too large to cause the spontaneous transmutation mercury, even the author of the article, Ştefania Mărăcineanu had to come to the conclusion that lead would be a metastable element and external agents such as sunlight could accelerate the spontaneous process by a factor of 10^{29}. In point of fact, the decay period would change from 10^{27} years to only 200 days.

BIOGRAPHY

Ştefania was born June 17, 1882 in Bucharest and her birth was added to the official registry the next day by her 20-year-old father, Sebastian Mărăcineanu.

Very few details of her childhood have been found. What we do know is that they were not happy years; Ştefania did not like to talk about them. In 1907, she enrolled at the *Facultatea de ştiinţe a Universităţii din Bucureşti* where, three years later, she received a doctorate in the chemical and physical sciences.[76] She followed courses in pedagogy for a short period and, in 1914, she passed the qualifying examination that permitted her to teach in secondary schools. She was present in Bucharest, teaching at the "Şcoala Centrală" during the Austro-German invasion of 1916. After the conclusion of World War I, she obtained a scholarship and went to the *Institut du Radium* in Paris, where she worked on and off until 1925.[77] Meanwhile, she had enrolled at the Sorbonne for a research PhD, which she obtained in 1924. Returning to Romania in 1925, the Faculty of Science at the University of Bucharest gave her a post as assistant instructor. However, in that same year, she returned to Paris for four years, working at the Astronomical Observatory of Meudon.

In 1929 we find Ştefania Mărăcineanu back once again in Romania. In that year, she had the opportunity to hold a conference on the constitution of matter at the "Şcoala Centrală de fete" that she subsequently repeated at the "Universitară Carol I."[78] It was printed[79] and it served as the nucleus of a manual on radioactivity that Ştefania Mărăcineanu would write some years later.[80]

When in 1929 she returned to Romania for good, perhaps in response to criticism leveled at her for her improbable discoveries, Ştefania Mărăcineanu installed, manned and directed the first laboratory for the study of radioactive substances in Romania.

Meanwhile, on January 15, 1934, Irène and Frédérick Joliot-Curie announced the results of their experiments and shocked the world with their discovery: artificial radioactivity. With uncommon haste, the Nobel Committee awarded them the Nobel Prize in chemistry the following year.

In early June of 1934, Irène Joliot-Curie, after having brought her terminally ill mother to the sanatorium of Sancellemoz in the Haute Savoy, traveled to Vienna to hold a conference hosted by the famous physicist Stefan Meyer (1872-1949).

On June 5, 1934 in the *Neues Wiener Journal*, an article appeared that reported excerpts of that conference, including anecdotes, bits of the animated discussions with colleagues, the opera galas, and interviews with journalists. Among the latter, the name of Ştefania Mărăcineanu was mentioned, and the enlightening contribution to understanding this new physical phenomenon of this relatively unknown researcher was emphasized.[81]

> *It was a Romanian, Miss Mărăcineanu, who a few years ago was probably the first one to observe that non-radioactive elements could be made radioactive under certain conditions, meaning they emit radiation similar to the type which, until now, has been only observed for the few radioactive elements.*

It was the only recognition, albeit marginal, that Marie Curie's daughter was willing to give to the Romanian researcher. On November 29, 1935, eleven days before Irène Joliot-Curie and her husband received the Nobel Prize from the hands of the king of Sweden, in Romania, Nicolae Vasilescu-Karpen[82] (1870-1964) gave a lecture at the Academy of Romanian Science entitled: *Radioactivitatea artificială şi lucrări româneşti în acest domeniu*[83] with clear allusions to the work of Ştefania Mărăcineanu's unique research done years earlier.

On June 24, 1936, Ştefania Mărăcineanu officially asked the Academy of Sciences of Romania to support her officially and to recognize the priority of her work. Her request was granted and in 1937 she was elected a corresponding member of the Academy of Sciences of Romania, and two years later *Sefa de lucrări*, *i.e.*, Director of Research.

In a letter preserved at the Academy of Sciences, Mărăcineanu, wrote a strongly critical version of the events that took place in Paris in the early twenties, while Marie Curie was still living:

> *Nu contest premiul Nobel soţilor Curie Joliot pentru perfecţionarea ce au adus în această descoperire ca metode de investigaţie, punere în evidenţă a fenomenului şi chiar pentru aporturi noui. Cer însă să mi se recunoască rolul ce am avut în această descoperire. Am fost prima care am îndrăsnit să anunţ acest fenomen în 1924,când părea o nebunie.*
> *Aceiaş metodă a întrebuinţat şi D-na Joliot Curie la începutul cercetărilor D-sale. ... Singura deosebire consista în faptul că D-sa aşeza foiţa metalică peste poloniu iar eu depuneam polonium pe foiţa metalică.*

D-na Pierre Curie nu mi-a permis a da această explicație în teza de doctorat și mia spus: vom continua lucrarea și va figura și numele d-tale. Am făcut totuși rezerve în teza de doctorat. [...] Imediat după obținerea gradului de Doctor am publicat pe propria mea răspundere la Academia Română...[84]

By 1941 Ştefania Mărăcineanu was 59 years old and was nearing the end of her life and just in time to be appointed Associate Professor. It would be her last personal "victory," as documented in several passages taken from letters addressed to colleagues. She spent much of her time in the laboratory, in a workplace which she had personally built at the cost of great sacrifice:

... Laboratorul acesta este viața mea,de care nu m'aș putea despărți de cât când n'aș mai fi.[85]

From personal sources, it can be clearly seen that the final days of the scientific collaboration between Ştefania Mărăcineanu and Marie Curie was not painless:

A fost o persecuție și o opoziție care m'a urmărit pas cu pas, de când am rupt cu Institutul de Radium pe chestia dreptului meu.[86]

For as long as she lived, the (Romanian) Academy denied her the highest recognition by not creating a professorship of radiochemistry.

This could have been due to the concurrent political situation. The follies and the horrors of the despotic regime of King Carol II (1893-1953) of Romania led him to accede to, in 1940, the triple dismemberment of his kingdom.[87] When, in June of 1941, General Ion Antonescu (1882-1946) threw Romania into the war against the Soviet Union, many Romanians were happy about it. What attracted them was not only the possibility of regaining the lost province of Bessarabia, but the prospect that the uncomfortably neighboring and powerful Russian State, a constant threat to national integrity for over twenty years, would be destroyed. That thousands of persons would be sent to their slaughter on the battlefields of Odessa, Sebastopol, Stalingrad, and the Caucasus, although appalling, ultimately did not seem to matter very much.

For Ştefania Mărăcineanu the news that arrived on June 20, 1942 was the prelude to the end of her career; the Ministry of Culture announced its decision to relieve her of her position by reason of age, effective October 1, 1942.

Her retirement would be neither a long nor happy one. She undertook volunteer work at a hospital, at Câmpulung Muscel, in the Muntenia region, but at the same time she continued to devote herself to various scientific issues that were dear to her heart.

On February 5, 1943, Ştefania Mărăcineanu sent a communication to the Academy of Sciences of Romania, entitled "Artifical Rain During the Drought Year of 1942." It would be her last work; she took care to assure her academic colleagues that her data were officially recorded. However, with the country at war and all that followed from that, the work was never published.

Simultaneously with the worsening of the war against the Soviet Union, Ştefania Mărăcineanu's health continued to deteriorate. She had been certifiably ill from cancer for quite some time, undoubtedly caused by long and unprotected exposure to nuclear radiation. She died on August 15, 1944 in Bucharest, two weeks before the Soviets invaded the city which was devastated by U.S. air strikes and direct fire from Russian artillery in the front line. As a result, the documents concerning Mărăcineanu's death were destroyed. Her last resting place, along with many other Romanian personages, is the Bellu Cemetery in Bucharest.[88]

Although some historians record her date of death as March 18, 1947, and the place of burial Bellu cemetery, in fact, neither this nor the previous data were confirmed by the "Consiliul General Municipuli Bucuresti." The only burial documents on file in the monumental cemetery is related to a certain Ştefan Mărăcineanu, who died March 18, 1944. Ironically, the authenticity of Ştefania Mărăcineanu's discoveries as well as the circumstances surrounding her end, are still a topic of discussion.

CONCLUSION: COULD THE ALPHA RADIATION EMITTED BY POLONIUM ACTIVATE LEAD?

Leaving aside any quantum interaction, "tunneling," or short-range effects, but maintaining a purely deterministic perspective, it may be assumed that:

The minimum kinetic energy required for an alpha particle to diminish the distance between itself and the lead nucleus, equal to or less than the sum of their nuclear radii, is obtained as a simple interaction between two charged particles which are acted on only by the Coulombic force.

Cross sections (σ) for inelastic scattering of α particles on lead are not reported in the literature, but the energies of α particles emitted by polonium are known to be about 5 MeV.[89]

In the case of bombardment of a lead target (Pb) with alpha particles (He), the barrier (determinable in MeV) is given by the approximate formula:

$$\frac{0.9 \cdot Z_1 \cdot Z_2}{\sqrt[3]{A_1}\sqrt[3]{A_2}} \qquad (1)$$

where Z_1 and Z_2 are the atomic numbers of the two elements and A_1 and A_2 are the atomic masses of the interacting nuclei.

The value obtained is about 20 MeV, or about four times the energy of alpha particles emitted by isotopes of Po, and therefore a simple calculation excludes alpha particle activation of lead by that source. In fact, recent work shows that lead activation can occur with alpha particles with energies of about 40 MeV,[90] or even 30 MeV.[91]

However, relying purely on classical physics, the theoretical results can have different values from those observed in the laboratory by a factor of ten. Having recourse to quantum mechanics can help the investigator explain how some phenomena can happen when a deterministic calculation predicts that they are forbidden. In fact, a not so simple quantum calculation permits, for a sufficiently short period of time, that an alpha particle can have a much greater kinetic energy than normal because of the tunneling effect, provided that Heisenberg's uncertainty principle

$$\Delta E \Delta t \geq \frac{\hbar}{2} \quad (2)$$

is not violated. Therefore, it would be theoretically possible that an alpha particle with an energy of about 5 MeV could overcome the Coulomb barrier between itself and a lead nucleus, thus giving rise to the latter's activation as allegedly observed by Ştefania Mărăcineanu.

However, it should be mentioned that Enrico Fermi (1901-54), in his work on slow neutron bombardment of a large number of known elements, did not observe the activation phenomenon for lead.[92]

In the end, in the case of the "official" discovery of artificial radioactivity by Irène and Frédéric Joliot-Curie at the beginning of 1934, an aluminum foil was bombarded with alpha particles from a radium source with energies of about 4.6 MeV.[93] In this case, Eq. 1 would give an approximate result as 4.8 MeV.

In light of our current knowledge of the physics of cosmic rays and on the basis of the work appearing in the literature,[94] cosmic rays would have been able to induce radioactivity in the lead nuclei. But since all the substances present in the lead were exposed to the cosmic rays as well, then they all should have become radioactive, which we know is not the case. Cosmic rays, or rather cosmic radiation, is a shower of high-energy particles arriving from outer space. It is very different from the alpha and beta radiation emitted by radioactive nuclei. When the primary radiation coming from space interacts with the atoms and molecules of the atmosphere, it produces swarms (a sort of decay) of secondary particles, some of which may reach Earth. The primary cosmic rays have much higher energies than those in play in the decay of the radioactive substances, while secondary swarms have much lower energy, but higher than those required for activation of the lead and through which Ştefania Mărăcineanu may have observed this phenomenon. But it must be said that the flow of secondary particles that reach sea level is very low; only one particle per cm^2 per minute. This heterogeneous mix of modern data and those reported in the 1920s and 1930s shows that it is impossible to treat them strictly quantitatively. Therefore, it is not possible to give a clear assessment of the reliability of the investigations conducted by Mărăcineanu. It is not possible to make clear-cut, definitive judgment, although Ştefania Mărăcineanu's hypothesis was possibly derived from erroneous experimental data or certainly by poor interpretation of them.

On the other hand, it is possible to point to an objective piece of data, about which Romanian historians are very insistent: how Ştefania Mărăcineanu was removed from Marie Curie's entourage and how some members of the *Institut du Radium* openly condemned and refuted her work.

But not only that. These historians claim that the results were stolen from Mărăcineanu, at night, when, for a reason not specified, she was not at home. Romanian sources make mention also of a great scandal and a subsequent lawsuit that involved her and the Curie family. If we follow these allegations to their appropriate conclusion, the chair at the University of Bucharest that would be given to Ştefania Mărăcineanu would be at the price of her silence. But all these statements, with no supporting documentation, are nothing but speculations, incipient libel. If they actually existed, they would deserve to be studied thoroughly and objectively.

To date, the only evidence proving the hostile resentment of the "clan Curie" against Ştefania Mărăcineanu is in a document produced by the latter; in a letter addressed by the Romanian researcher to Lise Meitner on March 12, 1936 and found in the Meitner Files of Churchill College Archives (Cambridge), she wrote:[95]

> *Madame,*
> *J'ai présenté au mois de février mes travaux sur la Radioactivité artificielle à l'appréciation de la Science allemande. Vous éte une autorité dans la spécialité et votre opinion la dessus comptera beaucoup. J'espère que les travaux vous ont été déjà présentées par qui de droit.*
> *Madame, je ne demande pas une faveur, mais seulement*[96] *la justice et je fais chaleureusement*
> *appel à vôtre*[97] *esprit de "équité" et a vôtre amour pour la science.*
> *Je ne demande pas à tenir les lauriers de M.me Joliot-Curie; mais je demande seulement que l'on reconnaisse la part que j'ai joué au début de cette découverte et que l'on contrôle aus-*

si la question de la pluie artificielle. J'ai vu qu'en France on commence à parler aussi de cette question sans mentionner mes expériences dans cette direction.
Madame, vous avez été connue moi dans l'élève de M.me Curie, je ne sais pas de quelle manière M.me regarderez cette question; dans tous les cas, je vous prie beaucoup de ne pas en parler au M.me J. Curie. Ne pas lui écrire que je me suis adressée aussi à vous. Elle ne m'aime pas et elle s'appuye[98] *sur une group organisation très puissante judéo-massonique.*[99] *Elle est communiste.*[100] *M[']en parle ici, je la croyons,*[101] *car j'ai eu l'occasion de sentir sa puissance. Seulement en Allemagne on pourrait me rendre raison.*
Je vous prie d'agréer, Madame, l'expression de mes salutations très distinguées,
Dr. Stéphanie Mărăcineanu[102]

It was known that at the *Institut du Radium*, there was competition among the scientists, not only present, but downright encouraged. It was compounded by the alleged disparities in the treatment of some of its members at the expense of others. Not surprisingly, people grumbled about the special treatment that Mme. Curie had reserved for her daughter.[103]

Ştefania Mărăcineanu did not belong to the Curie family circle and, moreover, she was a foreigner. The same adjective with which Mme. Curie had been labeled at the beginning of the century, before marrying a Frenchman (and university professor), then, widowed, and then trying to steal a married woman's husband. Yet, the insidious poison of xenophobia with which she was greeted in France by the most reactionary fringe of the country turned into a paternalistic scientific nepotism towards her daughter, who was assured - according to some – a too rapid career at the Institute which she directed. Regarding the more personal, Marie became extremely jealous: the most prestigious discoveries in the field of radioactivity could not but be due - as if it were by right of blood – to any other than a member of her family. And so it seemed regarding the discovery of artificial radioactivity in 1934: a milestone in the study and understanding of atomic nuclei.

When a great discovery reaches its fiftieth or hundredth anniversary, it is usually remembered with great celebration in the country that boasts of being the birthplace of the discoverer and recognizes him/her first as their own child and then as a their teacher. If the country is really great, it organizes a conference where scholars discuss the discovery, and commissions documentaries on the life of this man or woman of science. This is exactly what happened in 1984 for the celebration of the fiftieth anniversary of the discovery of artificial radioactivity.[104]

When the discovery involves a minor character, maybe embarrassing or in a marginal country, often we limit ourselves to a biographical retrospective, perhaps out of a condescending gallantry, not wanting to point out the inadequacy of the small country or the mediocre scientist compared to such a great discovery: in fact, because of ingrained prejudice, the discovery is assumed to be less influential.

In our study, however, elements of judgment are mixed up with the most insidious and agonizing doubts: did Ştefania Mărăcineanu actually discover induced radioactivity? To this question we can answer with certainty: no.

But it might be better to reformulate a more complex question thus: when Ştefania Mărăcineanu announced her discovery was it reasonable to consider her correct?

Although it may seem counterintuitive, with what was written a moment ago, the answer is: yes.

Therefore, we could sense a certain "stink of persecution" in her regard and so feel first hand "the ostracism assigned to her by Mme Curie." The same aloofness that Marie experienced as a student would then be ascribed to her students when she became a professor, and Romanian historians perhaps too often tend to emphasize this.

An objective fact, already well documented, is the decline of French science (chemistry[105] and physics) between the two world wars. It can be said that most of French science was addressed by leading ideas coming from Paris and in Paris there were the so-called Tetrarchs: Marie Curie, for Radioactivity; Paul Langevin for Theoretical Physics; Jean Perrin (1870-1942) for Physical Chemistry; Georges Urbain (1872-1938) for General Chemistry and Mineralogy. All these famous people, as well as being linked by having maintained relationships with their own subordinates or colleagues,[106] had strongly authoritarian, if not downright despotic, personalities.[107]

Let's not dwell too much on the details of events that could simply be traced to adulterous characters in the public eye, but this point of view is also very important, not merely voyeuristic, because it solidifies with uncommon clarity a bond, sometimes ideological, sometimes loaded with political and social tensions, that allows us to appreciate yet more the strength and power of these "masters of French science."[108]

After the death of Marie Curie, direction of the *Institut du Radium* passed to André Debierne (1874-1949), who had, in common with many of his colleagues, the dubious repute of observing physical or chemical phenomena that do not exist, for example, the frigdaréction a supposed nuclear reaction that would take place at temperatures of the order of -200 °C.

As another example, Georges Urbain posited a unifying theory of organic chemistry with mineral or inorganic chemistry[109] (Homéomérie) on a basis so qualitative and so simplistic as to be already obsolete at the time of its publication, so much so that no one ever considered it.

His many colleagues and disciples were careful to mention it only at the time of drawing up his numerous obituaries.[110]

Finally Jean Perrin, a sacred cow of French science: Ministre de la Troisième République, founder of CNRS (*Centre national de la recherche scientifique*), the father of the atom, Nobel Laureate in Physics in 1926, between the end of World War I and the early 1920s put forth - with stolid determination - the fallacious radiative theory, according to which every chemical reaction would be caused by luminous radiation and its kinetic energy would be determined by the intensity of said radiation.[111] Perrin, in addition to being the author of erroneous assumptions, was the mentor of two famous physicists, Yvette Cauchois (1908-1999) and Horia Hulubei (1896-1972) who, in turn, announced the discovery of three nonexistent chemical elements: *sequanium*, *dor*, and *moldavium*.[112]

When, in the early 1920s, Ştefania Mărăcineanu arrived in Paris, we are no longer in the Belle Epoque, where the capital was one of the driving forces of an enthusiastic confidence in the future, nurtured by continuous discoveries and inventions, regularly augmented by recurring expositions. We could advance the hypothesis that the environment of the chemists and physcists in France in those years[113] could have stimulated students and researchers over a healthy competition in the search for new physical phenomena and that this research has turned into obsession of wanting to discover something new at any cost, thus committing inevitable blunders. If an Urbain was driven to do this to refresh his fame in a futile attempt to bring down upon himself the attention of the Nobel Foundation, for Ştefania Mărăcineanu, we could talk about self-deception.[114]

The illusion of finding oneself before a vast unexplored ocean that represented the ultimate structure of matter and to be able to scrape together a few more great experimental discoveries escaped the scrutiny of the great scientists of the previous generation. But Ştefania Mărăcineanu's flaw, like many researchers formed at the *Institut du Radium*, was that although they belonged to the generation following that of Marie Curie, continued to remain mentally contemporary, unable to grasp many of those discoveries that would have been the preserve of scientists more cosmopolitan: in the U.S., Britain, and Germany. Because ultimately Ştefania Mărăcineanu, coming from a peripheral and marginal country in terms of the international scientific scene, had acquired French know-how when it was at its lowest point at the international level. For example, Jean Perrin, the undisputed head of French physical chemistry between the two world wars, forbade publication of any article on quantum mechanics in the journals he directly or indirectly controlled.[115]

On the one hand we have the characters (Curie and Perrin to name only two) so famous that they have become monuments of our cultural history that the very idea of attacking them frightens us. Yet we have to pull together the threads of this story.

For a long time a misunderstanding has surrounded the figure of Ştefania Mărăcineanu as if the glow of the flames burning Bucharest in her long siege, had clouded her virtues as a scientist and the city collapsing into ruin deleted along with her true and presumed discoveries its anti-Semitism and adherence to an authoritarian fascist regime, which it was replacing bloodily with a long communist dictatorship. It is difficult in this climate to move important details out of the shadows, like the fact that in her narrow view of the physical world, Ştefania Mărăcineanu, saw too many phenomena being derived from or, ultimately, due to radioactivity. Certainly to Ştefania Mărăcineanu it was not an easy life, but it should be added that when, in 1929, she returned to Romania, she did not stop to making an "incendiary tour" wherever she went, thundering against her old mentor and, after her death, against her daughter.

Her improbable discoveries of the 1920s were side by side, a decade later, with others: she wanted to see a correlation between exposure of radioactive substances to air and the formation of storm clouds or earthquakes. It was almost a leap of faith, made with an old nationalistic spirit of science in spite of the continued declining times; World War II was unveiling its monstruous dimensions and its obscene ideology leading to the extermination of men, women, old people, and children, using in all this the only too willing and zealous men of science. It is a situation in which Mărăcineanu took part, against her will, at the end of her life: a military conflict, the political and cultural identity, which has destroyed the conscience of a generation of her scientific peers.

At a time when all the characters seem to "shout and no one listens to the other's voice," we can only conclude that stories like these are - in our opinion – an incomparable antidote to the temptation of writing scientific hagiographies.[116]

ACKNOWLEDGMENTS

The authors wish to thank Mr. Adrian Tudoroiu, Doctors Alessandro Ciandella, Dina Scarpi, Roberto di Camillo and Stefano Fedeli, Professors Roberto Livi, Andrea Stefanini and Massimo Chiari for their help in the preparation of the present work.

A simple thank you cannot express the immeasurable help from the personnel of the *Biblioteca del Polo Scientifico di Sesto Fiorentino* in the persons of Laura Guarnieri, Serena Terzani, Sabina Cavicchi, Marzia Fiorini, Sabrina Albanese and Angela Landolfi, as well as the Archives Assistants Julia Schmidt and Heidi Egginton of the Churchill College Archives Centre (Cambridge, UK).

BIBLIOGRAPHY

1. Greater Romania, which assumed the name of Romania between 1918 and 1940. In 1918, Romania was defeated by the Austro-Germans but actually won the war. It participated with the winners in the partition of the territories of both its Austro-Hungarian enemy as well as of its Russian ally. The only country that had its territory doubled by the terms of the Peace of Versailles, Romania basically had designs on establishing its hegemony over the entire area of the Lower Danube. But it made the error of overestimating its own strength, leading to the failure of its more ambitious ideas and to a foreign policy that struggled mightily to forge its own path in a post-World War I Europe, skirting both integration and a less-welcome annexation, thus paralyzing its internal politics for twenty years.
2. M. Popescu, M.F. Rayner-Canham, G.W. Rayner-Canham, "Stefania Mărăcineanu: Ignored Romanian Scientist" in "A Devotion to their Science: Pioneer Women in Radioactivity" by Marelene F. Rayner-Canham, Geoffrey W. Rayner-Canham Editors, **1997**, Chemical Heritage Foundation, Philadelphia & McGill-Queen's University Press, Montreal; pp. 87-91.
3. I.N. Iacovachi, *Noesis*, No. 10, **1984**; M. Rogai, *Evenimentul Zilei*, 13 septembrie (2009); G. Marcu, *Ziarul Financiar - Ziarul de Duminică*, 26 noiembrie **2009**; Professor Ing. Dănuţ Şerban's website: http://www.stefania-maracineanu.ro/; last access 06/12/2016.
4. M. Rogai, *Formula AS*, nr. 928, **2010**.
5. M. Popescu, M.F. Rayner-Canham, G.W. Rayner-Canham, "Stefania Mărăcineanu: Ignored Romanian Scientist" in "A Devotion to their Science: Pioneer Women in Radioactivity" by Marelene F. Rayner-Canham, Geoffrey W. Rayner-Canham Editors, **1997**, Chemical Heritage Foundation, Philadelphia & McGill-Queen's University Press, Montreal; p. 90.
6. I. Langmuir, "Colloquium on Pathological Science", held at the Knolls Research Laboratory, Niskayuna, New York on 18 December 1953. A recording of the actual talk was made, but apparently lost, but a recorded transcript was produced by Langmuir a few months later. See also: I. Langmuir, *Physics Today*, **1989**, *42*, Issue 10, October, pp.36–48.
7. The alleged discoveries relating to artificial rain induced by radioactive substances and the link between radioactivity and earthquakes, as we shall see, were not refuted presumably for two reasons: the announcements were made in minor scientific journals, in the middle of World War II; in addition, Mărăcineanu died shortly after the publication of these works.
8. J.-P. Adloff, G. B. Kauffman, *Chem. Educator*, **2008**, *13*, 318-325.
9. www.segretidipulcinella.it/sdp24/temp_02.htm, last accessed 18/10/2016: Stefania Mărăcineanu (1882-1944), in *Segreti di Pulcinella, Rivista di Letteratura e Cultura Varia*, numero 24.
10. G. Steinhauser, G. Loeffler, R. Adunka, *J. Radioanal. Nucl. Chem.*, **2013**, *296*, 157-163; Arhivele Naţionale ale României – Direcţia Municipiului Bucureşti, Stefania Mărăcineanu; Ion N. Iacovachi, *Noesis*, **1984**, No. *10*.
11. Romanian historian, politician, and man of letters. President of the Council between 1931-32, he was also adviser to King Carol II (1893-1953). For reasons of cultural affinity, he was fascinated by Italy, although not an admirer of Benito Mussolini (1883-1945) and fascism. He was rather suspicious of Soviet and German hegemonic designs on his country and because of his firm opposition to the Romanian government's pro-Nazi policy, he was assassinated by elements of the radically fascist "Iron Guard" in 1940.
12. Professor Ing. Dănuţ Şerban's website: http://www.stefania-maracineanu.ro/; last access 06/12/2016.
13. The half life, $T_{1/2}$, and the decay constant, λ, are often used interchangeably; they are related by $T_{1/2} = 0.693/\lambda$.
14. M.E. Wieser (2006). *IUPAC Technical Report, Pure and Applied Chemistry*, **2005**, *78*(11), 2051–2066; G. Audi, A. H. Wapstra, C. Thibault, J. Blachot, O. Bersillon, *Nuclear Physics A.*, **2004**, *729*, 3–128; N. E. Holden. "Table of the Isotopes." In D. R. Lide. *CRC Handbook of Chemistry and Physics* (85th ed.), **2004**, CRC Press. p. 11-50.
15. M. Curie, *C.R.*, **1906**, *142*, 273; Rutherford, E., *Phil. Mag.* **1905**, *10*, 290; Marckwald W., *Jahr. d. Rad.*, **1905**, 136; Meyer, von Sweidler, *Wien Ber.*, **1906**, *115*, 63; Regener, *Ber. der D. Physik Ges.*, **1911**, *13*, 1027.
16. This precaution was considered necessary because of the extreme difficulty in the treatment of polonium. One milligram of the isotope ^{210}Po (the only one manageable because the other four isotopes' half lives were too short), emits the same number of alpha

particles as five grams of radium. In the process of decay, polonium-210 also releases a large amount of energy.

17. Ş. Mărăcineanu, *C.R.*, **1925**, 774.
18. Ş. Mărăcineanu, *C.R.*, **1926**, 345.
19. "On aurait pu croire à une pénétration du polonium d'une face a l'autre du plomb; mais dans ce cas on aurait dù avoir une forte perte de polonium à l'intérieur du blomb, ce qui n'a pas été constaté…"
20. "…semblent inique que le rayonnement solaire peut provoquer la réintégration du Radium-E [Bi] a partir du Radium-F [Po], et donc una reversibilité dans la série radiactive"
21. Ş. Mărăcineanu, *C.R.*, **1927**, 1322.
22. Madame Curie was a combative woman and so sure of herself that she never gave way in debate, even when fraught with a possible acrimonious aftermath. She savagely attacked both Willy Marckwald and Sir William Ramsay when they committed egregious errors in the field of radioactivity. The two colleagues harbored bitter memories of this incredible woman's stubborn tenacity. It seems very strange that Marie Curie did not openly take a position on this matter, which was nurtured under her own roof. See M. Fontani, M. Costa, M. V. Orna, "The Lost Elements: the Periodic Table's Shadow Side", Oxford University Press (2015), p. 471-475.
23. The Institute of Radium, according to Bertrand Goldschmidt (1912-2002), one of the last students to have known her personally, was ruled despotically and with certain inclinations toward nepotism by Marie Curie. After her death, André Debierne (1874-1949), the new director, had repeatedly clashed with her daughter, Irène Joliot-Curie (1897-1956). The following anecdote is worth quoting as an explanatory example: "During one disagreement, when Irène objected to the appointment of Bertrand Goldschmidt to a position she believed belonged to someone else, Debierne retorted 'Goldschmidt possesses a quality that ALL the others do not have - he did not work with your mother. Now get out of here!' " Goldschmidt, B. Atomic rivals. Rutgers University Press, New Brunswick & London; 1990, page 19.
24. Marie Curie's granddaughter, Hélène Joliot, was born on September 17, 1927 and at 21 years of age, she married Michel Langevin, the grandson of her grandmother's lover, Paul Langevin (1872-1946).
25. "a midi, quand le Soleil darde sur l'appareil, le plomb semble devenir deux fois plus active…"
26. It is not clear what lead compounds might have been formed; their identities would certainly depend upon the acid used. It is also not clear if the lead compound thus formed were reduced by experiment to elemental lead prior to testing.
27. "Le plomb du commerce, préparé toujours avec la galéne, n'est pas, comme on sait, radioactif…"
28. H. Deslandres, *C.R.*, **1927**, 1324.
29. "Les persone qui ont du plomb longtemps insolé, et qui n'ont pas appareils nécessaires à la recherche de la radioactivité, sont priées d'en envoyer un échantillon à l'Observatorie de Paris".
30. Ş. Mărăcineanu, *C.R.*, **1927**, 1547.
31. H. Deslandres, *C.R.*, **1927**, 1549.
32. "Les recherches de Mlle Mărăcineanu sur le toitures anciennes de l'Observatorie de Paris offrent un intérêt de plus en plus grand. Le plomb n'est pas le seul métal qui acquiere, sous l'influence des rayons solaires, une radioactivité spéciale…".
33. W. Kolhorster, *Physikalische Zeitschrift*, **1914**, *14*, 1153; W. Kolhorster, *Naturwissenschaften*, **1926**, *14*, 290.
34. R.A. Millikan, R. M. Otis, *Physical Review*, **1926**, *27*, 645.
35. H. Deslandres, *C.R.*, **1922**, 622.
36. Ş. Mărăcineanu, *C.R.*, **1927**(*II*), 122.
37. "On a vu que le courant d'ionisation donné par la côte opposé est proportionel à la valeur initiale du polonium déposé".
38. "Si l'on considère l'allure des cuorbes, ce courant d'ionisation qui augmente chaque jour de lui-même passe par un maximum, descend ensuite d'après une loi explonetielle, ainsi qu'il se passe, quand une substance radioactive prend naissance, se développe et se detruit, je pense qu'il y a formation d'une substance radioactive nouvelle dans la masse du plomb".
39. H. Deslandres, *C.R.*, **1927**(*II*), 124.
40. The Argus, **1927** August 6, Saturday, No. 25269, p. 10, Australia, Melbourne; Kalgoorlie Miner, **1927** August 15, Monday, Vol. 33, no. 8680, p. 1, Australia, Kalgoorlie; The Canberra Times Week-End Edition, **1927** August 19, Friday, Vol. I, no. 67, p. 12, Australia, Canberra; The Border Watch, **1927** August 20, Saturday, Vol. LXV, no. 6661, p. 2, Australia, Mount Gambier; The Western Argus, **1927** August 23, Tuesday, Vol. 34, no. **1937**, p. 2, Australia, Kalgoorlie; The Daily News, **1927** August 30, Tuesday, Vol. XLVI, no. 16.329, p. 9, Australia, Perth; The Evening Post, **1927** September 10, Saturday, Vol. CIV, no. 62, p. 13, New Zealand, Wellington; The Geraldton Guardian, **1927** September 17, Saturday, Vol. XXI, no. 4743, p. 1, Australia, Geraldton. Professor Ing. Dănuţ Şerban's website: http://www.stefania-maracineanu.ro/; last access 06/12/2016.
41. Professor Ing. Dănuţ Şerban's website: http://www.

stefania-maracineanu.ro/; last access 06/12/2016.
42. Ş. Mărăcineanu, *C.R.*, **1928**(*II*), 746.
43. "Si l'on considère l'allure des cuorbes, ce courant d'ionisation qui augmente chaque jour de lui-même passe par un maximum, descend ensuite d'après une loi explonetielle, ainsi qu'il se passe, quand une substance radioactive prend naissance, se développe et se detruit, je pense qu'il y a formation d'une substance radioactive nouvelle dans la masse du plomb".
44. Ş. Mărăcineanu, *Bullettin de la Section Scientifique de l'Academie Roumaine*, **1929**, *12*, 5.
45. "L'action du raynonnament solaire porrai peu-être provoquer une transmutation del 0,001% plomb en or".
46. "Mais c'est dans les radioations solaires qu'on doit voire la pierre philosophale et la source de la formidabile énergie radioactive, don't la necéssité s'impose et s'imposera de plus en plus".
47. N. Vasilesco Karpen, *Bullettin de la Section Scientifique de l'Academie Roumaine*, **1929**, *12*, 60.
48. "Les expériences en question ont conduit à des résultats exactement contraires à ceux indiqués par M-lle Mărăcineanu".
49. It is not inconceivable that the French physicists were particularly "sensitive" to a similar subject, whose only result could only lead to the accusation pathological science. The unfortunate incident relating to Nancy rays or "N" rays was a blow to the pride of French science, whose ghost had to be still very present in their minds. Regarding this see: Nye, M. J., *Historical studies in the physical sciences*, **1980**, *11*(*1*), 125.
50. She was a French chemist and physicist. On the recommendation of the physicist, Paul Langevin in 1926 she arrived at the Curie *Institut du Radium* laboratory as an "aide-bénévole" (a volunteer) and then the following year became a "travailleur libre" (independent collaborator). She became Paul Langevin's lover twenty years after he had had a turbulent affair with Marie Curie, and she remained faithful to him, especially in the period of his exile in Troyes during the war. From their relationship, Paul Gilbert Langevin (1933-86) was born.
51. E. Róna, E.-A.W. Schmidt, *Wien. Ber.*, **1927**, *136*, 65.
52. She was a Dutch chemist and crystallographer. After completing her studies in 1932 she became assistant to the chemist A. Smits at the General and Inorganic Chemistry Laboratory of the University of Amsterdam. She is mainly known for her work in X-ray crystallography.
53. Smits, A., MacGillavry, C.H., *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*, **1929**, *32*, 610.
54. Ş. Mărăcineanu, *C.R.*, **1925**, 774.
55. "…ces résultats étaient peut-être de grande importance parce que si vraiment le plomb s'active et émet des particules α, il estvraisemblable qu'il y a une transmutation de plomb en mercure".
56. Dănuţ Şerban - *Drumurile mele toate ..., Ştefania Mărăcineanu,* Memoriae Ingenii, Revista Muzeului Naţional Tehnic *Prof. ing. Dimitrie Leonida*, octombrie **2013**, page 6.
57. Voi lupta, dragă Doamnă, şi pentru mine şi pentru dreptate şi pentru onoarea ţării şi a femeilor.
58. Ş. Mărăcineanu, *C.R.*, **1930**, *190*, 373.
59. "Ne serait-ce pas là le resultat d'une transmutation poussée au delà du plomb dans la serie periodique des éléments? et la radioactivité ne serait-elle pas une propriété générale de la matiére?"
60. "je ne peux pas comprendre comment M. M. Fabry et Dureuil n'en ont pas trouvé [trace d'or, d'helium ou de mercure]".
61. He was a French physicist and chemist. He was appointed Associate Professor of Physical Sciences in 1908. He then became Professor at the Faculty of Sciences at Dijon, where he spent all of his career. He was also a member of the Academy of Sciences, Arts and Letters of Dijon. Wounded in World War I, he was decorated with the Legion of Honor in 1929.
62. A. Boutaric, *Bulletin de l'asociation des Diplomes de Microbiologie de la Faculté de Pharmacie de Nancy*, **1941**, *19/23*, 5.
63. A. Boutaric, Mlle. Madeleine Roy, *C.R.*, **1930**, *190*, 483.
64. Mme Mary Wallace Shillito was the widow of a wealthy Mauritian businessman, Assan Farid Dina (1871-1928). Both were allegedlly occultists and alchemists. She died at the age of 62 of a heart attack brought on by an accident, and is buried in Geneva.
65. A. Smits, Mlle. MacGillavry, *C.R.*, **1930**, *190*, 635.
66. H. Deslandres, *C.R.*, **1930**, *190*, 637.
67. G. Reboul, *C.R.*, **1929**, *189*, 1256; G. Reboul, *C.R.*, **1930**, *190*, 374.
68. Pokrovsky, *Zeitschrift fuer Physik*, **1930**, *59*, 127.
69. "il faut attendre que l'étude des faits ait été pousée plus loin".
70. A. Lepape, M. Geslin, *C.R.*, **1930**, *190*, 676.
71. Ş. Mărăcineanu, *Bullettin de la Section Scientifique de l'Academie Roumaine*, **1930**, *13*, 55.
72. A. Boutaric, Mlle. M. Roy, *C.R.*, **1930**, *190*, 1410.
73. Catalan physicist, whose name is often written as Josep Baltà i Elies.
74. J. Baltá Elías, *Anales de Física y Química*, **1941**, 180.
75. C.R. Lawrence, JPL, for the Planck Collaboration,

Astrophysics Subcommittee, NASA HQ (18 March 2015) "Planck 2015 Results" (See page 29 of pdf).
76. Faculty of Science of the University of Bucharest.
77. Professor Ing. Dănuţ Şerban's website: http://www.stefania-maracineanu.ro/; last access 06/12/2016.
78. Middle school for girls.
79. S. Mărăcineanu, *Radioactivitatea şi constituţia materiei*. (*Efectul razelor solare in fenomenele radioactive*), Editura Casei coalelor, Bucuresti, **1929**, pp. 37.
80. S. Mărăcineanu, *Radioactivitatea*, Tipografia C. Lazarescu, Bucuresti, **1936**, pp. 218.
81. I. Joliot-Curie,"Gespraech mit Irene Curie. Die Tochter derr Radiumentdeckerin in Wien" "Conversation with Irene Curie. The daughter of radium's discoverer at Vienna", Neues Wiener Journal, 5 giugno **1934**, pag 6.
82. "Romanian engineer and physicist, and also known for some of his achievements in mechanical engineering and electrochemistry. He created a controversial contrivance that goes by the name of the Karpen Pile: a battery capable of self-perpetuating recharge which provided power for over 60 years. A fraud according to scientists; an example of perpetual motion according to some newspapers". Sandru, Ovidiu. "Karpen's Pile: A Battery That Produces Energy Continuously Since 1950 Exists in Romanian Museum". Retrieved 20 July 2012. http://www.greenoptimistic.com/karpen-pile/; last access 06/12/2016.
83. "Artificial radioactivity, a discovery of Romanian [scientists] in this area". Professor Ing. Dănuţ Şerban's website: http://www.stefania-maracineanu.ro/; last access 06/12/2016.
84. I do not dispute the award of the Nobel Prize to Mme. Joliot-Curie for the advancements that she made to this discovery, such as investigative methods, highlighting the phenomenon that I consider to have discovered. But I ask you to recognize the role I played in this discovery. I was the first to announce this phenomenon in 1924 when it seemed utter foolishness. Mme. Joliot-Curie used the same method that I used at the beginning of her research. ... The only difference is that she placed a metal sheet over polonium, while I deposited a polonium solution on the metal foil.
Pierre Curie's widow [in this second stage of the letter, the Romanian researcher refers to Marie Curie in 1923] did not allow me to give this explanation in my thesis and assured me that if I listened to her, the work would be continued and that when my PhD was finished, an article in my name would appear. In that case, I held back. […] Immediately after obtaining the PhD, I published my results on my own at the Romanian Academy". English translation from http://www.mnt-leonida.ro/09Noutati/090043Noutati2013.10.17/StMaracineanu2013AR.pdf; last access 06/12/2016.
85. "... This laboratory is my life, from which I could never be separated." English translation from http://www.mnt-leonida.ro/09Noutati/090043Noutati2013.10.17/StMaracineanu2013AR.pdf; last access 06/12/2016.
86. It was persecution and personal opposition that has followed me step by step, since I broke off with the *Institut du Radium* ... English translation from from: http://www.mnt-leonida.ro/09Noutati/090043Noutati2013.10.17/StMaracineanu2013AR.pdf; last access 06/12/2016.
87. France was the only ally and guarantor of Romanian borders. Her collapse under German tanks in May 1940 threw the Romanian government into complete panic. King Carol decided to make a last-minute proposal to Hitler to curry favor with the Axis, but a few days afterward, Russia commanded Romania to cede the province of Bessarabia, while the Axis didn't bat an eyelash. During July and August 1940, the Hungarians and Bulgarians prepared (with German support) to further amputate Romania (the Kingdom of Transylvania and Southern Dobruja). The day after signing the *Diktat of Vienna* (August 30, 1940) King Carol named General Antonescu governor, and abdicated in favor of his son, Michael (b. 1921) who ten years earlier had been deposed with a *coup d'état*.
88. Information supplied by Gheorghe Bezviconi (1910-1966) in his book "Necropoli Capitale", published posthumously by the Institute of History "Nicolae Iorga," 1972.
89. D.G. Karraker, A. Ghiorso, and D.H. Templeton, *Phys. Rev.*, **1951**, *83*, July, 390.
90. Woolum, S. Dorothy, D.S. Burnett, L.S. August, *Nuclear Instruments & Methods*, **1976**, *138*(*4*), 655.
91. J.J. Howland, D.H. Templeton, I. Perlman, *Physical Review*, **1947**, *71*, 552; D. H. Templeton, J.J. Howland, I. Perlman, *Physical Review*, **1947**, *72*, 766.
92. E. Amaldi, O. D'Agostino, E. Fermi, B. Pontecorvo, F. Rasetti, E. Segrè, *Proceedings of the Royal Society*, **1935**, *149A*, 522; O. D'Agostino, E. Fermi, B. Pontecorvo, F. Rasetti, E. Segrè, *Ricerca Scientifica*, **1934**, *1*, 380.
93. W.Y. Chang, *Phys. Rev.*, **1946**, *70* November 1, 632.
94. J. Clay, K.H.J. Jonker, *Physica* (*The Hague*), **1938**, *5*, 171.
95. CCA, Doc. Reference MTNR 5/12; letter from Ştefania Mărăcineanu to Lise Meitner, 12/03/1936.

96. Word written between the lines.
97. Grammatically, it should be "vos".
98. In the original letter, the "y" is written "i".
99. It should be: "maçonnique".
100. Words added between the lines.
101. In the original letter, the "y" is written "i".
102. Madam,
   In February I presented my work - on artificial radioactivity - to the attention of German Science. You are an authority in this field and your opinion on it will be highly esteemed. I hope that the work has already been presented to you by those people who may be concerned. Madam, I do not ask for a favor, but only justice and I warmly do appeal to your spirit of "equity" and your love for science. I do not ask for the laurels of Madame Joliot-Curie; but I only ask that the part I played at the beginning of this discovery is recognized as well as my pioneering work on artificial rain. I have seen that in France they are beginning to talk about this subject without mentioning my experiments in that area. Madame, you have known me as Mme. Curie's pupil, I do not know how she would have looked at this question; In any case, I beg you very much not to speak of me to Mme. J. Curie. Do not write to her that I have also addressed you [by this letter]. She hates me and she belongs to a very powerful Judeo-Masonic organization. | She is a Communist |. I speak of it knowledgeably, believe me, because I have had occasion to feel her power. Only in Germany can I be vindicated. Please accept, Madam, the expression of my most distinguished greetings,
   Dr. Stéphanie Mărăcineanu
103. E. Tina Crossfield, "Irène Joliot-Curie: following in her Mother's Footsteps", in "A Devotion to their Science: Pioneer Women in Radioactivity" by Marelene F. Rayner-Canham, Geoffrey W. Rayner-Canham Editors, **1997**, Chemical Heritage Foundation Philadelphia & McGill-Queen's University Press, Montreal pp. 97-124.
104. E. Amaldi, "La radioactivité artificielle a 50 ans, 1934-1984", Éditions du Physique, **1984**, pp. 164.
105. J.C. Gomes, "Georges Urbain (1872-1938), chimie e philosophie", Doctoral dissertation, **2003**, Université de Paris X, Nanterre, 235-242.
106. M. Charpentier-Morize, "Perrin, Savant et homme politique", **1997**, Ed. Belin, 217-226; B. Bensaude-Vincent, *Langevin (1872-1946) science et vigilance*, Paris, Ed. Belin, **1987**, 271.
107. J.C. Gomes, Ibid., 40-44.
108. A colleague, Fortunée Schecroun (1896-1978), known as Nine Choucroun, officially became the *compagne* of Jean Perrin after the death of Heniette Perrin (1869-1938); Eliane Montel (1898-1992) had a lengthy relationship with Paul Langevin after he left his first lover, Marie Curie, and their bed-sit that they had rented in rue de Banquier, not far from the Sorbonne. Finally, Georges Urbain (1872-1938), left a widower in 1936, married his "personal nurse," Jacqueline Nancy Ullern (1910-78), nearly forty years his junior.
109. G. Urbain, *Scientia* (*Milan*), **1934**, *56*, 71; G. Urbain, *Bulletin de la Société Chimique de France*: *Memoires*, **1937**, *4*, 1612.
110. Between 1938 and 1940, about a half-dozen obituaries were published to remember him. Also, two biographies came out on the occasion of the centenary of his birth (1972). In one of them, there is an outline of his *homéomérie* theory.
111. J. Perrin, *Annales de Physique*, **1919**, *11*, 5.
112. M. Fontani , M. Costa, M.V. Orna, "The Lost Elements: the Periodic Table's Shadow Side", Oxford University Press, **2015**, p. 331-334.
113. D. Pestre, *Physique et physiciens en France 1918-1949*, Edition des Archives Contemporaines, **1984**; M.J. Nye, *From Chemical Philosophy to Theoretical Chemistry 1800-1950*, University of California Press, **1993**.
114. R. Trivers, *Annals of the New York Academy of Science*, **2000**, *907*, 114.
115. M. Charpentier-Morize, "Perrin, Savant et homme politique", **1997**, Ed. Belin, 107-109.
116. R. Hoffmann, in M. Fontani, M. Costa, M.V. Orna, "The Lost Elements: the Periodic Table's Shadow Side", Oxford University Press, **2015**, p. xvi.