Piedad de la Cierva and Women in Spanish Science in the Silver Age

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Abstract

Piedad de la Cierva was a scientist from Murcia who began her research career in 1930s Spain. Through her testimony, we explore Piedad's scientific career and encounter other women with truly fascinating lives and scientific trajectories, shaped by their time, gender roles, and the circumstances surrounding them. The objective of this project is to highlight the contributions of these pioneers, addressing the discrimination and obstacles they faced in a male-dominated field.

1 Introduction

A few months ago, by chance, I discovered that one of my grandfather's cousins had been a renowned scientist at the beginning of the last century. Apparently, I was the only one in the family who didn't know this, despite having studied Physics and currently pursuing a PhD in Theoretical Physics. The fact that she was not mentioned or that her legacy was not discussed even within her own family prompted me to investigate her. I began searching for information and was truly impressed when I discovered not only her scientific career but also the careers of a whole group of women who, in the 1930s, were dedicated to science in Spain. Ultimately, meeting Piedad was just the beginning of the great discovery I made about a brilliant era of scientific research in Spain. Her study allowed me to delve into and explore the Silver Age of Spanish Science, learn about research, institutions, scientific groups, and especially the large number of women who were beginning to enter these circles, which had been exclusively male just a few years earlier.

With this, I do not intend to present a History or Sociology thesis, mainly because I am not an expert in those fields. However, it has allowed me to learn about a period, some names, and a facet of Spanish science that I was previously unaware of. This has enriched my knowledge by investigating the lives of the researchers who pioneered the journey of women in the field of science in our country, and especially within Spain's largest scientific institution, the Higher Scientific Research Council (Consejo Superior de Investigaciones

Figure 1: Piedad de la Cierva.

Científicas, or CSIC). I simply wish to share what I have discovered: a collection of experiences lived by these women, to highlight the incredible scientific value of this period in Spain, and to bring attention to the names of these pioneers who have not been, nor are they being, recognized enough, given the difficulties in finding documentation about them and the potential emotional impact of this information. I want to give these women the recognition they deserve.

For this reason, I am focusing on the life of Piedad de la Cierva, about whom it has been easier to find information. She witnessed the first steps of Spanish women in science during the early 20th century and became the first female researcher to join the CSIC. We will follow Piedad's path and, along the way, meet many other women - pioneers and colleagues - who contributed their work and effort to science and equality in Spain.

2 Context

At the beginning of the 20th century, the home was considered a woman's natural place, a conviction shared even by many who supported her right to higher education. Gender determined a structure and division of labor, with certain jobs being deemed suitable for one sex or the other. Although this is less pronounced today, science, often closely associated with power, was viewed as a predominantly male domain, while the home was seen as the realm of women's work. Despite this, a slow and gradual awakening provided women with opportunities for quality education, parallel to that of their male counterparts, though the patriarchal system's shadow persisted. From the 1910s to the 1930s, the rate of women entering universities and scientific fields in Spain increased, though not as rapidly as in other countries. This slower progress is attributed to the strong Catholic influence in Spain, the social situation, and the limited formal education of the population [35, 38, 39].

In the 1910s, the creation of the Free Teaching Institution (Institución Libre de Enseñanza, known as ILE) and the Board for the Expansion of Studies (Junta de Ampliación de Estudios, or JAE), which was responsible for scientific, cultural, and educational policy from 1907 until the onset of the dictatorship in 1940, marked a significant shift in Spain's academic and scientific landscape. Under the leadership of Santiago Ramón y Cajal as its first president, these institutions represented the greatest effort in Spain's history to promote these activities with autonomy and freedom. Consequently, pedagogical movements advocating for educational reform and equality began to emerge. In 1910, the Spanish University opened its doors to women.

Mercedes Montero has documented female participation in Spanish universities during this period [38, 39]. In the 1920s, the number of women in higher education increased, with Pharmacy being the most popular field, as it was associated with women's roles in health and caregiving. Today, stereotypes persist, with Children's Teaching being the most sought - after career among female students, comprising 92% of the student body. Montero also compares the number of men and women in universities: by the late 1920s, 5% of university students were women, whereas today the figure has risen to 56%. Despite these advances, the integration of women in Spain lagged behind that of neighboring countries; in 1930, women constituted only 6% of university students in Spain, compared to 26% in France, due to factors such as Spain's Catholic, rural, and less educated society.

With this context in mind, we will now reconstruct the life of a female scientist in 20th-century Spain. To do this, we will use the figure and memoirs of Piedad de la Cierva, who described herself as a *"witness and protagonist of some exceptional years in which women began to enter University and Science"* [12]. Through her memoirs, we can learn not only about her professional career and research but also gain insight into the situations, feelings, experiences, and thoughts of a female scientist in Spain during the early 20th century.

3 Her beginnings in her scientific career

Piedad was born in 1913 in Murcia into a prominent family, with relatives who held high-ranking political and legal positions. Her great-uncle, Juan de la Cierva Peñafiel, had been a minister under Alfonso XIII and, interestingly, is credited with naming the "de la Cierva" cake, a traditional Mar Menor confection that combines sweet and savory elements. She was also the niece of the inventor of the autogyro, Juan de la Cierva Codorniú, and, of course, her father, Juan de la Cierva López, was a renowned lawyer and law professor in Murcia. Piedad was the eldest of four siblings, all boys, but she demonstrated an exceptional aptitude and studious nature from a young age.

Her father, profoundly affected by the societal changes brought about by World War I, was convinced that the role of women in the 20th century would differ significantly from their historical roles. He believed that women would assume a much more prominent role in the post-war world. Encouraged by her father, Piedad pursued a university education after completing high school at IES Alfonso X El Sabio in Murcia, the third-oldest institute in Spain. Of the four siblings, Piedad was the only one to attend university.

MURCIA.—Una licenciada en Ciencias Químicas. La señorita Piedad de la Cierva Viudes, de diecinueve años de edad, maestra nacional, ha obtenido con la más alta calificación, en la Universidad de Valencia, la licenciatura en Ciencias Químicas. (Foto Mateo.)

Figure 2: Piedad in the Murcia Journal.

During her childhood, Piedad was influenced by the patriarchal atmosphere in her home, where her father was strict, and her mother, Serafina Viudes, was dedicated to domestic duties, lacked formal education, and was deeply religious - a common situation at the time. This environment shaped Piedad's relationship with religion, leading her to lead a Christian and austere life. Her memoirs reflect this experience [2, 12]:

"My father's demands, despite his good intentions, had given me very difficult years that I prefer not to remember. Additionally, the family financial plans, in which my mother could not intervene, created an unpleasant atmosphere. Stuck at home, I had little contact with people my age who had different life plans; I was shy. During those years, my protection was my mother, who also suffered a lot." (Cierva Viudes, 1993, fol. 12)

This text reveals Piedad's empathy for her mother, as she was aware of her suffering and the constrained life that both Serafina and many women of the time experienced. It also highlights the duality in her father's approach: while he supported his daughter's higher education and had high academic expectations, he did not extend that same support

for gender equality to his wife.

Her father wanted her to study Pharmacy, as it was a career closely aligned with traditional female roles. As noted, Pharmacy was the most popular career among women in the 1920s; in 1930, women studying Pharmacy made up 46% of all women in Spanish universities, while Science attracted less than 13% of female students. Although the situation has changed considerably today, there is still a predominant tendency for women to pursue careers in health, caregiving, or teaching, while it remains more challenging for the percentage of women in pure sciences or engineering to increase. Despite her father's insistence, Piedad refused to study Pharmacy. As she mentions in her memoirs, *"she didn't want to study so much just to open a store"* [12]. Instead, she chose to begin her university studies at the University of Murcia, enrolling in the Faculty of Sciences in 1928. Her father agreed to this decision under two conditions: she had to complete her Teaching subjects and be accompanied by a chaperone to her classes at the Faculty, where she was the only woman enrolled - a common situation for many women throughout Spain. Piedad objected to the latter condition, feeling embarrassed to be accompanied when none of her male classmates were.

At the University of Murcia, she was well accepted and established a strong relationship with her Physics professor, Fernando Ramón Ferrando, who would assist her in her subsequent endeavors.

3.1 Era in Valencia and María Moliner

After that year in Murcia, she moved to Valencia to pursue a degree in Chemical Sciences, again being the only woman in her class. She graduated in 1932 with an Extraordinary Prize and a final thesis on steel and iron. Upon arriving in Valencia, she was able to escape the "unpleasant" atmosphere at home and experience life in a larger, busier city. She stayed at the Escolapias Residence, where she met other university women her age, who became her first friends, including three girls from the Teaching degree program and two from Medicine.

However, what most marked her time in Valencia was the closure of the Residence following the proclamation of the Spanish Second Republic. At the same time, Fernando Ramón Ferrando, the Professor of Theoretical Physics, joined the University. Since they knew each other from their time in Murcia, he offered her accommodation in his home. Piedad thus had the opportunity to live in a different environment and with another family. As she recounts in her memoirs [12]:

"The atmosphere of that house was totally different from that of my family and from all the families I knew. They treated each other as equals, with great cordiality and delicacy. They discussed what the newspapers said; I had never read any. Furthermore, they commented on what the government was doing, etc." (Cierva Viudes, 1993, fol. 18)

Figure 3: Marriage Ramón-Moliner.

Piedad was completely surprised to see that in a marriage, spouses could treat each other as equals. This household allowed the wife to discuss politics, read, and even manage the family

finances, all while maintaining their Christian life. The woman who particularly impressed Piedad was María Moliner, a critical and educated individual.

María Moliner was born in Paniza, Zaragoza, in 1900. She was a career philosopher and one of the first Spanish university women. She was also an archivist and librarian by competitive examination, and the first female professor at the University of Murcia in 1924, where she met her future husband and where their two older children were born. Moliner was a strong advocate for the Pedagogical Missions during the Second Republic, promoting book loans and education in rural areas. She developed her own project, the "María Moliner Library Plan," supported by the republican government during the Spanish Civil War. However, like many officials, she faced a purge file after the war, was accused of being "red and a sympathizer of the reds" without further explanation, and was removed from all her responsibilities, not returning to the archives (similarly to her husband, whose professorship was also revoked).

Figure 4: María Moliner.

But it was in the 1960s that this remarkable woman made her mark on all Spanish speakers. Every afternoon, after leaving her workplace, she would begin work on the "Dictionary of Spanish Use," which was published in 1967 after 15 years of effort. This dictionary is one of the most important works in the Spanish lexicon, offering clear and useful definitions. This achievement highlights not only the admiration María Moliner deserves but also the discrimination women faced in intellectual circles. Despite being proposed by some members, she was never admitted or recognized with a chair at the Royal Academy of the Spanish Language, although she could have been the first woman to achieve such recognition [19, 24, 56].

Today, María Moliner is celebrated for her legacy and contributions in the Spanish-speaking world. Renowned intellectuals, authors, academics, and linguists have admired her work, including Gabriel García Márquez, who said:

"María Moliner accomplished a feat with very few precedents: she wrote alone, in her home, with her own hand, the most complete, most useful, most thorough, and most entertaining dictionary of the Spanish language."

3.2 Arrival to Rockefeller Institute

After finishing her degree in Valencia, Piedad wanted to continue her scientific career. Her Chemistry professor, Antonio Ipiens, supported her and wrote a recommendation letter for her to pursue a doctorate in Madrid.

In the early 20th century, Madrid, during a period known as the Silver Age, was a hotbed of intellectual activity. Although mostly the names of male artists are remembered, there were also notable women such as Carmen Conde, Maruja Mallo, and María Zambrano. Concurrently, a scientific movement emerged; Spanish Science was truly cutting-edge and internationally relevant. Professor Ipiens' letter reached Julio Palacios, a renowned physicist and pioneer of crystallography at the Rockefeller Institute, which is now the Blas Cabrera Institute of the CSIC and was previously known as the National Institute of Physics and Chemistry of the JAE. The JAE succeeded in elevating Spanish Science to the international stage, with Physics and

Chemistry as some of its most advanced branches, promoting new techniques and research areas such as Atomic Physics, while also emphasizing co-education and the full integration of women as scientists [4, 11, 16].

At this institute, there were figures such as Enrique Moles and Miguel Catalán, who, as a principle in his research group, ensured an equal number of women and men. In her memoirs, Piedad describes her arrival at the institute [12]:

Figure 5: Rockefeller Institute.

"Arriving with my father at the Rockefeller Institute dazzled me [...]. The institute was a large, very modern building, with wonderful facilities for research in different branches of Physics and Chemistry. It had been promoted by the JAE and equipped with the most complete equipment after visiting several large research centers in Europe." (Cierva Viudes, 1993, fol. 21).

4 Women at the Rockefeller Institute

There, Piedad would meet other pioneering scientists [34, 35, 36], who made significant contributions and discoveries, but whose names have not received the same recognition as their male counterparts, with many even being erased from history after the war. Here, we highlight some of these women scientists who were also studying and working at the Rockefeller Institute. During the Second Republic, of the 64 theses defended, 5 were by women. After the closure of the building during the war, documentation includes 36 women linked to the center out of a total of 158 people, all of whom contributed to the growth in both quantity and quality of Spanish Science.

Thus, during these years, 22% of the scientific staff at the Rockefeller Institute of Physics and Chemistry were women. This is quite surprising, as it represents a notably high percentage for that time, even higher than the current percentage of women working in CSIC Physics institutes, which averages 20% [14].

Figure 6: Felisa Martín.

One of the women at the institute was Felisa Martín (Donsoti, 1898), the first PhD in Physics in Spain, in 1926. Her thesis on crystallography and X-rays was directed by the aforementioned Julio Palacios. She later went on to study at Harvard, Yale, and Cambridge, attending theoretical classes by Lord Rutherford. She finally dedicated her research career to atmospheric studies and worked at the Spanish Meteorological Service, where she was the only woman in the institution from the 1929 until 1935, managing an observatory during the Spanish Civil War. After the war, she was judged for her research with the republican government, although she was finally able to continue with her investigation in Spain, working in the Meteorology Service until her retirement.

Jenara Vicenta Arnal (Zaragoza, 1902), in addition to being the only researcher at the institute who was the daughter of a laborer (the others came from upper-class

families[1]), was the first PhD in Chemistry in Spain. She worked on spectroscopy at Rockefeller, sometimes without remuneration. She was awarded a JAE scholarship to study in Switzerland and Germany, and her scientific legacy is quite extensive.During the Spanish Civil War, she moved to France, but finally she could be back in Spain and she ended up working at the CSIC, which she combined with great teaching and dissemination work [3].

Figure 7: Jenara V. Arnal.

Another of the first women to earn a PhD in Spain was Mª Teresa Salazar (Seville, 1903), who defended her thesis on the measurement of atomic weights in 1931, and extending her studies in Paris on the atomic nucleus. She worked at Rockefeller Institute in Madrid and as an assistant professor at the University of madrid before and after the war, often going to the exams to obtain her own place as a professor, although she never succeeded due to the fact that she was a woman, she always denounced it and never stopped trying. These facts will be addressed later.

Amelia Garrido defended her thesis in 1937 at Rockefeller, although it was later invalidated by the Franco administration "because it was carried out during the Red Age." She was not the only one, neither woman nor man, affected by this event after the war. She remained a great friend of Piedad throughout her life, as Piedad's memoirs show, and eventually became a professor of Physics and Chemistry at a high school.

Piedad also met Narcisa Marín at this institute, with whom she formed a great friendship. Narcisa studied Physics and Chemistry and dedicated her life to the management and direction of various high schools throughout Spain [3].

Cecilia Mossín (Argentina, 1910), the first woman with a Bachelor's Degree in Physics in Argentina, was also in Madrid working at the Rockefeller Institute. Specifically, she collaborated with Piedad on studying the atomic factor of zinc, and they met again on several occasions [35].

Figure 8: Cecilia Mosín.

4.1 Piedad in the X-ray Section

In 1932, the X-ray section was opened at the Rockefeller Institute, directed by Julio Palacios, where Piedad began her PhD thesis. Once again, she was the only woman and the youngest person in the group. There, she learned experimental techniques for studying crystalline structures through X-ray diffraction.

During this period, she began attending international courses, published seven articles, and completed her PhD thesis on the atomic factors of sulfur and lead, receiving an Extraordinary Award. She would later remember this time with great admiration for the incredible scientific and inclusive environment at Rockefeller, especially the high number of women.

A notable anecdote she shared in an interview with Néstor Herran in 2004 is that in 1933, Marie Curie's third and final visit to Spain took place. Marie Curie was world-renowned and perhaps the only physicist whom people on the street would recognize if asked about a female physicist. While Madame Curie's career is well-

[1]As a curiosity, the archives of the Rockefeller Institute indicate the professions of the parents of each student, and the profession of each mother is specified as "work typical of their sex."

Figure 9: Piedad with Julio Palacios's group at the Rockefeller Institute.

known globally, it is worth mentioning that she faced certain discrimination; despite having won two Nobel Prizes, one in Physics and another in Chemistry, she was rejected by the Paris Academy of Sciences. The first woman was admitted to this academy in 1962.

Piedad recounted that when Curie visited Spain for the third time in 1933, she toured most of the Rockefeller facilities. Piedad recalled [2]:

"[...] a few months after I arrived, Marie Curie came. She was visiting the laboratory, which was at the end of Castellana. They invited Curie to see the Rockefeller Institute and offered her a snack in a tearoom there. I was the only woman present, and they asked me to take care of her. I was about twenty years old, and it was my first year there. They asked me to look after her. I mentioned that I had put sugar in her tea." (Interview with Néstor Herran, 2004)

This situation is peculiar, considering that none of her male colleagues were asked to attend to Curie. While the age difference might be a factor, as seen in Figure 9, Piedad was not the only young student in that research group.

5 Piedad and the JAE Scholarship

Upon completing her PhD thesis and publishing seven articles, she was awarded a JAE scholarship to continue her research abroad. This was quite common after PhD defenses in Spain; the JAE granted these scholarships to expand studies internationally. It is clear that one of their goals was to send researchers to study, train, and learn from the most prestigious international scientific centers (a practice that continues today). Most of the scientists mentioned also benefited from these stays, reflecting the JAE's positive approach to not discriminating against women. We are looking at a period, prior to the war, when Spanish science was highly relevant internationally, hence the term "Silver Age" (also applied to Art and Literature), and international collaborations and stays were common. Of the 36 international scholarships awarded by Rockefeller during the Second Republic, 8 were granted to women.

Piedad was awarded a scholarship to work at the Niels Bohr Institute of Theoretical Physics in Copenhagen, alongside Professor George von Hevesy, who had discovered hafnium and, years later, in 1943, would win the Nobel Prize for his study of isotopes.

This center, one of the most prestigious institutes in the field of Physics, was home to researchers from all over Europe, allowing her to surround herself with a

Figure 10: Piedad de la Cierva at the Niels Bohr Institute, 1935.

select group of distinguished scientists; in total, there were 30 researchers. Many had arrived fleeing Nazi Germany, including Dr. Hilde Levi, a German Jew and refugee from Nazi persecution, who was the only other woman alongside Piedad. Levi collaborated with Piedad and established a strong friendship with her.

Levi obtained her PhD in Physics and Chemistry from the University of Berlin in 1934, the same year she had to flee her country due to Nazi persecution. She then arrived in Copenhagen, where she began working as an assistant to researchers James Franck and George von Hevesy at the Niels Bohr Institute. Later, with the Nazi occupation of Denmark in 1943, she had to flee again, this time to Sweden, and the University of Berlin revoked her doctoral degree. After the war, she managed to return to Denmark and continued her research, focusing on the application of carbon-14. She developed the first age-detection device using this substance in Europe, which was first used in 1951 on a corpse. After her retirement in 1979, Hilde Levi became involved in the history of science, publishing a biography of physicist George von Hevesy.

Figure 11: Hilde Levi.

Figure 12: Piedad and Hilde Levi.

At this time, Piedad stayed in a residence where she had complete freedom to come and go, and each student had a tutor. Piedad's tutor was Mother Hildegarda, who was also a PhD in Physics, though there is not much other information about her. In her memoirs, Piedad recounts their conversations about atoms and their studies [2, 12]:

"She offered to give me German lessons, and we chatted from time to time, commenting on the wonders of God who had invented and created atoms." (Cierva Viudes, 1993, fol. 36).

At this time, research centers, especially the Niels Bohr Institute, were working on what would later become Nuclear Physics. Piedad's goal was to learn the revolutionary methods and techniques in the artificial disintegration of the atom, focusing on aluminum and bromine. Upon returning to Spain, she implemented these new methods at Rockefeller.

5.1 Little Trips Around Europe

During this period, Professor Hevesy organized several visits to other European centers for her. She had the opportunity to visit the Paris Radio Institute, where Irène Joliot-Curie, who had won the Nobel Prize the previous year for her work on the synthesis of new radioactive elements, showed her the laboratory and they discussed their respective research.

Figure 13: Lise Meitner.

Piedad also had the opportunity to meet Lise Meitner at her laboratory at the Kaiser Wilhelm Institut für Chemie in Berlin. Meitner even invited Piedad to her house for dinner, as Piedad herself mentioned in a letter to Hevesy upon her return to Spain. Dr. Meitner was a key figure in the discovery of nuclear fission, yet she is often overshadowed by other physicists of the time. Meitner, who proposed the idea of the chain reaction, discovered nuclear fission with Otto Hahn in 1938. Despite this, Hahn was awarded the Nobel Prize in 1944 for a discovery he had made with his "forgotten" female colleague.

5.2 Back in Spain

Upon returning permanently to Spain, Piedad was tasked with putting into practice what she had learned, including assembling a beta particle counter at the Rockefeller Institute and contributing to the study of this new branch of Physics. However, her work was cut short when the Spanish Civil War began on July 18, 1936. The Rockefeller Institute, along with other JAE research centers, was closed. Piedad and other Spanish scientists halted their research and frequently went to high schools to teach. This was the case for Piedad and her colleagues.

6 Purgation of Scientists

When the war ended, everything changed, and distinctions began to emerge among researchers for reasons unrelated to Science. Following the years of the republican regime and the notable growth in women's roles across various fields, many researchers faced persecution, purges, separation, and even lifelong disqualification. The JAE had detractors from conservative sectors, who viewed its successes as a triumph of intellectual circles over the previous three decades. The purge of JAE members, carried out by the Falangists, affected 40% of the staff, with an especially severe impact on researchers in leadership positions, where the purge rate was 67%. This seemed to reflect a desire to remove the scientific leadership of the board.

Figure 14: Rosa Bernís.

At Rockefeller, the purge rate was even higher than average, at 45%, and many workers saw their careers cut short with the onset of the Franco dictatorship [9, 15, 17, 22, 45]. Some of these women included:

At that time, Rosa Bernís (Salamanca, 1909), who was a collaborator of Miguel Catalán in the spectroscopy section at the Rockefeller Institute and a close friend of many Spanish poets from the Generation of '27, was purged after the war, although she remained in

Spain. After her dismissal, she did not return to research and spent the rest of her life teaching Mathematics at a secondary school [13].

Pilar de Madariaga (Madrid, 1903) was also a lauded pioneer in Chemistry, who would enjoy scholarships at universities such as Stanford and Columbia. After her negative purge file, being disqualified, she went into exile to that same country, the USA, where surprisingly she completed another degree and doctorate, this time in Linguistics and worked as a Spanish language teacher until her retirement [33].

Figure 15: Pilar de Madariaga.

María de Maeztu (Vitoria, 1881), PhD in Philosophy, was the only woman who was part of the JAE management circle and was director of the "Residencia de Señoritas", whose objective was the union of university women around cultural activities, conferences, libraries, scholarships and aid, reproducing the soul that the Student Residence had, exclusively male. In this residence, the work of the Foster Chemistry Laboratory stands out, reserved exclusively for the practices of the female students, dedicated to the training of women in this field and which was so successful. Unfortunately, she had to go into exile to Buenos Aires, where she maintained her History Chair until her death and continued her brilliant pedagogical work [32].

Figure 16: María de Maeztu and the Foster Laboratory at the Residencia de Señoritas.

Figure 17: Dorotea Barnés.

Dorotea Barnés (Pamplona, 1904), also a PhD in Chemistry from the Rockefeller Institute, studied spectroscopic techniques at Yale and returned to Spain as the first person to introduce Raman Spectroscopy techniques in the country, demonstrating her solid preparation and competence. From her experience in the US, she wrote to María de Maeztu:

"I am delighted with this feminine university city that I would gladly transplant to my country. This is much easier than the tough competition we are forced to maintain. [...] I often remember when you said [...] that we needed to create a culture for ourselves, neither better nor worse, but different and feminine."

Despite her ability and talent, a purge file was opened against Dorotea after the war, leading to her disqualification in Spain, as happened to her sister Adela, also a chemist. While Adela continued her work in exile in Mexico, Dorotea chose to

remain in Spain, possibly due to her newborn daughter, and did not return to work or research for the rest of her life [58].

Josefa González Aguado (Granada, 1907), who had been a student at the Foster Laboratory and a fellow at Rockefeller in Miguel Catalán's Spectroscopy section, had her thesis defense suspended due to the war and was unable to present it. This was a source of great suffering and regret for her throughout her life. There are even indications that others, close to the regime, later took advantage of her research. Meanwhile, she lived in internal exile, was removed from research, and dedicated herself to running a pharmacy [51].

Trinidad Arroyo (Palencia, 1872) was not a chemist or physicist but an ophthalmologist and the third woman to obtain a PhD in Spain, in 1896. She and her husband built a clinic and laboratory, where she treated Benito Pérez Galdós, and she was also the first woman to teach at the Central University of Madrid. After the war, she was purged and went into exile with her husband to Mexico, where they continued their scientific careers [44].

María Teresa Toral (Madrid, 1911), also a chemist, presents another striking case. After her time at the Rockefeller Institute, she was imprisoned in Las Ventas in 1939 and sentenced to 12 years in prison due to her ideology, serving three years. In 1945, she was imprisoned again, with a death penalty requested, which attracted significant attention, including from the International Committee of Anti-Fascist Women. To illustrate her scientific recognition, Nobel laureate Irène Joliot-Curie attended the oral hearing of her trial in person. María Teresa escaped the death penalty and went into exile in Mexico, where she continued her scientific career. As a curiosity, in her exile she used her knowledge in Chemistry to create several engravings of poems by Spanish artists that had great success. [47, 52, 57].

María Antonia Zorraquino (Zaragoza, 1904), although not purged or exiled, represents a common case that illustrates the conditions that hindered women's access to research careers. This Aragonese chemistry graduate, who worked with physicist Rocasolano, ceased her career after the war because her husband, a professor of Chemistry at the University of Zaragoza, did not support her career, viewing it as a disadvantage for himself. This case highlights that even having an academic spouse did not guarantee professional development for women [35].

Figure 18: Trinidad Arroyo, María Teresa Toral and María Antonia Zorraquino.

These women illustrate the tremendous injustice of those years—a loss of talent, training, and individuals that should never happen again, although human beings never seem to learn.

7 Dictatorship and Foundation of the CSIC

After the Civil War and the proclamation of the Franco dictatorship, Piedad was fortunate, experiencing what might be called "cradle luck," and she was aware of it. Piedad was neither purged, prosecuted, nor punished, given her family's high political power and ideology close to the new regime. With the imposition of Francoism and the beginning of the fascist dictatorship in Spain, the regime sought to establish an institution analogous to the JAE that would promote and develop Spanish science and technology to serve the country.

Thus, in 1939, the Higher Council for Scientific Research (CSIC) was founded, based on the structure and material assets of the JAE, though it did not inherit its spirit or philosophy. Instead, the new institution aimed to intervene in and control the education and culture that had developed under the JAE. Its first president, José Ibáñez, defined in his inaugural speech a project of return to "*Spanish imperial and Catholic Science*" [50, 54].

"We want a Catholic Science. We liquidate, therefore, in this hour, all the scientific heresies that dried up and exhausted the channels of our national genius and plunged us into atony and decadence. [...] Our current Science, in connection with that which in past centuries defined us as a nation and as an empire, wants to be above all Catholic." (Ibáñez, 1940 Memoria CSIC, 1942: 15).

Initially, the outlook for women within this new institution was not very encouraging, largely due to the men who ran it. The equitable atmosphere of the old Rockefeller building disappeared with José Casares, the newly appointed director of the institute, who was openly opposed to the integration of women in research centers. However, with the reorganization of the different sections of the new CSIC, José María Otero Navascués, who was responsible for forming the Optics section of the new Alfonso de la Cruz Institute of Physics, personally contacted Piedad to join the working group, as there were no women on the CSIC staff at the time. This was due not only to Piedad's remarkable knowledge but also to her political neutrality and her family's ties with the new leaders of the country. In 1940, she joined the staff as the first woman admitted to the CSIC. Both Navascués and Palacios were supportive of working with women, leading to a gradual increase in female staff at the Physics Institute. By the 1940s, twenty women out of a total of seventy-eight scientists worked there [25].

7.1 María Egües

Despite this progress, precautions were necessary. For example, the anecdote of María Egües illustrates this. María (San Sebastian, 1917), who already knew Piedad from her PhD thesis years at Rockefeller and was a great friend of hers, was one of the first women to join the CSIC and played a crucial role in the research of optical instruments during those years.

Figure 19: María Egües.

The detailed fact is that Armando Durán proposed to both Piedad and María to participate in a course on Optics, Geometry, and Systems Calculus, with the caveat that they had to leave the building immediately at the end of classes because José Casares *"didn't want women in his institute."* María even recalls how, on

more than one occasion, they had to hide under the table because *"Casares was approaching."* One day, Casares allegedly encountered María and reminded her that he did not want to see her in the building outside of course hours. He told her he had to tolerate Piedad's presence because *"she had been working there for longer, he knew her family, and he had a commitment."* This example illustrates how Piedad's privileged background, due to her family connections, helped her continue her scientific career under the Franco regime, while many other researchers fell by the wayside [40, 41].

Figure 20: Piedad de la Cierva and María Egües on the roof of the Alfonso de la Cruz Institute of Physics.

The situation for women in the CSIC began to improve when José María Albareda took charge of the institution, as he allowed women to freely enter the buildings.

7.2 Teaching Assistant

At the same time, Piedad began teaching at the Central University of Madrid as a Teaching Assistant for the subject "Atomic-Molecular Structure and Spectroscopy" in the PhD courses, a chair held by Miguel Catalán. Piedad believed that working for Catalán would be a great opportunity. However, Catalán was purged and removed from the university, so she could not work with him and had to take charge of the theoretical classes. This was outside her responsibilities as an auxiliary, and it was not recorded in any documents nor did she receive a salary supplement for it. Despite this, she remained in contact with Catalán, who advised her while awaiting his reinstatement, which did not occur until 1945. This was the most common way for women to begin teaching at the university—typically as interns or teaching assistants, generally poorly paid and without the same promotion opportunities as their male colleagues. Moreover, none of the researchers mentioned prior to 1936 managed to secure a permanent position at a Spanish university.

7.3 Oppositions to Chair

In early 1941, competitions for Physics chairs were announced at the universities of Seville, Valencia, and Murcia. Three men and two women, María Teresa Salazar and Piedad, competed for these positions. Piedad's father had once again insisted that she participate because [2, 12]:

"My father dreamed of his daughter being the first female university professor." (Cierva Viudes, 1993, fol. 67)

Both women had enough merit to compete with their peers. Otero Carvajal, who has studied professorship appointments during the Franco regime, notes that both women even had superior CVs compared to the male candidates. It was rumored—and this reached Piedad's ears—that the results were predetermined, with an agreement among the universities to exclude women from these positions; some colleagues even advised her not to participate. Although neither of the women had been purged, discrimination against women had not been eradicated, and those who remained continued to suffer from it. Despite this, both women decided to compete. Unfortunately, the treatment they received from the Court was devastating; their work was undervalued, with negative evaluations based on the fact that their work was collaborative [2]:

Figure 21: Mª Teresa Salazar.

"This candidate presents a series of works carried out in collaboration with Messrs. Palacios, Rivori, and Prof. Hevesy from Copenhagen. [...] none of the works presented are the candidate's own initiative; all must be considered as carried out in collaboration and at the initiative of others." (Court Report, 1941)

The Court did not consider the prestige of their collaborators. Ultimately, the Chairs at Seville and Valencia were awarded to two of the three men, while the position at Murcia was left vacant. In other words, they preferred to leave a Chair unfilled—despite it having been awarded through a competitive examination and two qualified women applying—rather than appoint a woman. Despite their qualifications, the women who continued to pursue research careers under the dictatorship were not exempt from gender discrimination. Following this, María Teresa Salazar requested a review of the qualifications, arguing that the Court was unsuitable since none of its members were professors of physical chemistry, and hinted that her gender might have influenced the decision. This appeal was rejected, deemed "out of time." Salazar would try again later but was unsuccessful once more.

Piedad, on the other hand, chose not to pursue further complaints or attempts. This negative experience, which greatly disappointed her, revealed that the Spanish University remained a closed domain for women. This discrimination, combined with her experience as a teaching assistant—where she received only a third of the annual salary and no formal recognition—led her to forgo further attempts to enter the University. Instead, she spent the rest of her career conducting research outside of it.

7.4 Daza de Valdés Optical Institute

Around 1945, Piedad began focusing on her work at the new Daza de Valdés Optical Institute, which marked an expansion of CSIC's studies in this field. During this period, as a female scientist at the CSIC, Piedad produced many publications that highlight her significant contributions [8, 29, 48, 49]. At the same time, other women scientists were also making their mark at the institute:

Mª Teresa Vigón, head of the Photography and Photochemistry section, held several important positions. Her legacy is somewhat obscured and requires careful

examination of the documentation, partly because she had a sister, María Aránzazu Vigón, who was involved in the early Francoist nuclear policies. Both sisters are referred to as "Ms. Vigón" in the CSIC records, making it difficult to distinguish between them. It even appears that there might be confusion about whether there was only one Miss Vigón [26].

Olga García Riquelme was also among the first women to work at the CSIC. She joined Miguel Catalán's group after his return from exile and focused on the atomic spectra of astrophysical interest, collaborating with numerous international organizations [21, 28].

Figure 22: Mª Teresa Vigón and Olga G. Riquelme.

7.5 LTIEMA

In the mid-1940s, the Laboratory and Research Workshop of the General Staff of the Navy (Laboratorio y Taller de Investigación del Estado Mayor de la Armada, or LTIEMA) was established under the direction of Otero Navascués. The main research focus was on optical glass, electronics, and communications. During this period, there was a notable overlap between defense and scientific policies, as the institution aimed to leverage science for national security, with the Franco regime prioritizing defense and military technology. Navascués hired Piedad to work on anti-reflective coatings for lenses, which aimed to improve night vision. By 1945, these coatings could be used in the production of binoculars. Her work in this area was recognized in 1946 with the First Prize of the Academy of Sciences, making her the first woman to receive such an award [27, 42].

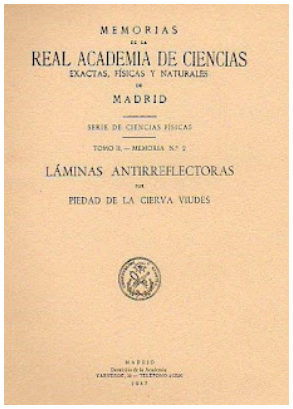

Figure 23: Memory "Anti-reflective coatings".

After the success of this work, Otero sent Piedad to the United States several times, as he wanted to start the industrialization of optical glass at LTIEMA and wanted her to be in charge of this task. She visited laboratories in Washington, Ohio, New York, and other locations. Upon her return to Spain, Piedad began to set up her own research group, which included several women. In 1954, they managed to manufacture the first batch of optical glass in Spain, a project that was published by the CSIC and won the First Prize for Technical Research "Juan de la Cierva."

7.6 PhD Thesis Supervision

Another example of the support network that existed among women in the field of research is that Piedad supervised three PhD theses, all of them by women, thus providing space and opportunities for other female colleagues to start a scientific career.

The three women were Francisca de Andrés, who completed her thesis on refractory clays; Luisa Arroyo, who worked on glass surfaces; and Guadalupe Ortiz, who focused on Piedad's last line of research, insulating materials, specifically the husks of rice grains. However, although Piedad was the true supervisor, she could not offi-

cially sign these theses as such, since she was not a university professor, and at that time, one had to be a professor to sign as the supervisor of a doctoral thesis. Piedad had to ask several of her colleagues to sign these theses; as a result, as Inmaculada Alva notes [**??**], Albareda appears as the supervisor of Francisca de Andrés's thesis, and Ángel Viau as the supervisor of Guadalupe Ortiz's thesis, thereby rendering Piedad de la Cierva's contribution invisible and once again silencing the name of a female scientist. [2]

Figure 24: Piedad during one of her trips to Washington.

When Otero left the direction of LTIEMA, everything related to optical glass was dismantled, but not before Piedad experimented with rice grains, observing their insulating and refractory properties. This led Piedad to become interested in rice husks, with the idea of applying this material to bricks used in industrial ovens, particularly in construction. The new leaders of LTIEMA appreciated this line of research, and they allowed her to continue and expand her working group, which included two other women: Antonia Muñoz and Guadalupe Ortiz [**??**].

8 Her Retirement

Despite the success of her research and having signed several patents, Piedad's work gradually had fewer opportunities for development. She eventually found herself writing standards for types of materials used in the Spanish Navy, a task that was not very motivating for her. After a series of personal difficulties, such as the death of her brother and her mother's illness, she decided to retire early at the age of 63, after 35 years of work at the CSIC and a career as a pioneer in Spanish science.

After her retirement, she spent her last years fighting memory loss, but not before writing memoirs in 1993 that have informed this and other works about her. Through her writings, we can get to know her and gain a much closer understanding of her as a person; perhaps without these diaries, her legacy would be far less known. The documentation and information about her and her work are rather scarce, appearing in some scientific memoirs and letters of the time almost anecdotally. This is not unique to Piedad but is common to all the women we have had the opportunity to learn about through this work. Their contributions are less highlighted, and their names frequently go unnoticed in the documents, although, as we have seen, they have been a major and highly relevant part of the scientific work in our country,

[2] Currently, in the UCM archive, Piedad de la Cierva is listed as the supervisor of Luisa Arroyo's PhD thesis.

from the Rockefeller Institute to the creation of the CSIC, and evidently up to the present day.

Figure 25: Family photographs of her last years.

9 Conclusions

Figure 26: Piedad with her nephew and nieces in Murcia.

With the figure of Piedad, I have tried to reconstruct the life of a woman scientist during the complicated and traumatic decades that Spain endured. She was a woman fortunate in ways that others were not, but thanks to her memories, we can not only get closer to her and become aware of her luck, but also get to know other contemporaries of hers about whom there is perhaps not much documentation. We must not stop approaching and inquiring about this Silver Age of Spanish Science, getting to know the Rockefeller Institute and its cutting-edge research, as well as its gender equality, and all these women who faced a world that a few years before had been exclusively male and who must be named and recognized.

Both Piedad and the others struggled to occupy spaces to develop their work and did not obtain the recognition they deserved at the time, nor often do they now. There are countless biographies and essays about Julio Palacios, Miguel Catalán, Blas Cabrera, and Otero Navascués, but very little about these women who were part of their research and whose work has led these men of science to be remembered.

I hope that this work has served several purposes. One of them is to capture the political intervention in the scientific and intellectual community that our country experienced, which stripped them of their academic freedom, and to reflect on what this meant for the development of science and research in Spain—how brilliant careers were cut short and the unfortunate loss of talent, training, and capital invested in modernizing Spanish science that the JAE had carried out. The memory of the JAE must inspire us to achieve a scientific policy that seeks development and knowledge through full academic freedom, promoting talent and the integration of all types of people.

Another purpose is to raise awareness of the incredible struggle that many women carried out to occupy academic and cultural spaces, demonstrating a great network

of support and sisterhood among them, so that today we can access all of them naturally, although there are still remnants of this patriarchal structure that is so deeply rooted in our society.

Finally, and personally, I hope to have managed to convey the admiration and recognition that all of them deserve by "taking them out of the trunk," making them visible, and giving them the time that belongs to them. Criticism, based on recognizing the situation from which we start, is the best interpretation we can make, since both pride and forgetting the facts only condemn us to repeat history—something that frequently happens to human beings. With this, I conclude, as Carmen Magallón says, that building a science with a human face, a science with both feminine and masculine aspects, is the basis of responsible science [**??**]. We must recognize the women who dedicated themselves to scientific research in Spain in the first half of the last century. There were many of them—our countrywomen, who could be our mothers, grandmothers, neighbors, or aunts—and they deserve to be named in each one of the CSIC spaces.

Acknowledgment

Firstly, I thank my cousins, who mentioned Piedad in our WhatsApp group for the first time, which sparked the beginning of my research that has culminated in this work.

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I cannot forget my mother, who, as a historian and archivist, has provided me with help, contributed to, and advised me on this research, which is so far removed from what I am used to doing.

Thanks, of course, to them—the protagonists of this memoir—Piedad, Felisa, Jenara, María de Maeztu, Dorotea... for being who they were in their time, for moving and inspiring me so much nearly 100 years later with their lives and their talent.

However, this work is dedicated to all of us who have ever been or are women scientists, so that we remember our predecessors and continue to occupy more and more spaces. But especially to girls from all countries—because yes, you can also do science and math.

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