

THE PHYSICIST AND HIS GHOSTS: THE SCIENTIFIC WRITING OF ERNESTO SABATO

ÓMAR VARGAS

University of Miami

Abstract: This article examines the dialogues and intersections between science and literature regarding Ernesto Sabato. A close reading of his scientific, science-related and literary texts and the account of the most significant facts of his career during the 1930's, 1940's and early 1950's, as well as an archival review of his files in La Plata, Buenos Aires and Paris in the same period of time, reveal how his scientific and literary works are intertwined manifestations of the same talent and sensitivity, and that, in the end, all of Sabato's writing should be considered scientific.

Key words: atomic physics, thermodynamics, cosmic rays, Universidad Nacional de La Plata, science and literature, Curie, Teseo, Sur, Crisóstomo Ugarteche

The Elements of Physics

The publication in 1944 of *Elementos de Física para las Escuelas Nacionales de Comercio. Primer curso. Programa oficial de 1942* represents the first time Argentine Ernesto Sabato (1911-2011) appears as an author of a book, sharing credits with his fellow countryman Alejandro de Bisschop. For a person who would win worldwide recognition as novelist, essayist, painter and key reference in the intellectual, cultural, social and political history of Latin America, it is highly noteworthy that the first association of his name with any book is tied to a physics textbook.

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Figure 1: Cover and credits page of the first version of *Elementos de Física* by Sabato and De Bisschop (Courtesy of Ariel Fleischer)

The textbook would have different incarnations and different authors. A second version, this time with the more succinct title *Elementos de Física*, and with Sabato sharing authorship with one of his former students, physicist Alberto Maiztegui, was released in 1946 and would even go on to have a second edition in 1950.

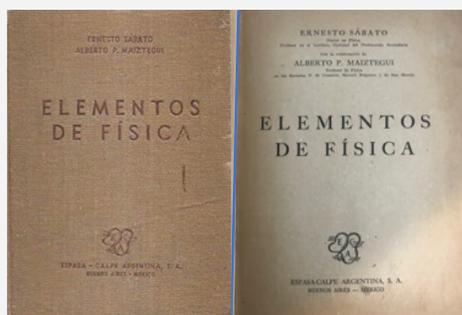


Figure 2: Cover and credit page of *Elementos de Física* by Sabato and Maiztegui.

The need to update and adjust the textbook's content to new pedagogical and theoretical requirements led to a 1951 third and classic version, *Introducción a la Física*. By this time Maiztegui had to join forces with another Sabato, Jorge Alberto (1924-1983), a cousin of Ernesto and fellow physicist, because Sabato was by then exclusively committed to his literary career. *Introducción a la Física* would become one of the most important textbooks for the teaching and learning of physics in Argentine and Latin American secondary schools during the second half of the 20th century.

This first book by Sabato is at the center of his existential and vocational crisis and would epitomize what is conventionally known as the end of his relationship with science, a process that had started six years before, at the Institut du Radium in Paris. Just when he was about to achieve the dream of any young nuclear physicist —to work along the greatest scientists of his time in one of the most prestigious institutions of the world — he began to experience a tension between “el universo abstracto de la ciencia y la necesidad de volver al mundo turbio y carnal al cual pertenece el hombre concreto” (*Antes del fin* 66). He explained his breaking up with science as a crisis of faith: “Trabajaba en el laboratorio

Curie como uno de esos curas que están dejando de creer pero que siguen celebrando misa mecánicamente, a veces angustiado por la inautenticidad” (*Obra Completa. Narrativa* 726). Instead of laboratories, electrometers and test tubes, he spent most of his time in Paris in bars, hanging out with surrealist artists and writers like Wilfredo Lam, Óscar Domínguez and Tristan Tzara. He was feeling extremely unhappy. It was precisely in those days that he began to write the novel *La fuente muda*, his first literary project.

His transition from science to literature was gradual and unstoppable. In what follows, a chronological overview of most of Sabato’s scientific, science-related and literary texts of the 1930’s, 1940’s and early 1950’s helps to explain that transition. Sabato’s work in those years oscillated between different roles as researcher, professor, author and science communicator, and eventually creator of fiction. The range of scientific problems addressed by Sabato, his vital reactions to the institutional, social, political, aesthetic and personal conflicts he experienced, as well as his search for answers to his turbulent spirit, converge and evolve in a writing style that foreshadows his distinctive and acclaimed literary prose. Yet a great deal of his literary and fiction writing displays an arsenal of images, rhetorical strategies and metaphors taken from scientific backgrounds and resembling scientific methods and reports. For example, in *El túnel*, Juan Pablo Castel cross-examines María Iribarne like a stubborn scientist who follows the conviction that she, like nature, responds to experimental interrogation. Castel also attempts several times to prove the truth of statements by apparently following rigorous logical procedures. In Chapter I he upgrades the declarative sentence “el mundo es horrible” to “una verdad que no necesita demostración” (*Obra Completa. Narrativa* 26)). However, his next declaration (“Bastaría un hecho para probarlo, en todo caso: en un campo de concentración un ex pianista se quejó de hambre y entonces lo obligaron a comerse una rata, pero viva” (*Obra Completa. Narrativa* 26)), according to the rules of logic, constitutes a proof by example, a logical fallacy because the validity of this statement is illustrated through one example, rather than through a full-fledged proof. Of course, from a poetic perspective the reasoning is flawless. Similarly, and in a rather delirious and distorted incarnation, both *El túnel* and “Informe sobre ciegos,” the third section of *Sobre héroes y tumbas*, contain elements of experimental work, like collecting and analyzing data, formulating and verifying hypotheses and writing and submitting reports.

In spite of his well-known background in science, not many works have taken an approach of establishing dialogues and intersections between science and literature regarding Sabato or have explored the impact of his physical-mathematical training on his literary production. Sabato himself seems aware of the many instances in the history of Western culture in which people with scientific backgrounds like his (he mentions, for example, the engineer Dostoyevsky) end up fighting their inner demons by switching to literature. He contends that he is just one more case:

Son muchos los que en medio del tumulto interior buscaron el resplandor de un paraíso secreto. Lo mismo hicieron románticos como Novalis, endemoniados como el ingeniero Dostoievski y tantos otros que estaban destinados finalmente para el arte. A mí, como a ellos, la literatura me permitió expresar horribles y contradictorias manifestaciones de mi alma, que en ese oscuro territorio ambiguo, pero siempre verdadero, se pelean como enemigos mortales (*Antes del fin* 69)

In fact, there are well known examples of this crisscrossing of science and literature in 20th century Latin American narrative fiction that have been the subject of important and plentiful works and academic studies. Cuban painter, writer and essayist Severo Surduy, who had experience as a medical student and scientific journalist, incorporates cosmological

notions and terminology to formulate his theory of baroque and to write his poetry. Another Cuban, Antonio Benítez Rojo, published in 1989 the book *La isla que se repite. El Caribe y la perspectiva posmoderna*, an analysis, from the perspective of Chaos theory and fractal geometry, of economic, social and cultural phenomena in the Caribbean.

Reading some of the work of Argentine Jorge Luis Borges immediately triggers connections with specific topics in mathematics, like probability theory in “La lotería en Babilonia” or transfinite cardinals and the notion of infinity in “El Aleph.”¹ Furthermore, it is possible to establish a clear correspondence between Bertrand Russell’s paradox of the set of all sets that are not members of themselves and Borges’ proposal of the catalogue of all catalogues, as presented in his short story “La biblioteca de Babel.” Some of these findings are examined in *The Unimaginable Mathematics of Borges’ Library of Babel*, by William Goldbloom Bloch and by Argentine author Guillermo Martínez in his 2003 book *Borges y la matemática*. Martínez discusses themes stemming from Borges’ writing such as the short story as a logical system and literature and rationality. However, Ernesto Sabato is by far the best representative of the dialogues and intersections of science and literature.

The UNLP’s Instituto de Física

The relationship of Sabato with science began at Universidad Nacional de La Plata (UNLP). The institution was founded on September 25, 1905, with the mission statement of advancing a scientific, modern and experimental school that would be an alternative to the predominantly humanistic orientation of the already established universities of Córdoba and Buenos Aires in the Argentine Republic. But it was also meant to play a decisive social role in promoting familiarization with scientific knowledge among the less educated members of the lower social classes. In this context Sabato, the tenth of eleven children of Calabrian immigrants struggling to make their way in a new country, found favorable conditions for his education and for his intellectual and professional growth.

Between 1924 and 1928, Sabato was a high school student in UNLP’s Colegio Nacional. He was exposed to a pedagogical system that emphasized a humanist approach, with important scientific and positivist components, and was strongly influenced by the great Dominican writer and intellectual Pedro Henríquez Ureña, one of his professors. According to author Osvaldo Graciano, students in this institution received a citizenship education grounded on the national liberal ideas of the early 20th century while being exposed to an English-style boarding and tutorial system (Graciano 37). These students would become, during the first years of the 20th century, the core of a new intellectual class that embraced predominantly left-wing political ideas and became the protagonists in the rise of an influential Argentine student movement. However, as Sabato often claimed, his cloudy, turbulent and chaotic spirit would first find hope and reassurance not in political militancy but in science; discovering order and harmony through the demonstration of a mathematical theorem: “cuando el profesor de matemáticas demostró el primer teorema, yo quedé fascinado con ese orden perfecto” (*Obra Completa. Narrativa* 14)

In 1929 Sabato applied and was admitted to the UNLP School of Physical-Mathematical Sciences, officially entering the program on March 4th, 1929. In 1930, a military coup led by General José Félix Uriburu unseated constitutional President Hipólito Irigoyen and young Sabato, up till then flirting with anarchist groups, joined the Communist Youth Federation and began neglecting his studies. In 1933 he taught Marxism courses and was elected to be a delegate representing Argentina at the 1934 International Congress Against War and Fascism in Brussels, Belgium. It was there where, in a drastic change of direction, he renounced his militancy and escaped to Paris and then returned to Argentina to resume his studies.

1. See Omar Vargas’ “El extraño comportamiento de las palabras en el infinito: la teoría fractal, la teoría de conjuntos y «El Aleph».”

During this turbulent period, he had begun writing and publishing papers. His first publication was a satirical article entitled "Ciencia e iglesia" that appeared in the Journal *Claridad* on April 11, 1931. In it, he reacts to the news of a radiotelephone device being installed in the Pope's office in Rome. He finds it rather amusing that "S. S. el Papa, sin desplazamientos gravosos para su nada alada humanidad, puede ahora comunicarse cómodamente desde su escritorio con el rebaño y cuidar mejor que nunca que alguna oveja descarriada tome el camino ancho" ("Ciencia e Iglesia" 106). God has given that tool to the Pope to avoid His own public appearances. But God is actually disconnected from reality and modern life, which has led Him to failure and dejection. He has even avoided attending any Polytechnic or University to study a little bit of astronomy, mathematics or physics and other modern subjects. As a consequence, "se ha abandonado, se deja crecer la barba desmesuradamente, anda sucio, desaliñado, blasfema como un carrero delante de todos los santos, habla sombríamente de suicidarse" ("Ciencia e Iglesia" 106). Perhaps the real irony is that Sabato puts science alongside religion in this text, foreshadowing the type of contradictions and struggles he would later experience. In fact, science notions and activities would become an unsteady and oppressive system of faith and worship for him.

In 1935 he published his first scientific paper, "La relatividad de la masa," in the journal *Revista del Centro de Estudiantes de Ingeniería*.



Figure 3: "La relatividad de la masa". 1935.

Sabato looks at the fundamentals of Albert Einstein's special theory of relativity. In fact, he states in the introduction of his paper that, unlike what Newtonian mechanics holds, the mass of a body is not a constant magnitude, but one that varies with velocity. Therefore, he chose to determine the behavior of mass at the atomic level. Author Ariel Fleischer explains that Sabato conducted an experiment consisting of the deviation of the electrons of cathode and β rays through electric fields in a closed tube (Fleischer 31). By manipulating the speed of these electrons, he found that their mass is greater when they travel at very high speeds than when they are at rest. Sabato also illustrates these principles by means of an adaptation of an Einstein thought experiment. This time Sabato boards a plane that flies at the speed of light:

Supongamos que mi "masa en reposo" es m_0 y que luego subo a un avión que marcha a 297000 kilómetros por segundo. Yo no noto ninguna diferencia de mi masa, aún midiéndola con los instrumentos más precisos. ¡Y sin embargo en la tierra me comunican que, de acuerdo a los instrumentos de tierra, mi masa se ha hecho 10 veces mayor! ("La relatividad de la masa" 259).

He concludes that there are no systems at absolute rest and that mass, just like length and time, does not have an absolute value but is relative to the state of motion of the observer. His first known scientific work thus deals with relativity from an atomic perspective.

Notions of Atomic Physics

The 1946 book *Elementos de física* includes an Appendix designed to deal specifically with atomic physics, one of the main fields Sabato worked on as a scientist. The rationale for the last minute inclusion of this section in a rather comprehensive and deep fashion that was not usual in high school physics textbooks is to provide an idea of the most intricate theoretical fundamentals behind the construction and functioning of the atomic bomb, which at the time had just been dropped over the Japanese cities of Hiroshima and Nagasaki. The bomb is seen as the cause of “problemas complejos, numerosos y de difícil solución” (*Elementos de física* 325). Sabato and Maiztegui point out that, among all of these problems, the moral one stands out and that it is vital to balance the moral and the material powers of human beings because “un desequilibrio entre estos dos aspectos humanos del problema será, con toda seguridad, fatal para la humanidad” (*Elementos de física* 325). Hence, they conclude, it is necessary to offer young students, who will be the men and women of tomorrow, knowledge that allows them to recognize these problems. Sabato is well aware of the distrust science generates due to its persistent controversial moral standing. In the “Introducción” to 1951 *Hombres y engranajes* he writes:

Y así aprendimos brutalmente una verdad que debíamos haber previsto, dada la esencia amoral del conocimiento científico: que la ciencia no es por sí misma garantía de nada, porque a sus realizaciones les son ajenas las preocupaciones éticas (*Obra Completa. Ensayos* 105).

The Appendix is written with a very successful combination of expertise, effective pedagogical structure and captivating narrative style that manages to provide a clear and enjoyable account of the history and the fundamentals of the atomic theory. A central fact associated with the atomic investigation is that atomic research deals with the limits of the infinitely small, the invisible, the mysterious, the hidden. It is likely that this investigation triggered mystical and poetic sensitivities in Sabato. In the Appendix, which was mostly written by him alone, this is evident in the literary and artistic considerations regarding the size of the atom. The tactic consists of following the suggestion of Norwegian physicist Carl Støermer (1874-1957) who proposed that, in order to have an idea of the smallness of the atomic world, it suffices to imagine what would happen if every single object that surrounds us is enlarged by the same ratio, as many times as necessary, until atoms would be visible. After four successive enlargements, using a scale factor of 100 each time (everything would be 100 million times larger now), the hydrogen atom would be finally perceptible. But, at the same time, the thickness of a hair would be 10 Kilometers, microbes would be 10 meter-long monsters and a pool ball would have the size of the earth (*Elementos de física* 330). Sabato and Maiztegui conclude that:

Y sin embargo, el hombre ha sido capaz de medir el diámetro del átomo, de pesarlo y no sólo eso: ¡ha sido capaz de explorar su interior y ha descubierto allí dentro todo un universo planetario, con un sol infinitamente más pequeño que el átomo! Y no sólo eso: ¡ha sido capaz de explorar el interior de ese sol central!

La física ha realizado todas estas hazañas en menos de cincuenta años, ha revelado que ese núcleo o sol central es la sede de terribles energías y, lo que es más, han encontrado por fin la forma de desencadenarlas: El resultado es *la bomba atómica* (*Elementos de física* 330).

The narrative strategy of invoking drastic modifications of nature’s dimensions in order to give an idea of the size of the atom has a startling effect on the reader and constitutes a key element in Sabato’s literary

writing. Using the same approach, but in an opposite direction, Sabato appeals to an extreme size reduction in *Abbadón, el exterminador* to illustrate the unleashing of atomic energy:

Pensé que si de alguna manera pudiera achicarme hasta el punto de ser un liliputense habitante de aquellos átomos allí encerrados en su inexpugnable prisión de plomo, si de ese modo uno de aquellos infinitesimales universos se convirtiese en mi propio sistema solar, yo estaría asistiendo en ese momento, poseído por un pavor sagrado, a catástrofes terroríficas, a infernales rayos de horror y de muerte (*Obra Completa. Narrativa 762*).

The Appendix consists of five chapters (“Nociones de física atómica,” “Constitución del átomo,” “Transmutación de los elementos I,” “Transmutación de los elementos II,” and “La bomba atómica”) that cover the state-of-the-art of atomic physics. Sabato and Maiztegui begin by outlining a historical overview that connects the work of Greek atomists Leucippus and Democritus, who postulated the world is just atoms and void, to 20th century Neil Bohr’s atomic model, which reduced matter to miniature planetary systems formed by electrons and protons. Regarding the electron, works on electroplating and on the chemical decomposition of elements caused by electric current, that began in the second half of the 19th century, helped to determine that “la electricidad no era un flúido continuo, sino que *estaba compuesta por granitos*, como una arena finísima. Estos granitos de electricidad fueron llamados *electrones* y debían estar en el interior de los átomos” (*Elementos de física 330*).

Another phenomenon Sabato and Maiztegui detail is radioactivity. Discovered accidentally in 1896 by Antoine Henri Becquerel (1852-1908), it was vastly studied and developed by Pierre and Marie Curie in France. Radioactivity affects the nucleus of atoms and is the spontaneous phenomenon that, among many other properties, allows certain elements, like uranium and radium, to emit radiations that produce powerful photochemical and electrical effects. Even though in the Appendix Sabato praises Marie Curie for the isolation of radium (“este elemento fue aislado y estudiado por la señora Curie (*Elementos de física 333*)), he does not do the same in “Informe sobre ciegos”. In fact, through the character of Fernando Vidal Olmos, he brings into play Curie’s name to support a misogynistic tirade in which he diminishes her contributions to the development of radioactivity and portrays them as fortuitous events: “Madame Curie, señorita, no descubrió la ley de la evolución de las especies. Salió con un rifle a cazar tigres y se encontró con un dinosaurio” (*Obra Completa. Narrativa 351*).

Sabato and Maiztegui explain that radioactive atoms are like complex and unstable buildings consisting of positive or negative electric charged particles that somehow explode and release continuously and relentlessly energy in the form of both particles (alpha and beta rays) and electromagnetic waves (gamma rays). This liberation of energy does not happen in a sudden and explosive way, but rather through a very slow process. The prospect of releasing this energy in a complete and controlled fashion, they affirm, would allow, for example “hacer marchar la instalación eléctrica de una casa durante millones de años” or “hacer saltar un acorazado de 30.000 toneladas a una altura de 500 kilómetros” (*Elementos de física 343*). In order to perform this releasing, scientists managed to bomb matter with radioactive bodies as projectiles. One consequence of this was the transmutation of elements. First, it was confirmed that the radioactive decay is a natural form of transmutation. For instance, in the case of uranium, a heavy and unstable element whose nucleus suffers a spontaneous split and, as a consequence, transforms itself into other and lighter elements by means of a decay chain: first, it transforms into two elements and then those two elements into other lighter ones, and so on. Depending on the type of uranium, the decay chain might give rise to elements such as thorium, radium, radon and

polonium, until eventually it stabilizes when becomes lead. But then, mainly through works by Ernest Rutherford and Frederick Soddy, based on relentless blasting to the nuclear fortress, it was possible to achieve some artificial transmutations. Sabato and Maiztegui celebrate this milestone. According to them, science at last had allowed the ancient and medieval alchemists dream to come true: to transmute one chemical element into another. But they do it by bringing up metaphors and references to the recent WWII, like the allies and the Siegfried Line:

Los alquimistas antiguos y medievales querían convertir en oro los metales viles, pero los procedimientos de que se valían eran totalmente ineficaces: calentar, destilar, secar, quemar; las energías que estos hombres ponían en juego eran ridículamente insignificantes, pues, como veremos, eran millones y millones de veces más pequeñas que las necesarias para perforar la muralla nuclear; era algo así como si los aliados hubieran atacado la línea Sigfrido con flechas y piedras (*Elementos de física* 358).

Shortly after the works of Rutherford and Soddy, Irène Curie, the daughter of Pierre and Marie Curie, along with her husband and mother's assistant Frédéric Joliot, discovered artificial radioactivity. They were able to induce instant radioactivity in some stable nucleus by bombarding them with special particles. This breakthrough, followed by the discovery in 1932 of neutrons (constitutive particles of the atom nucleus with no electric charge), paved the way to the nuclear fission. Several beneficial applications of radioactivity are used in medicine, such as in diagnostic imaging and cancer treatment therapies. Sabato and Maiztegui also point out that making sense of Einstein's formula ($E = mc^2$), implies that a very small amount of matter contains a colossal amount of energy and that scientists turned to nuclear fission to generate energy: the principle behind the functioning of both nuclear plants and atomic weapons.

One important atomic physics related theory that Sabato and Maiztegui don't include in their account is quantum physics. The formulation by German physicist Max Planck of the existence of quanta —minimum, invisible and discrete quantities of energy— epitomizes the birth of quantum physics in 1901. This quantum theory allowed scientists to calculate how any atom emitted energy. In 1913 Neils Bohr linked the quantum physics to the structure of atoms. He showed that there exist discrete sequences of electron orbits. The experimental proof of this atomic model was presented one year later, when Germans James Franck and Gustav Hertz, physicists working on the energies of ionization (required energy for the extraction of electrons from atoms), confirmed the quantization of the orbits, that is to say, the quantum theory of atoms. Years before, in 1905, Albert Einstein explained the photoelectric effect, that is the expulsion of electrons as the result of the absorption of light. Einstein assumed that light may be both wave and particle.

But Sabato was well versed in quantum physics. In October 1936 he presented his thesis, "Los potenciales de excitación del átomo de Kr," the final requirement that allowed him, in December of that year, to earn a Ph.D. degree in Physical-Mathematical Sciences at UNLP. In this work Sabato studied krypton's levels of energy by using both Franck's and Hertz's procedure and Einstein's photoelectric effect. The paper is a report of the experiment designed and carried out by him to do so. The report consists of six sections that follow the usual structure of introduction, methods, results, discussion, conclusions and acknowledgements. This structure is a model of what Juan Pablo Castel and Fernando Vidal Olmos would do in *El túnel* and "Informe sobre ciegos," respectively, only that in those texts Sabato presents the research and the reports as they unfold.

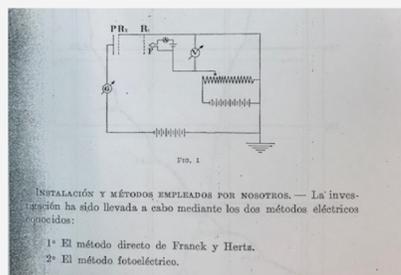


Figure 4: The Diagram of the installation used by Sabato ("Los potenciales de excitación del átomo de Kr" 183).

Krypton is a noble gas that is one of the products of the fission of uranium. Its name comes from the Greek adjective *kryptos*, meaning "the hidden one." In the last paragraph of his thesis Sabato thanks Ramón Loyarte for having suggested this topic of investigation and for his invaluable and constant support throughout it ("Los potenciales de excitación del átomo de Kr" 190). In fact, Loyarte himself had already performed two similar projects: first, in 1935, one called "Los potenciales de excitación del átomo del argón"; and then, just months before Sabato's, in March 1936, another one entitled "Los potenciales de excitación del átomo de mercurio." The main goal of Sabato's and Loyarte's research was to verify the potentials of excitation, or levels of energy, of the elements studied, as predicted by quantum theory, by experimentally decomposing the light spectrum beamed by them and then reporting the values they obtained.

After graduation, Sabato began to work at the Instituto as a professor. He also published a postdoctoral paper at the request of his professor Enrique Gaviola, not on atomic physics but on a topic related to the popularization of science, its resourcefulness and the wide range of applications of scientific expertise. That paper, "Cómo construí un telescopio de 8 pulgadas de abertura," was published first in *Revista Astronómica* of Buenos Aires, and then as an individual booklet in October 1937. The booklet included a Foreword by Gaviola where the astrophysicist underscores the importance of Sabato's article and how it was destined to encourage the construction of home-made telescopes by enthusiasts and friends of astronomy ("Cómo construí un telescopio de 8 pulgadas de abertura" 3).

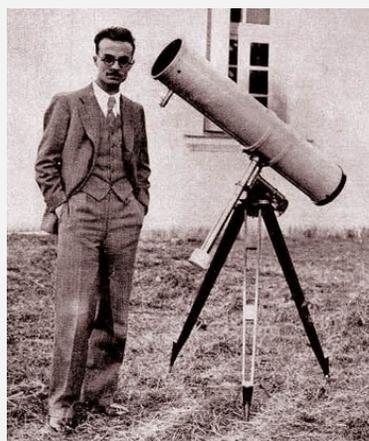
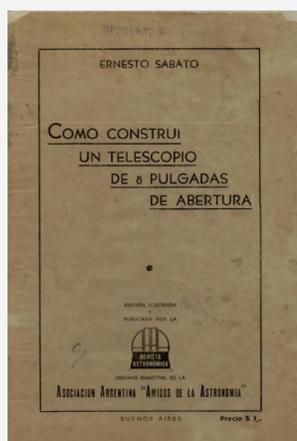


Figure 5: Cover of the booklet and the author and his telescope, 1937.

At the Institut du Radium, Paris, 1938-1939

At age 26, Sabato was well positioned for his professional and academic career and sought opportunities to advance it. He considered the Institut du Radium in Paris the best fit for his interests and skills. He contacted Bernardo Houssay (1887-1971) who, as director of the Asociación Argentina para el Progreso de las Ciencias, agreed to recommend him for an internship there, by letter of 27 May 1938 to Frédéric Joliot:

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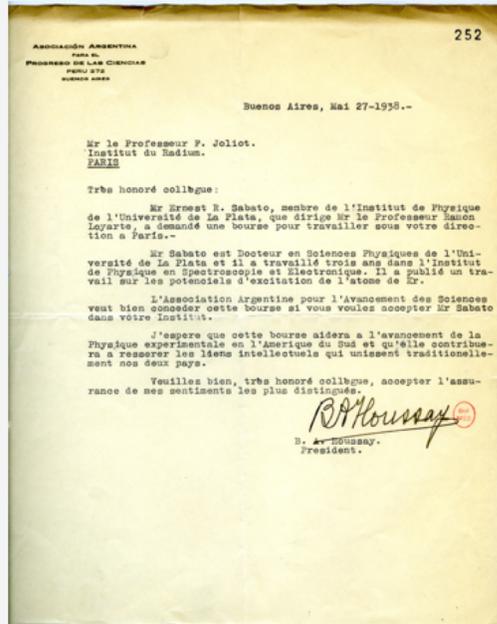


Figure 6: Houssay's letter. (BnF Mss Archives Joliot- Curie NAF 28161 / F 145 (f° 252))

Houssay was an important and influential Argentine physiologist, who was a co-recipient of a Nobel Prize for Medicine in 1947 for his discovery of the role played by pituitary hormones in regulating the amount of blood sugar in animals. He was the first Latin American scientist to become a Nobel laureate. On 23 June 1938, Houssay's petition on behalf of Sabato was accepted by Joliot:

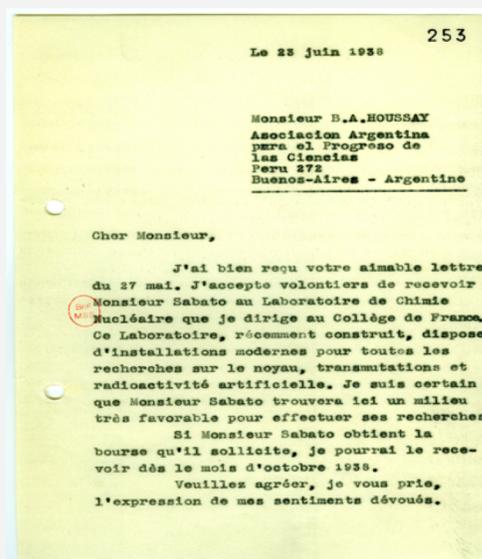


Figure 7: Joliot's letter (BnF Mss Archives Joliot- Curie NAF 28161 / F 145 (f° 253)).

Sabato was formally registered at the Institut on October 26, 1938.

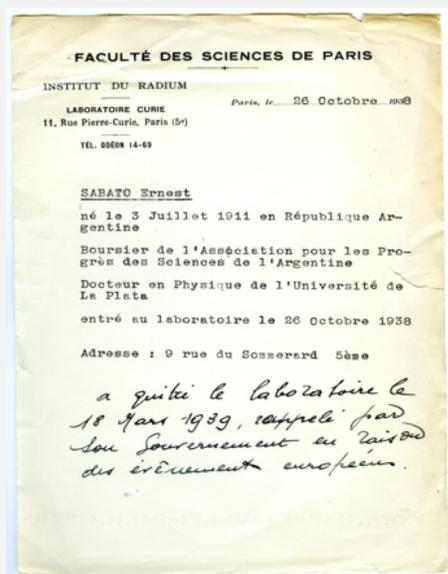


Figure 8: Sabato's file at the Institut (Archives from Musée Curie / AIR-LC-FNP / Sabato).

A handwritten note, added to his file at a later date, indicates that, due to the European political situation, he was ordered to return to Argentina. As a result, he could not complete his internship and left the Institut on March 18, 1939, less than 5 months after his arrival to Paris. While there, he was assigned to work under the direction of French Polish physicist Salomon Rosenblum (1896-1959), who was mainly involved in a research project along with Ukrainian French Moïses Haïssinsky (1898-1976) and Dutch Robert J. Walen. That research, according to the Laboratory Activity Book, was on "la non-existence d'électrons de masse multiple dans l'émission β du radium E" (*Archives du Musée Curie / AIR-LC-LRP Years 1927-1947 (2nd register)/218*).

It was at the Institut that works on artificial radioactivity had begun. This explains how the research Rosenblum, Haïssinsky and Walen were carrying out was akin to the appearance of positrons (positive charged electrons) in radioactive processes. But all of these works were facilitated by the advent of particle accelerators, especially one known as the cyclotron. The cyclotron was invented in 1929-1930 by Ernest Lawrence and Stanley Livingston, at University of California, Berkley, with the purpose of accelerating particles, only not in straight line but along a spiral path. Sabato and Maiztegui explain the advantages of the spiral path by comparing it with the image of a ballet dancer skirt:

...la órbita es espiral, en vez de circular, justamente porque la velocidad es cada vez mayor y, por lo tanto, también es mayor la fuerza centrífuga; es por la misma razón que las faldas de una bailarina se abren cada vez más a medida que gira con mayor velocidad (*Elementos de física* 369).

These devices, Sabato and Maiztegui contend, initiated a great age in transmutation since they made it possible to launch, at pre-fixed and at-will speeds, protons, deutons and alpha particles to different atom nuclei. They conclude their review of the cyclotron by stating that, from a theoretical perspective, "estos aparatos han llevado a un conocimiento más profundo y sistemático de los misterios del núcleo atómico y han abierto el camino de descubrimientos sensacionales" (*Elementos de física* 371).

While in Paris, due to his crisis between literary aspirations and scientific work, Sabato found it extremely difficult to fulfill his duties at the Institut.

Instead, he spent most of the time with Spanish painter and friend Óscar Domínguez (1906-1957). Domínguez knew well about Sabato's artistic skills and attempted to persuade him to quit science and become a painter. Given the incomplete and frustrating Paris experience, the Asociación Argentina para el Progreso de las Ciencias decided to send Sabato to the Massachusetts Institute of Technology in Cambridge, to complete the remainder of his internship. He worked there under the guidance of Mexican Manuel Sandoval Vallarta (1899-1977) and Uruguayan Félix Cernuschi (1907-1999). In spite of Sabato's ongoing interest in atomic physics, there is an important change of focus at this time since Sandoval and Cernuschi were working on cosmic rays at that moment. While radioactive elements shed radiation from earth to outer space, cosmic rays are subatomic particles coming from outer space to earth whose high energy is due to their high speed, close to the speed of light. These rays were discovered when it was verified that the electric conductivity of the earth's atmosphere is the result of the ionization caused by high energy radiation.

Many hypotheses had been (and still are) advanced to explain the origin of cosmic rays, but none of them, according to Swedish Hannes Alfvén (1908-1995), seemed to be able to account for the enormous amount of energy found. Alfvén proposed in his article "A Cosmic Cyclotron as a Cosmic Ray Generator?", published in October 1936 in the British journal *Nature*, that a double star may constitute a gigantic cyclotron, which can give rays with energies of the right order of magnitude (Alfvén 761). A year later, in May, the Swedish scientist expanded on his hypothesis in an article published in the German journal *Zeitschrift für Physik* under the title "Versuch zu einer Theorie über die Entstehung der kosmischen Strahlung" ("Attempted Theory About Emergence of the Cosmic Radiation") (Alfvén 319-33).

Sabato forcefully refuted Alfvén in a very short letter included in the "Letters to the Editor" section of the American *Physical Review* (vol LV, issue 12, 15 June 1939) under the title "On Alfvén's Hypothesis of a «Cosmic Cyclotron»" ("On Alfvén's Hypothesis of a «Cosmic Cyclotron»" 1272-3). The Argentine finds questionable the cosmic cyclotron hypothesis:

If we assume with Alfvén that the field of a double star is the field of two parallel dipoles, and that a charged particle can really describe in their common equatorial plane the motion assumed by him, which is questionable, there remains three important objections to the mechanism he suggests ("On Alfvén's Hypothesis of a «Cosmic Cyclotron»" 1272).

Sabato then points out the three specific theoretical objections that prevent these particles from abandoning the double star to reach the earth's atmosphere; this demolished Alfvén's premise. First, according to the Argentine, under the circumstances the Swedish scientist posed, the electric field vanishes "since then there is manifestly no relative motion between the charged particle and the second star" ("On Alfvén's Hypothesis of a «Cosmic Cyclotron»" 1272). Next, he goes on to argue that "the magnetic flux linking the elementary circular path of the charged particle, in Alfvén analysis, is constant so long as the condition of synchronism still obtains" ("On Alfvén's Hypothesis of a «Cosmic Cyclotron»" 1272), and therefore there would not be induced electromotive force in the magnetic flux to produce acceleration. Finally, he concludes, there would not be any chance for the particle to leave the double star's field. Furthermore, Sabato uncovers fundamental calculation errors in Alfvén's 1937 paper:

It seems, however, that his calculations are erroneous. In particular his Eq. (17), fundamental for his calculation of the energy, does not take into account the first dipole; since the particle does not, in general, describe a circle around the first dipole, there is no reason to neglect the latter's influence ("On Alfvén's Hypothesis of a «Cosmic Cyclotron»" 1272).

Even though this letter is not a formal scientific publication, it represents a peak in Sabato's career. The Argentine seems to belong to the most distinguished scientific circles of the time and is able to dismantle and correct, in few lines, the hypothesis of a physicist, Alfvén, who would go on to be a Nobel laureate in 1970.

Back in Argentina, thermodynamics, "Calendario" and translations

Upon his return to La Plata, the young physicist was engaged in teaching and research activities that kept him away from nuclear physics. He had a heavy teaching load at UNLP, at the Instituto Nacional de Profesorado Secundario and at the Escuela Nacional de Comercio Nº 5. Some of his students would become important personalities of science and culture in Argentina, like José Balseiro (1919-1962), who years later would create and direct the Instituto de Física de Bariloche, and physicist and philosopher of science Mario Bunge (1919-2020): "...enseñé Teoría Cuántica y Relatividad en la Universidad de La Plata, donde tuve como alumnos a Balseiro, cuyo nombre preside hoy un centro atómico en la ciudad de Bariloche, y a Mario Bunge" (*Antes del fin* 74).

Sabato co-wrote a paper with his colleague Enrique Loedel Palumbo, "Una nueva forma de introducir la temperatura" (Loedel Palumbo and Sabato 271-81), that was published in the journal *Anales de la Sociedad Científica Argentina* in January 1939, months before his return to Argentina. In this paper, Sabato and Loedel Palumbo held that a logical and consequential development of thermodynamics is possible by introducing the notion of temperature after adopting the first two laws of this discipline, a strategy they claimed was more economical than the usual one that does precisely the opposite: introducing the notion of temperature first (Loedel Palumbo and Sabato 271). The next collaboration of Sabato is with engineer Marcelo Mezny. Both Sabato and Mezny are the authors of "Contralor de piezas metálicas mediante rayos Gamma", a paper published in early 1940 in the journal *Revista del Centro de Estudiantes de Ingeniería* (Mesny and Sabato 264-73). That same year, in October, the UNLP's Faculty of Physical-Mathematical Sciences Journal includes the article "Equipo para estabilización de voltaje", where Sabato discussed how neon lamps can replace batteries or accumulators ("Equipo para estabilización de voltaje" 425-32). Later in 1940, Sabato revised and wrote the Foreword for his former professor Margrete Elisabeth Herberg Bose's translation into Spanish of a book by German Kurt Lipfert that dealt with the state-of-the art of the technique of television. The title of the book in Spanish was simply *La televisión* (Lipfert 9-11).

In 1941 Sabato formally launched his literary career as a critic when a review he wrote of *La invención de Morel* by Adolfo Bioy Casares was published in the magazine *Teseo*. Just as his scientific prose abounds in metaphors and poetic features, this first literary effort is supported by his scientific background, which will be an ongoing signature of his prose. He finds *La invención de Morel* a very original story that combines physical and metaphysical plots by successfully juxtaposing ghostly and real manifolds. In a similar way to what he did with Alfvén's cyclotron, he reacts in one section of his review to the critique of the novel by author Eduardo González Lanuza (1900-1984) who, bragging about his knowledge on thermodynamics, had claimed that, since Bioy Casares did not take into account in his narration the fundamentals of Energetic, his story was flawed. According to Sabato, González Lanuza mentioned the absence of any consideration by Bioy Casares of the "Suma of Temperaturas" and of the "Segundo Principio" as the reasons for weak spots in *La invención de Morel*. Sabato categorically rebuts González Lanuza:

No creo que sea éste el lugar para exponer las razones por las cuales se equivoca G. L. Sólo diré que: a) Dos soles deben calentar seguramente más que uno; b) que el eterno retorno no es imposible, a la luz de la Termodinámica Estadística: es cierto que la Entropía es la Muerte; pero también es el logaritmo de la

posibilidad. Lo necesario se funde, así, con lo contingente y aleatorio, en forma que sería grata a Hegel ("La invención de Morel")

Sabato appeals, in his rebuttal of González Lanuza, to the fact that in the developments on thermodynamics, most of them due to Austrian Ludwig Boltzmann (1884-1906), probability plays a central role. The Statistical Thermodynamics he refers to is based on the fundamental assumption that all possible configurations of a given system are equally likely to occur. Boltzmann showed that the second law of thermodynamics, also known as the entropy law, is a rule of disorder and a statistical fact ("Entropía es la Muerte"): disordered states are the most probable. The entropy of a system is technically defined as the logarithm of the number of possible configurations multiplied with Boltzmann's constant. That is why Sabato uses the expression "logaritmo de la posibilidad." In terms of probability, however, there is always a chance, so negligible that is almost effectively zero, for a system to some-day regain the state from which it first set out or, as Sabato would put it, "el eterno retorno no es imposible." This review was very well received by his former professor Pedro Henríquez Ureña, who recommended him to the prestigious literary magazine *Sur*, directed by Victoria Ocampo. In his first years as collaborator of *Sur*, 1942-1943, Sabato wrote reviews for new scientific books and was in charge of the section "Calendario," where he commented on national and international events.

Meanwhile, Sabato and Loedel Palumbo expanded on their own work on thermodynamics and, in March 1942, in the journal *Anales de la Sociedad Científica Argentina*, they published "Contribución a la fundamentación de la termodinámica." The goal of this paper, according to the authors, was to provide the basis of phenomenological thermodynamics by introducing the concept of temperature after setting out the second law and defining heat without the intervention of temperature ("Contribución a la fundamentación de la termodinámica" 222).

Sabato's writing skills had already begun to be noticed in the scientific community. On March 14 1940, the Soviet-American author, physicist and cosmologist George Gamow (1904-1968) sent a letter to his friend and colleague at UNLP Enrique Gaviola asking him for help with a potential Spanish translation of his book *The Birth and Death of the Sun*. Gaviola proposed Sabato for the job and introduced him to Gamow as "un joven hombre de ciencia que conoce bien la materia y nuestro idioma" (Fleischer 45). Thus, *Nacimiento y muerte del sol: Evolución estelar y energía intraatómica*, Sabato's translation into Spanish of Gamow's book, was published in 1942.

It is in 1943 when Sabato decided to step aside from his scientific duties at UNLP. He moved to a cabin in the province of Córdoba to start his literary career. However, his association with science continued, if exclusively in fields related to pedagogy and dissemination, and mainly for financial survival, a sort of marriage of convenience. That year he translated into Spanish *The ABC of Relativity*, the classic book by Bertrand Russell. Sabato had already published earlier that year a 25-page booklet, *Bertrand Russell y la teoría de los cuantos*. Both of these works represent evidence of how well acquainted Sabato was with the work of the English author. His translation appeared under the title *El A.B.C. de la relatividad*. With regard to his role in the dissemination of science, Sabato had taken the first steps in the newspaper *La Nación* where, on June 7, 1942, appeared "Valoración de Galileo, en el tricentenario de su muerte," a contribution written by him to commemorate the tercentenary of the death of Galileo Galilei. It is in 1944 when *Elementos de Física para las Escuelas Nacionales de Comercio. Primer curso. Programa oficial de 1942*, the book he co-wrote with Alejandro de Bisschop, is published.

During the austral fall of 1945 the first literary book by Sabato was released. The writing and publishing of *Uno y el Universo* were motivated by the necessity of dealing with his breaking up with science. Sabato himself explained that “De mi tumulto interior nació mi primer libro *Uno y el Universo*, documento de un largo cuestionamiento sobre aquella angustiosa decisión, y también, de nostálgica despedida del universo purísimo” (*Antes del fin* 75). The volume, a set of reflections on topics listed in alphabetical order, is described by him as “el documento de un tránsito” (*Obra Completa. Ensayos* 21). The critically acclaimed book includes material already published by Sabato in *Sur*, like adaptations of some of his “Calendarios;” and an entry on Galileo, which is essentially the same as the one *La Nación* had published. The entry on “Ciencia” is one of the longest and most forceful of the book. He questions the power and the moral standing of science:

El poder de la ciencia se adquiere gracias a una especie de pacto con el diablo: a costa de una progresiva evanescencia del mundo cotidiano. Llega a ser monarca, pero, cuando lo logra, su reino es apenas un reino de fantasmas (*Obra Completa. Ensayos* 29).

Los productos de la ciencia son ajenos al mundo de los valores éticos: el teorema de Pitágoras puede ser falso o verdadero; pero no puede ser perverso, ni respetable, ni decente, ni bondadoso, ni colérico (*Obra Completa. Ensayos* 31)

His intentions of focusing on his literary projects were interrupted by the requests from his professors Enrique Gaviola and Guido Beck to return to his work at UNLP. Eventually, both as a concession to them and as way to bring his scientific career to an end, he agreed to write and publish a final, formal academic paper. It was under these circumstances that “El concepto de temperatura en la termodinámica fenomenológica” appeared in 1945 in the journal *Revista de la Unión Matemática Argentina*. This paper was a thorough and better articulated development of the topic he had already worked on in 1939 and 1942 with Enrique Loedel Palumbo. Years later, Sabato explained the complications that surrounded the writing of this paper and emphasized that his attempt to correct what he considered was a mistake in the ordering of the three principles governing this discipline was not always well received:

Finalmente acepté concluir un trabajo sobre termodinámica, que me había preocupado en épocas de mi doctorado...Yo sostuve que había un error en el ordenamiento en que estaban enunciados sus tres grandes principios...Cuando expuse mis primeras ideas a los doctores Loyarte y Teófilo Isnardi, ellos pretendieron disuadirme, ya que la termodinámica es un armonioso edificio imposible de innovar...El segundo rechazo lo recibiría en el Laboratorio Curie, porque un salvaje sudamericano no podía cuestionar el fundamento mismo de la termodinámica (*Antes del fin* 76).

Crisóstomo Ugarteche

By March 1945, in the newspaper *El Mundo* and under the pen name Crisóstomo Ugarteche, Sabato began to publish scientific dissemination articles on a wide range of topics. It is very likely that he opted for using this pseudonym to avoid conflict with his literary career, since the release of *Uno y el Universo* was imminent at the time. There were eleven articles in total. The first eight were: “Mentira o verdad”, published on March 9; “Un siglo y medio de Volta”, on April 4; “¿Es infinito el universo”, on May 21; “Extraños seres sin altura”, on May 28; “Viajes planetarios”, on June 7; “Expedición a la Luna”, on June 11; “¿Qué hacemos en la Luna?”, on June 19; and “El silencioso radar”, on August 6. On the very day the article on radar was published, there was an eruption of worldwide dismay caused

by news of the atomic bombing of the Japanese city of Hiroshima. Sabato-Ugacherte and *El Mundo* reacted swiftly and three articles explaining the basics of the atomic theory were soon published: "El enunciado de Einstein", on August 8; "El universo de Rutherford", on August 9, the same day the second atomic bomb was dropped over Nagasaki; and finally "Los bombardeos atómicos", on August 10.

Sabato played a fundamental role, at least to the Argentine people, in informing and helping, in real time and in a historic moment, to reflect on theoretical and ethical issues related to atomic physics. The extraordinary turn of events in the history of mankind favored the quick writing and publication of a book that expanded on the contents of these three articles. That is how *Historia y principios de la bomba atómica* was released in September 1945.

In October 1945 the first issue of the Argentine journal *Fray Mocho* was unveiled. This particular journal (there was another one with the same title but different editorial line that circulated between 1912 and 1929) was created exclusively to serve the purpose of reviewing new books. Two of the works reviewed in this issue, in accordance with the understandable interest generated by atomic related topics, were *Historia y principios de la bomba atómica* and *El ABC de los átomos*. The latter was a translation into Spanish of a Bertrand Russell's book that had been originally published in English in 1923. The review for *El ABC de los átomos*, written by Sabato, ends with disturbing considerations that captured both the tensions of that historical moment as well as the poetic skills of the Argentine:

Ahora, después de un holocausto de medio millón de víctimas y de un mar de escombros, los hombres de ciencia se alistan en un torneo de presagios para prever una realidad semejante a un delirio y que reduce a un juego trivial el repertorio de quimeras del abuelo Verne y de Heriberto J. Wells.

¿Se aprovechará la fuerza atómica para la destrucción?

¿Será utilizada para una perfección inverosímil de la vida?

¿Podrá controlarse la fabulosa energía obtenida? ("El ABC de los átomos-Reseña" 112).

The review for *Historia y principios de la bomba atómica*, on the other hand, established beyond doubt that Crisóstomo Ugarteche was none other than Ernesto Sabato: "C. Ugarteche –seudónimo que traviesamente ha elegido E. S., escritor, físico y agudísimo crítico–" ("*Historia y principios de la bomba atómica-Reseña*" 114). But it also represented, most likely, the first time that his credentials as a writer were put above his scientific background.

In the 1946 textbook *Elementos de física*, by Sabato and Maiztegui, the five-chapter Appendix on notions of atomic physics included most of the content of "*Historia y principios de la bomba atómica*." In November 1947 a fragment of *La Fuente muda* appeared in issue 157 of *Sur*, followed by the 1948 publication of *El túnel*, Sabato's first novel. Sabato later wrote that:

El túnel fue la única novela que quise publicar, y para lograrlo debí sufrir amargas humillaciones. Dada mi formación científica, a nadie le parecía posible que yo pudiera dedicarme seriamente a la literatura. Un renombrado escritor llegó a comentar: "¡Qué va a hacer una novela un físico!" ¿Y cómo defenderme cuando mis mejores antecedentes estaban en el futuro? (*Antes del fin* 87)

In 1951 he came up with what turned out to be his last scientific related effort. It was a 100-page long text entitled "Física" that was included in Volume 5 of the Mexican *Enciclopedia práctica Jackson*. Sabato recycled

most of the material he had already written and published, especially most of the content of *Elementos de física*. Significant parts of the articles written for *El Mundo* were also incorporated, in particular those dealing with the exploration of the moon. The Argentine offered technical considerations concerning the challenges of a then distant and potential human mission to the moon. In two subsections of "Física," "Viajes siderales" and "La conquista de la Luna," Sabato explained the latest developments regarding that project and astonishingly and poetically anticipated, at least for the Latin American audience, the details of the 1960's NASA Apollo missions:

Con una fuerza gravitacional seis veces menos intensa que en la Tierra, estos hombres podrán recorrer la superficie de la Luna con esa levedad que sólo experimentamos en los sueños: parecerán casi flotar; podrán dar saltos de 20 ó 30 metros de largo salvando fácilmente algún precipicio; podrán elevarse hasta 10 metros de altura. Si han llevado una balanza de resorte, verán que sus pesos no llegan a 15 kilogramos.

Y cuando hayan recorrido esas llanuras como espejos que desde aquí nos parecen mares, los formidables circos de Clavius y Magnus, cuando hayan explorado la misteriosa cara que jamás vemos, entonces, si no han muerto, entrarán nuevamente a su nave y emprenderán el viaje para relatarnos su increíble aventura ("Física" 251-2).

It is here where Sabato's scientific career apparently stopped for good. However, as shown in this work, he never really abandoned science. His scientific writing, with strong and purposeful literary elements, and his literary production, that constantly feeds on his scientific background, if conventionally differentiated in time and space, are intertwined manifestations of the same talent and sensitivity. The ghosts of Sabato's scientific training, that one day appeared to calm his cloudy, turbulent and chaotic spirit, would accompany him throughout his entire career. Because, in the end, all of Ernesto Sabato's writing is scientific.

WORKS CITED

- Alfvén, Hannes. "A Cosmic Cyclotron as a Cosmic Ray Generator?." *Nature*, 1936, pp. 761.
- . "Versuch zu einer Theorie über die Entstehung der kosmischen Strahlung (Attempted theory about the emergence of the cosmic radiation)." *Zeitschrift für Physik*, 1937, pp. 319-333.
- Bloch, William Goldbloom. *The Unimaginable Mathematics of Borges' Library of Babel*. Oxford UP, 2008.
- Fleischer, Ariel Gustavo. *Ernesto Sabato: biografía completa (1931-2005). Con apuntes biográficos*. Cuadernos del Cenit, 2011.
- Gamow, George. *Nacimiento y muerte del sol: Evolución estelar y energía intraatómica*. Espasa Calpe, 1942.
- . *The Birth and Death of the Sun*. Viking Press, 1940.
- Graciano, Osvaldo. *Entre la torre de marfil y el compromiso político. Intelectuales de izquierda en la Argentina, 1918-1955*. Universidad Nacional de Quilmes. 2008.
- "Historia y principios de la bomba atómica-Reseña." *Fray Mocho*, 1945, pp. 114.
- Lipfert, Kurt. *La Televisión*. Espasa-Calpe. 1940.
- Loedel Palumbo, Enrique and Ernesto R. Sabato. "Contribución a la fundamentación de termodinámica." *Anales de la Sociedad Científica Argentina*, 1942, pp. 222-38.
- . "Una nueva forma de introducir la temperatura." *Anales de la Sociedad Científica Argentina*, 1939, pp. 271-81.
- Loyarte, Ramón G. "Los potenciales de excitación de átomo de mercurio." *Revista de la facultad de Ciencias Físico Matemáticas-UNLP*, 1936, pp. 7-19.
- . "Los potenciales de excitación del átomo del argón." *Contribución al estudio de las ciencias físico matemáticas*, 1935, pp. 15-23.
- Maiztegui, Alberto P. and Jorge A. Sabato. *Introducción a la Física*. Kapelusz S. A., 1951.
- Martínez, Guillermo. *Borges y la matemática*. Editorial Universitaria de Buenos Aires, 2003.

Mesny, Marcelo and Ernesto Sabato. "Contralor de piezas metálicas mediante rayos Gamma." *Revista del Centro de Estudiantes de Ingeniería*, 1940, pp. 264-73.

Russell, Bertrand. *El A.B.C. de la relatividad*. Imán (Serie Panorama Científico), 1943.

--. *El ABC de los átomos*. Imán, 1945.

--. *The ABC of Relativity*. Oxford: Bradford and Dickens, 1925.

Sabato, Ernesto. *Antes del fin*. Seix Barral S. A., 1999.

--. *Bertrand Russell y la teoría de los cuantos*. Compañía Impresora Americana, 1941.

--. *Cómo construí un telescopio de 8 pulgadas de apertura*. Revista Astronómica, 1937.

--. "El ABC de los átomos-Reseña." *Fray Mocho*, 1945, pp. 112.

--. "El concepto de temperatura en la termodinámica fenomenológica." *Revista de la Unión Matemática Argentina*, Vol. X, No. 4, 1945, pp. 109-27.

--. "Equipo para la estabilización de voltaje." *Revista*. Serie 2, No. 5, 1940, pp. 425-32.

--. "Física." *Enciclopedia Práctica Jackson. Conjunto de conocimientos para la formación autodidáctica*. México, D.F., 195, pp. 248-9.

--. "La fuente muda." *Sur*, No 157, Nov. 1947, pp. 24-65.

--. "La invención de Morel." *Teseo*, 1941.

--. "Los potenciales de excitación del átomo de Kr." *Instituto de Física de la Universidad de La Plata*, 1936, pp. 181-90.

--. "On Alfvén's Hypothesis of a 'Cosmic Cyclotron'." *Physical Review*, 1939, pp. 1271-2.

--. *Obra Completa. Ensayos*. Espasa Calpe / Seix Barral, 1996.

--. *Obra Completa. Narrativa*. Espasa Calpe Argentina /Seix Barral, 1997.

--. "Valoración de Galileo, en el tricentenario de su muerte." *La Nación* 7 Julio 1942.

Sabato, Ernesto and Alberto P. Maiztegui. *Elementos de física*. Espasa-Calpe, 1946.

Sabato, Ernesto and Alejandro De Bisschop. *Elementos de Física para las Escuelas Nacionales de Comercio. Primer curso. Programa oficial de 1942*. Losada, 1944.

Ugarteche, Crisóstomo. "El enunciado de Einstein." *El Mundo* 8 Agosto, 1945.

--. "El silencioso radar." *El Mundo*. 6 Agosto, 1945.

--. "El universo de Rutherford." *El Mundo*. 9 Agosto, 1945.

--. "Expedición a la Luna." *El Mundo*. 11 Junio, 1945.

--. "Extraños seres sin altura." *El Mundo*. 28 Mayo, 1945.

--. "Los bombardeos atómicos." *El Mundo*. 10 Agosto, 1945.

--. "Mentira o verdad." *El Mundo*. 9 Marzo, 1945.

--. "¿Es infinito el universo?" *El Mundo*. 21 Mayo, 1945.

--. "¿Qué hacemos en la Luna?" *El Mundo*. 19 Junio, 1945.

--. "Un siglo y medio de Volta." *El Mundo*. 4 Abril, 1945.

--. "Viajes planetarios." *El Mundo*. 7 Junio, 1945.

Ugarteche, Crisóstomo and S Bertrán. *Historia y principios de la bomba atómica*. Editorial Nova, 1945.

Vargas, Omar. "El extraño comportamiento de las palabras en el infinito: la teoría fractal, la teoría de conjuntos y "El Aleph"." *Variaciones Borges*. Vol. 42, 2016, pp. 139-59.