

The Collaboration of Mileva Marić and Albert Einstein

Estelle Asmodelle

University of Central Lancashire
School of Computing, Engineering and Physical Sciences,
e-mail: elle@ellenet.net; Phone: +61418 676 586.

This is a contemporary review of the involvement of Mileva Marić, Albert Einstein's first wife, in his theoretical work between the period of 1900 to 1905. Separate biographies are outlined for both Mileva and Albert, prior to their attendance at Zürich Polytechnic in 1896. Then a combined journal is described, detailing significant events. In addition to a biographical sketch, comments by various authors are compared and contrasted concerning two narratives. Firstly, the sequence of events that happened and the couple's relationship at particular times. Secondly, the contents of letters from both Albert and Mileva. Some interpretations of the usage of pronouns in those letters during 1899 and 1905 are re-examined, and a different hypothesis regarding the usage of those pronouns is introduced. We examine various papers and compare the content of each subsequent paper to the work that Mileva was performing. With a different take, this treatment further suggests that the couple continued to work together much longer than other authors have indicated. We also evaluate critics and supporters of the hypothesis that Mileva was involved in Einstein's work, and refocus this within a historical context, in terms of women in science in the late 19th – century. Lastly, the definition of, collaboration and co-authorship specifically, is outlined. As a result, recommendations are stated. The first of which is Mileva should be seriously considered as an honorary co-author of one, possibly two, papers. Secondly, it is recommended that a serious inquiry should be made, concerning the extent of Mileva Marić's involvement in Albert Einstein's published works between 1902 and 1905.

© Anita publications, All rights reserved.

1 Introduction

Albert Einstein is the most famous physicist to date, and his name is synonymous with genius. The work by Einstein during his life between 1901 and 1921 is considered the most valuable contribution to physics by one person, surpassing even that of Issac Newton. While some priority disputes have lingered the past few decades, most are contentious and lacking any real credibility. Einstein's various papers, from Brownian motion, the Photoelectric effect, the Special Theory of Relativity and the General Theory of Relativity, remain foundations of modern physics. This article, incidently, was completed on Einstein's birthday, the 14th March 2015, he was born 136 years ago. Our understanding of Einstein's life seems solidified in history, for most believe all that is to be known of his life has been well documented.

However, there has been some debate since the 1980s as to the involvement of Einstein's first wife, Mileva Marić, in his work between 1899 and 1905. The impetus for this controversy was the release, by the family, of old letters between Albert and Mileva. These were later published in the book entitled, "*Albert Einstein/Mileva Maric: The Love Letters*," [1]. Many letters can be found, amidst other documents of the period, in an anthology entitled, *The Collected Papers of Albert Einstein: The early years, 1879-1902, Volume 1*, edited by John Stachel, David C. Cassidy, and Robert Schulmann. [2] This work was published in 1987 as the first volume of the Einstein Papers Project. Both these books are considered the most valuable primary reference material for Albert's early life. However, many of the letters Mileva wrote to Albert are missing or destroyed, so too are Einstein's original drafts of his old papers. [3] The contents of the existing letters and the absence of most of Mileva's letters started a silent controversy that has continued since the mid-1980s.

Most of the debate seems to be divided between two schools of thought. The first being that Mileva had no involvement and only acted as a sounding board. While the second was that Mileva was a genius who did most of the mathematical treatments and was co-author of all the work, during this period but never received any credit. The conservative view is that Mileva was merely a loving wife who supported Einstein and was simply an intelligent sounding board for his ideas. This is primarily the accepted viewpoint by most historians today. All this remained relatively academic and was not known by the general community until the release of a PBS documentary entitled, *Einstein's Wife – The Life of Mileva Marić Einstein*. [4] Since that time many books have surfaced which have fanned the debate to a new level.

In this review, we will look at some of the remarks found in letters, and the historical context in which they were written. As well as the sequence of events leading up to Einstein's 1905 *annus mirabilis* or miracle year and ending in the couple's divorce. We will also review Albert's and Mileva's academic achievements and

failures. In order to perform such an analysis, we must first examine the social perception of women scientists during the period in question. For the emancipation of women in academic institutions during late 19th-century, Europe is as relevant to this review as is the relationship between Mileva and Albert, described by the letters of the time.

2 Educational Opportunities for Women in the 19th Century

Women during the 19th-century were defined by their marriage to a man. In fact, women were not permitted to vote in most of Europe during this century, for the first right to vote in Europe was in Finland in 1906 while the last was in Liechtenstein in 1984. [5] The 19th-century was very much a time of change for women's rights, but it would be a very slow change indeed. Essentially women had no civil rights and suffered institutionalised sexism, whereby administrators doubted their intellectual capacities and their right to participate in university education. [6]

Gentlemen of Science

In Sue Rosser, book, *Women, Science, and Myth*, the author depicted the attitude of the time, "science had been a domain open to the privileged gentlemen of science." By the end of the 19th-century, men still dominated the sciences but as the century progressed, women participated increasingly in the scientific culture that had become part of everyday life. The women who did pursue education were exceptional pioneers in the expanding fields of science, many women, still undiscovered, played crucial roles as educators, observers, and explorers of scientific knowledge. [6]

The new world

The significant changes occurred in the late 19th century, characterized by the transition from autocratic rule of monarchs to the bourgeois republic, and so this removed many of the feudal constraints on an industrial revolution. Life in the 19th-century was changing dramatically, and women wanted to be part of the new world.

Elizabeth Garrett Anderson was the first female in Britain to gain a medical qualification in 1865. Institutions in Europe were almost on par with Britain. Switzerland Universities began to admit female students after 1867, but women at that time were not permitted to matriculate at either German or Austrian universities until the turn of the twentieth century. [7]

Gasthörer

Matthias Tomczak in a paper entitled, *Mileva Maric, an unfulfilled career in science*, points out that there is confusion about the enrolment status of women between 1867 and 1917 at the Zürich Polytechnic. For the official student statistic of the Polytechnic does not show any enrolled women before 1917. In view of the official student statistics, this has to be understood to mean that before 1917 women were enlisted as Gasthörer or auditors, within University life. This meant that much of a woman's student life, during this period, was without academic credit. [8] This transition from Gasthörer to regular student would happen slowly.

However, in 1874 Sofia Kovalesky was the first women in modern Europe to gain a Ph.D.. It was at the University of Göttingen, and her research involved applying the theory of differential equations to the study of the shape of the rings of Saturn. [6] In the United States, the first doctoral degree was issued a few years later in 1886 to Winifred Edgerton Merrill, in the field of mathematics from Columbia University. [9] The Swiss Federal Polytechnic in Zürich proclaimed itself an institution in which women could graduate.

Women in science

Moreover, so in the late 19th century in Europe women were starting to enter science, including the fields of physics and mathematics. However, they suffered discrimination, and so only the strong minded women could deal with the daily sexism. [7] These attitudes would eventually change, but it would take a century to redefine women in science; not only in Europe but across the world.

Many women in science in this century are still treated less than their male peers today. [10] In fact even at this present time, the perception of women in physics is still not encouraging. It is understood that at most 18% of female Ph.D. are graduates in physics, within the US, compared with 49.5% in neuroscience. [11]

It is this period, the late 19th-century, in which a young shy Mileva Marić began to pursue a career in science.

3 Early Biography – 1875 to 1896: Mileva Marić

Mileva Marić was born on the 19th December 1875 in Titel, Vojvodina, within the then Austro-Hungarian Empire, and what is now Serbia. Mileva was the eldest of three children of Marija and Miloš Marić. Her family were quite wealthy, for Miloš was the Confidential Supervisor at the Royal Court of Justice [3]. The family were of Eastern Orthodox Christian faith. This young girl was somewhat shy and enjoyed watching the other classmates from a distance. [3]

Early school years

In 1886, she attended a high school for girls in Novi Sad but transferred to another school in Sremska Mitrovica a year later. Four years later, in 1890 Mileva enrolled at the Royal Serbian Grammar School in Šabac. In the book, *Mileva & Albert Einstein: their love and scientific collaboration*, Djordje Krstić confirms Mileva's aptitude. "Mileva among 14 pupils of her class, had excellent marks in both mathematics and physics." [3] Interestingly, Mileva had also learned German to a proficient level before 1890. From an early age, the young Serbian girl played the tamburitza, a traditional mandolin-like instrument, and later also played the piano as well. [12]

High school

Then in 1891, Miloš attained special permission to enrol Marić at the exclusively male; the Royal Classical High School in Zagreb, as a private student. John Stachel, who became the first editor of the Einstein Papers Project, has stated, "Her secondary education was quite unusual for a girl of that time and place." [13] This young Serbian girl passed the entrance exam and entered her tenth grade in 1892. Two years later in 1894 Mileva won special permission to attend physics lectures in February of that year and passed the final exams in September of the same year. Her grades in mathematics and physics were the highest awarded. [14] Then Mileva fell quite ill and moved to Switzerland, and after her recovery she attended the Höhere Töchterschule (girl's high school) in Zürich during the 1894-1896. [14]

University acceptance

In 1896, Mileva successfully passed the Matura-Exam and was accepted into medicine at the University of Zürich. Although, medicine was not to her liking and in autumn of 1896, she transferred to the Zürich Polytechnic, which later became known as Eidgenössische Technische Hochschule (ETH). At that time, Switzerland was one of very few countries where women were permitted to attend university. This young woman, who clearly had an academic intellect passed the mathematics entrance examination, on a scale 1–6, with an average grade of 4.25. [15] Mileva then enrolled for the Diploma course within section VIA, which would allow her to teach physics and mathematics for secondary school students. She was the only woman in her group of six students, and the fifth woman to enter VIA section. She was 20 years of age at that time. Albert Einstein had enrolled in the same program in that same year. However, they would become much more than classmates. [3]

4 Early Biography - 1879 to 1896: Albert Einstein

Albert Einstein was born on a Friday on the 14th day of March 1879 in Ulm, in the Kingdom of Württemberg in the German Empire, which had recently along with Swabia joined the new German Reich. Albert was the first born to Pauline and Hermann Einstein. [12] Pauline thought the baby was quite large and angular and believed this may indicate a birth anomaly. [16] At the age of two little Albert was referred to a *der Depperte*, or the dopey one, as he had difficulty talking. His parents even consulted a physician and resigned themselves to the fact that the child was a little backwards. [12] In 1881 a baby girl's birth followed, it was Albert's young sister Maria, and she was later nicknamed Maja. [16]

Early life

The Einstein family moved to Munich. There Hermann founded an electrical manufacturing company based on direct current, called: Elektrotechnische Fabrik J. Einstein & Cie. Hermann had previously failed in a featherbed business, so this was a wonderfully new opportunity. [16]

The Einstein family were Jewish but not observant. At the age of six Albert attended a Catholic elementary school. Then, at the age of nine between 1886–1895, a Catholic Primary School. It was the Luitpold Gymnasium¹; here he received advanced primary and secondary school education until he left Germany seven years later.

The legendary story of Albert being mesmerized by pocket compass is entirely correct, as the child realised that there must be some unseen force involved. The first signs of Albert's interest began to emerge. Albert took music lessons on the Violin from the age of six till he was thirteen, often accompanied by Pauline, his mother, on Piano. [17] It is apparent that this was when Einstein's love of Mozart's music first sparked.

Upheaval

In 1885 Hermann's electrical business had over 200 employees and had supplied the first electrical lights for Munich's Oktoberfest. However, by 1894, at which time Albert was fifteen years old, the Elektrotechnische Fabrik J. Einstein & Cie had failed, due to the supremacy of alternating current over direct current. Later in life Albert would claim, at that time he had mastered differential and integral calculus. [12] The Einstein family then moved to Italy, seeking new business opportunities while Albert stayed, in Munich, to finish his studies. However, by late December 1894, he travelled to Pavia to Italy to join his family. While living in Pavia in 1895, Albert did calculations on his uncle Jakob's new invention and astounded his uncle and the whole family. [12]

¹ This school is now known as the Albert Einstein Gymnasium.

Failed acceptance to University

In the same year, Albert sat for the entrance examinations for the Swiss Federal Polytechnic in Zürich (Eidgenössische Technische Hochschule ETH). However, he failed to attain the required standard in the general part of the examination, yet scored exceptional grades in physics and mathematics. [12]

Successful graduation

A friend of the family recommended that the boy attend the Argovian Cantonal school in Switzerland in the town of Aarau, near Zürich, which he did in the fall of 1895. In 1896, Albert graduated from the Aarau school, achieving the highest marks overall in his class with the best grades in mathematics, physics and German. [16] It was at this time, living in Switzerland, that Albert decided to renounce his German citizenship. Although the Nazis had not yet seized power, the anti-Semitic propaganda had blatantly emerged. [18]

First writings on light

Interestingly, in the summer of 1895 Albert sent his uncle Jakob a document that detailed the propagation of light through the ether, mathematically. As Jeremy Bernstein in his book, *Albert Einstein: And the Frontiers of Physics*, suggests, “The document could have been written by any conventional 19th-century physicist.” [17] [19] This was before Albert had entered university, and it clearly shows his obsession with light.

Successful acceptance to University

In September 1896, Albert passed the Swiss-Matura with reasonably good grades. This included a high mark of 6 in physics and mathematics, on a scale of 1–6. Though he was only 17, this young man enrolled in the four-year mathematics and physics teaching diploma program at the Zürich ETH. [16]



Fig. 1 Mileva Marić. Circa 1896.
Credit: Wikipedia.

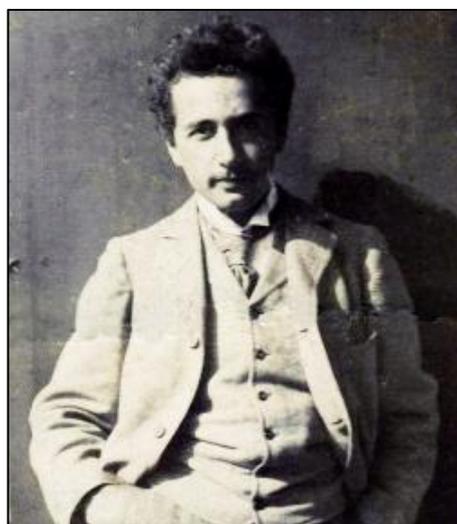


Fig. 2 Einstein at Zurich Polytechnic.
Circa 1896. © 2015 Leo Baeck Institute.

5 Mileva & Albert – 1896 to 1919

In their first year at Zürich ETH, Albert was 17 years old, and Mileva was three years his senior. It was not long before they noticed each other in lectures and soon became friends. Einstein instantly liked this reticent Serbian girl. Milan Popović describes Mileva’s personality, in his book, *In Albert's Shadow: The Life and Letters of Mileva Maric, Einstein's First Wife*. “Mileva Marić was a quick wit, a talented musician and accomplished mathematician and a promising physicist.” [20] Mileva excelled in her studies at the beginning of her time at Zürich ETH. Clearly, a young woman studying theoretical physics in a European institution in the late 19th-century would have been a thorn in the side of the conventionally stoic world of academia. However, this would not deter a young, ambitious, Albert Einstein. After all he was something of a rebel himself and believed the Zürich ETH was not keeping pace with progress in physics.

Friendship

Over the next couple of years, Mileva and Albert’s friendship had become solidified, for they read books together on new physics, which was not part of the course work. These books were something Einstein was taking an increasing interest in. As a result, they spent much time together. [12] Albert also made friends with other students at the university and seemed well liked. However, Mileva was slower to form friendships and appeared somewhat reticent. In fact, Albert relied on a friend that would become very instrumental in his life, Marcel Grossman, who took meticulous notes and lent them to Albert on many occasions. It seems that Albert missed lectures because he believed the course material was not up to date, especially seeing Maxwell’s equations were not included in the course curriculum. [21]

Gasthörer

After the 5th October 1897, in the 3rd semester, Mileva attended Heidelberg University. Her professor was Philipp Lenard, who would later win the Noble Prize in 1905. [22] Mileva was very excited about the work that Lenard was doing. She wrote to Albert about details of experiments on the 20th October of that year. “Oh, it was really neat at the lecture of Prof. Lenard yesterday; he is talking now about the kinetic theory of heat of gases.” Moreover, she continues to reiterate details of what Lenard did. (Letter 36, page 34) [2] Einstein was very interested in what Mileva was studying and replied with details of important course work at the Zürich ETH. Being a woman, Mileva was only permitted to audit the course at Heidelberg, but not obtain credit. She was, of course, Gasthörer. Of particular interest to Albert was Lenard’s work on cathode rays or electrons. Hans C. Ohanian states in his book, *Einstein's Mistakes: The Human Failings of Genius*, “Lenard found that the energy absorbed by the electrons from the ultraviolet light increased with the frequency of light, but it did not depend on the intensity of light.” [23] Walter Isaacson in his lucid biography, *Einstein - His Life and Universe*, reveals the seeds of their romantic involvement. “After she moved to Heidelberg, shows glimmers of a romantic attraction but also highlights her self-confident nonchalance.” [12]

Returning to Zürich ETH

In April 1898 Mileva returned to Zürich and the ETH, and Albert wanted to hear all the details of the lectures with Lenard. Back at the Zürich ETH Mileva’s studies included: experimental, applied and theoretical physics, mechanics, differential and integral calculus, descriptive and projective geometry, and astronomy. While both together at the Zürich ETH, they had become inseparable, “It is easy to see why Einstein felt such an affinity for Marić. They were kindred spirits who perceived themselves as aloof scholars and outsiders.” [12] Albert sat for his intermediate exams in October of that same year and finished first in his class with an average mark of 5.7 out of a possible 6. In second place was his friend and confidant Marcel Grossman.

Albert wrote to Mileva in early August of 1899 and confirmed that he was enjoying the collaboration with her, “I find the collaboration very good.” (Letter 50, page 129) [2] This was pointed out to be a significant letter by Evan Harris Walker, in a paper entitled, “*Ms. Einstein*”. [24] As this letter does not pertain to the course material but extracurricular studies.

Intermediate diploma examinations

A little while later in that same year Mileva sat for the intermediate diploma examinations; she was one year behind other students in her group because of her stay at Heidelberg University. She obtained a grade average of 5.05 out of a scale 1–6. This put Mileva fifth out of the six students. Einstein in the previous year's group had come top of the class with a grade of 5.7. Interestingly, Mileva attained the same mark in Physics as Albert did; namely, 5.5. [3] As with their early schooling, it was clear they were evenly matched in physics.

From 1899 onwards Albert, Mileva, and a good friend of hers by the name of Helene Kaufler, often played music together. [20] The relationship had development into one of mutual adoration and from October of that year they became lovers. [3]

Dissertations

By the 9th of March 1900, Mileva has chosen the topic of her dissertation. In a letter to her close friend Helene she wrote, “Professor Weber accepted my proposal for my diploma work and was very satisfied with it. I am glad of the research, which is ahead of me. E (referring to Albert) also accepted an interesting theme for himself.” (Letter 63, page 138) [2] Interestingly, we do not know the exact area of research the letter refers. However, both their written works were accepted. There is also an interesting letter from Helene Kaufler to her mother Ida of the Einstein’s progress regarding the outcome of these dissertations, “... Miss Marić and Mr. Einstein have now completed their written works. They planned them together, but Mr. Einstein left the most beautiful part to Miss Marić. He will probably become an assistant to his professor and will remain here. Miss Marić was also offered an assistant’s post at the Polytechnic.” These comments were paraphrased by Krstić. [3] Letters outside the couple’s correspondence, such as this, shows the public perception of their progress, which seems both advanced.

1900 was a time of the final grading and graduation. Heinrich Friedrich Weber was both Mileva and Albert’s thesis advisor and gave their respective papers the two lowest essay grades in the class, with 4.5 and 4.0, respectively. Einstein did not like Weber and had exclaimed on more than one occasion that his lectures were 50 years out of date for they did not contain Maxwell’s equations. [12] Despite Albert’s poor performance, he managed to attain a final average grade of 4.9, making him forth in the class. However, Mileva did reasonably well in all subjects, except in the mathematics component or theory of functions. In that subject she had scored 2.5, this made her final grade of 4, being the lowest mark in the class. [2] Albert graduated with the diploma in July 1900 while Mileva resigned herself to retrying the examination the following year. [14]

Considered equals

The couple were clearly in love and devoted much time to each other, but the real passion for both the young students was physics. They discussed topics, read books, and became somewhat autodidact as well, studying new physics that was not part of the Zürich ETH curriculum. [16] It has been stated by Djordje Krstić that, “Mileva regularly worked, mostly in the evenings and during the nights, at the same table with Albert –

quietly, modestly and never in public view.” [3] At this time Einstein had proclaimed in letters to Mileva that he considered her an intellectual equal, “...you a creature who is my equal.” (Letter 79, Page 152) [1]

Wilhelm Fiedler

Interestingly, Wilhelm Fiedler taught the geometry that comprised in the theory of functions course. While many writers reiterate Mileva’s failure, very little is mentioned of the tutor who was also the marker of the paper. Interestingly, the other students in her small group, all male, obtained at least 5.5 in this subject. It was only Mileva who attains such a low grade. [2]. Wilhelm Fiedler was at that time a member of the Prussian Academy of Sciences, and some members of that body felt there was no place for women in science, let alone physics. Medicine seemed like a more acceptable area of specialisation. [16] Some researchers have merely suggested that Mileva had poor mathematics grade and thus incapable of obtaining the diploma, and the most vehement critic of her grades is Allen Esterson. [25] Most researchers, like Esterson, fail to take into context the historical attitude towards women of that time in universities such as the Zürich ETH, with its conservative Prussian gentlemen of science. The Prussian Academy of Sciences was a stoic society, and it was not until 1964, almost a century later the first woman joined the society. Elisabeth Charlotte Welskopf was elected the first female as a full member in the successor organization to the Academy of Sciences of the GDR. [26] Perhaps the Zürich ETH just wanted Mileva to be merely, Gasthörer.

Their ideas

Mileva was busy studying as she was very much hoping to go on to a complete a doctorate and become a physicist. Her parents had invested a great deal, both emotionally and financially, and she needed to succeed. Meanwhile, Albert was busy looking for work. It seems no one wanted to employ this new graduate, yet all of his classmates had secured good positions. [16] Mileva and Albert continued to study together the new physics papers, with passion. In fact, Albert wrote to Mileva, dated the 27th of March 1901, stating something quite profound. “How happy and proud I will be when the two of us together will have brought *our* work on relative motion to a victorious conclusion!” (Letter 94, page 161) [2] [24] Then a little while later in another letter, Albert writes to her, “The local Prof. Weber is very nice to me and shows interest in *my* investigations. I gave him *our* paper.” (Letter 107, page 171) [2] Clearly, in this letter, Einstein is talking about two different research items, his investigations and their collaboration. Soon after there is more evidence in another letter of their collaborative research, “I am again studying Boltzmann’s theory of gases. I think, however, that O.E. Meyer has enough empirical material for *our* investigation. If you once go to the library, you may check it,” and later in the same letter, “I am very curious whether *our* conservative molecular force will hold good for gases as well.” (Letter 102, Page 168) [2] Stachel and other writers have suggested that Albert’s use of pronouns was merely a romantic inflection. [13] However, there is no evidence elsewhere, the soon to be world famous physicist, mixed up his ideas with other people’s. The most natural conclusion is there were several ideas, some were his, others were theirs and perhaps still others were originally conceived by Mileva.

Pregnancy

Mileva academic career was further disrupted in early 1901 when she became pregnant. Zürich at that time was a centre of a burgeoning birth control industry, whereby advertisements offered mail order abortion drugs. She could have terminated the pregnancy but decided to have Albert’s baby even though he was not prepared to marry. [12]

Final diploma examination

On Friday the 26th of July 1901, while three months pregnant, Mileva sat for the final diploma examination. This was her second attempt. However, this young Serbian girl did not pass the same subject, theory of functions. It was very stressful for the new mother to be. Strangely, her marks in theoretical and experimental physics were lower than the previous attempt. Djordje Krstić suggests, “the stress of being secretly pregnant and not married may have affected Mileva’s concentration.” Krstić, further expounds the reason for the lower mark from Weber, “because of Albert’s caustic relationship with Professor Weber, Mileva was no longer was on good terms with Professor Weber.” [3] This is a very reasonable argument; for Mileva’s second failure. However, was it more than that? Was it because she was a woman? As a result, she then discontinued work on her diploma dissertation, which she had hoped to become a doctoral thesis. This also was under the supervision of the physics professor Heinrich Weber.

Swiss Citizenship

At the same time, Albert was awarded Swiss Citizenship. Since renouncing his German citizenship, some years earlier, he had been stateless. However, this acceptance into Switzerland as a resident must have given him some type of belonging.

Physics

Many critics have said that Mileva never wrote about physics to Albert. In a letter dated early November 1901, she says, “What nice books you sent me... I’ve also read the one by Forel, when I finish it; I’ll write to you about it. Have you read the one by Planck? It seems to be interesting.” (Letter 123, Page 182) [2] The real issue here is that many of Mileva’s letters to her sweetheart cannot be found. There is no doubt she

wrote many letters to her devoted Albert about physics but are not privy to them. The reason the letters are missing remains a mystery.

First Scientific Paper

Later, that same year, on the 13th December of 1900, Einstein submitted his first real scientific paper. *Folgerungen aus den Kapillaritätserscheinungen, Conclusions Drawn from the Phenomena of Capillarity*, to the prestigious *Annalen der Physik*². It was published in March of 1901. [27] It was a time of great excitement for Albert, and also Mileva. It is clear that Einstein saw this work as the product of their collaboration. On the 4th April 1901, Albert writes to Mileva in letter 96, “He (Michele Besso) is very interested in *our* investigations... The day before yesterday, he went on *my* behalf, to see his uncle, Prof. Jung, one of the most influential professors of Italy and also gave him *our* paper.” (Letter 96, page 162) [2] Clearly, this refers to the paper, *Conclusions Drawn from the Phenomena of Capillarity*, which was obviously a product of their collaboration. In fact in the documentary, *Einstein’s Wife*, Robert Schulmann, an editor of The Collected Works of Albert Einstein, who worked along side John Stachel had the following to say about Mileva’s involvement. “It is very conceivable that Mileva had input on the paper, on Capillarity. That, of course, has nothing to do with special relativity. However, it is fair enough to say that Mileva could conceivably have contributed to the first paper of his.” [28] Other writers vehemently disagree and again Esterson is most vocal. [25]

Relative motion work

In another letter from Albert to Mileva on the 19th December 1901, he writes, “Today I spent the whole afternoon with Kleiner in Zürich and explained *my* ideas on electrodynamics of moving bodies to him and otherwise talked about all kinds of physical problems.” (Letter 130, page 189) [2] We see here, that Einstein is taking a departure from the collaboration. Although he refers to the work prior to this time as theirs, even the relative motion work, he is clearly adding more to the idea and is now starting to see it as *his* idea. However, there seems to be a dichotomy here, with what is collaborative and what is individually novel for Einstein. In the same letter, he adds, “I will certainly write the paper in the coming weeks.” [2] Many writers, especially Stachel have iterated the point that this is evidence that Einstein was only referring to our ideas, in the romantic sense. [13]

However, I propose an alternative hypothesis here; namely, that Einstein had been considering two sets of ideas, one he developed with Mileva, and a second he developed himself. This second letter indicates that he preferred his ideas over their ideas. This seems more in line with the theoretical process when developing a concept to explain physical phenomena and is more natural explanation. As Stachel was so influential regarding the interpretation of the letters, other authors merely reiterated the sounding board idea, so much so even a recent article perpetuates Stachel’s idea or misinterpretation. [29]

Unwanted Baby

The pregnancy had subdued Mileva's excitement. This was essentially an illegitimate and unwanted child in the late 19th-century. It was most certainly a cause for anxiety, amidst joy. However, the stress of being pregnant to Albert, whose family had shown disdain for her in every possible way, must have been unbearable.

In late January of 1902 Mileva gave birth to their first child, Lieserl. Albert never visited Serbia to meet the baby. Moreover, he certainly didn’t want his family finding out about the illegitimate child. The girl is believed to have had scarlet fever and lived at Mileva’s parent’s home in Novi Sad. Walter Isaacson has said, “when the Lieserl turned 19 month of age, she was given up for adoption.” [12] However, in the book, *Einstein’s Daughter: The Search for Lieserl*, by Michele Zackheim, the story is more complex and compelling. The author who researched Lieserl’s short, poignant life, suggests she died of scarlet fever as no record of her existence appears afterward. [30] It would be 30 years before the truth of Albert’s first child would surface.

Around the 8th of February 1902, while Mileva is at Novi Sad, Albert writes to her, “I am now expounding to Habicht (his friend Conrad) the paper I have handed into Kleiner (his Ph.D. supervisor). He is quite enthusiastic about *my* good ideas and nages me to send to Boltzmann the part of the paper that refers to his (Boltzmann) book.” (Letter 136, page 192) [2]. Apparently, Einstein is making a pure distinction between here with what is his work, as opposed to their collaborative work cited in other letters.

Second Scientific Paper

In April 1902, Einstein publishes his second paper, in *Annalen der Physik*. *Thermodynamische Theorie der Potentialdifferenz zwischen Metallen und vollständig dissoziierten Lösungen ihrer Salze, und eine elektrische Methode zur Erforschung der Molekularkräfte, On the Thermodynamic Theory of the Difference in Potentials between Metals and Fully Dissociated Solutions of Their Salts and on an Electrical Method for Investigating Molecular Forces*. [31] Interestingly, he would in 1907 say that this paper and the previous one were worthless and irrelevant.

Akademie Olympia

A group of Albert’s friends, mostly from Bern in Switzerland, in Easter of 1902 formed an intellectual society of sorts. It was half discussion forum and half dinner party. The name of the gathering was Akademie

² *Annalen der Physik* (Annals of Physics) is one of the oldest scientific journals on physics, since 1799.

Olympia, or in English: the Olympia Academy. They usually met at Albert Einstein's apartment and discussed philosophy, mathematics and physics. Mileva attended most meetings but as Maurice Solovine later recalled, "Mileva, intelligent and reserved, listened intently but never intervened in our discussions." [12] Mileva took notes of everything that was said and listened quite intently.

The founding members of the Akademie Olympia, were Albert, Conrad Habicht, and Maurice Solovine. Maurice Solovine was a Romanian philosophy student who answered a newspaper advertisement concerning physics tutorials that Einstein had published. Soon after, a mathematician by the name of Conrad Habicht joined the group, which had now become Akademie Olympia. Solovine and Habicht would become lifelong friends of Einstein. [12] There were other people who participated in some meetings. Paul Habicht, the brother of Conrad Habicht, came to a few. A mechanical engineer by the name of Michele Besso and Marcel Grossmann, a mathematician and Albert's friend at Zürich ETH, also joined in periodically. Then there was Lucien Chavan, an electrical engineer, and, of course, the very reticent Miss Mileva Marić. [12]

Not only had this young Serbian woman studied physics and mathematics at two prestigious European universities, but she also attended regular meetings of a think-tank that would be instrumental in Albert's later scientific publications. In addition, according to Djordje Krstić, during the evenings alone with Albert, Mileva collaborated with him on scientific problems. [3]

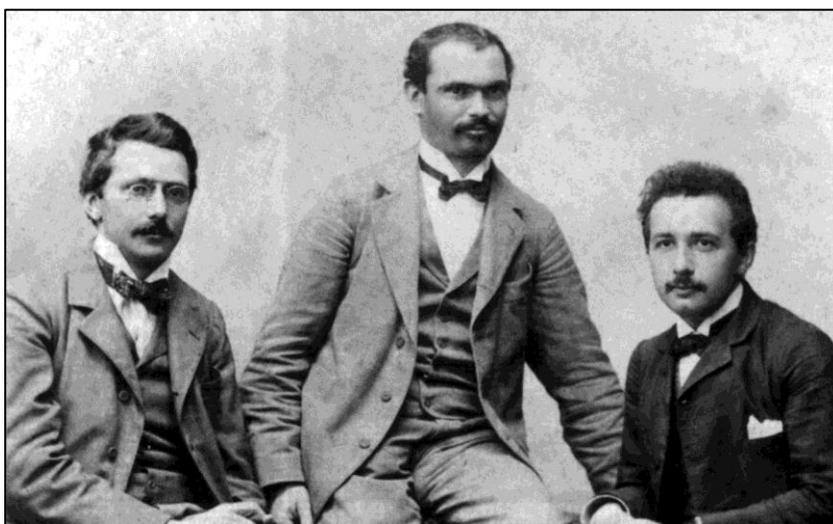


Fig. 3 Akademie Olympia. Left to right: Conrad Habicht, Maurice Solovine, and Albert Einstein. Circa 1903. Credit: Wikipedia.

Third Scientific Paper

In June 1902 Einstein publishes his third paper, in *Annalen der Physik*, *Kinetische Theorie des Wärmegleichgewichtes und des zweiten Hauptsatzes der Thermodynamik, Kinetic Theory of Thermal Equilibrium and of the Second Law of Thermodynamics*. [32] Again this paper pertains to some elements of correspondence between Mileva and Albert. However, as in the other two articles, only Einstein's name appears on the document, and that would be the case with all the scientific papers.

Patent clerk position

Albert had been living hand to mouth since leaving Zürich ETH, and had heard of a patent clerk job becoming available in Bern. "The official advertisement announcing the patent office opportunity finally appeared in December 1901." [12] And on the 16th June 1902 the job finally came through. Albert was now employed as the lowest rank patent clerk, provisionally as a Technical Expert Class 3. He would remain a patent clerk till 1909.

Mileva was happy that Albert now had work, it gave their relationship the security it needed and allowed them to continue their studies and hold meetings of the Akademie Olympia. Even though Mileva was no longer at university, her interest in physics continued as did her love for Einstein. The two had become inseparable. There is no doubt that Akademie Olympia played a significant role in Einstein's intellectual development, leading up to his 1905 *annus mirabilis*. It is fitting to remember at this time Mileva was immersed in all of Albert's activities and would undergo a similar intellectual development. These were happy days for the young couple, filled with fond memories. [16]

Marriage of Mileva and Albert

Then on the 6th of January 1903 Albert and Mileva married, at the Bern registrar's office in a tiny civil ceremony. The Akademie Olympia colleagues, Maurice Solovine and Conrad Habicht, served as witnesses to

the wedding. There were no family members from either side. It was merely the same group of intellectual confidants, who later that evening at a restaurant dined together in a small reception.

There was no honeymoon; the couple quietly returned to the apartment together later that night. [12] It is interesting to realise that these people were significant in the young couple's life, so much so, they were the only attendants to their wedding. Mileva did not have a maid of honor nor a bridesmaid, but was happy with simply the presence of two intellectual friends.

Life in Bern

In letters to friends, both Mileva and Albert talk of their happiness and love, more so than the Zürich days. Life in Bern had become very comfortable. Mileva writes to a friend, "I am even closer to my sweetheart if it is at all possible than I was in our Zürich days." [12]

Sadly, however, Mileva eventually became unhappy with the situation. She felt as if she had become an onlooker, while science discussions were taking place. [20] Perhaps this was a comment on her personality, and not her academic ability, for she was known to be withdrawn at times and also suffered from depression.

Fourth Scientific Paper

In the same month of that year, Einstein published his fourth paper in the *Annalen der Physik*, *Eine Theorie der Grundlagen der Thermodynamik, A Theory of the Foundations of Thermodynamics*. [33] This fourth paper, like the three before it are all statistical in their mathematical form and bear a heavy dependence on the sigma notation.

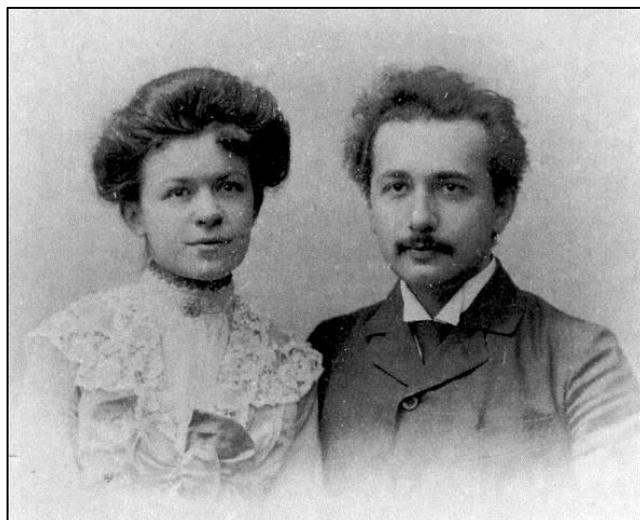


Fig. 4 Mileva and Albert Einstein on their wedding day.
Credit: Tesla Memorial Society.

Fifth Scientific Paper

In March of 1904, he publishes his fifth paper, *Annalen der Physik, Allgemeine molekulare Theorie der Wärme, On the General Molecular Theory of Heat*. [34] Up til now the papers went unnoticed, but the best was yet to come. However, it would take years before the real value of these papers were understood.

First Son is Born

Then in May 1904, the Einstein's first son is born in Bern, Hans Albert Einstein. It is a happy event, and it gives the marriage a much need boost. Mileva has a new purpose, taking care of Hans Albert. It must have meant a great deal to her after the situation with her first born, Lieserl. The couple welcomed Hans Albert's arrival. Moreover, the spark had returned to their lives. In a modern sense, Mileva may have been classified as suffering from a depression condition, and sooner or later it would find her again. [16]

Doctoral Thesis

On 30th day of April 1905, Einstein submitted his now completed thesis, to Alfred Kleiner, Professor of Experimental Physics. The doctoral dissertation was entitled, *A New Determination of Molecular Dimensions*. Shortly afterwards, Einstein was awarded a Ph.D. by the University of Zürich. [35] Interestingly, this is the same work that Albert and Mileva had corresponded about in earlier letters. Moreover, some of the work was something that Mileva had also researched. There is a good chance that her thesis work was on a similar topic.

Annus Mirabilis

That very same year, 1905, is referred to as Einstein's *annus mirabilis*, for he published four monumental papers in physics. These were fundamental pieces of work that he had apparently been working on for some time. Although they were released only a month or two apart sequentially, but were clearly the product of many months or even years of work.



Fig. 5 Mileva and Albert with Hans Albert. Circa 1904.
Credit: Tesla Memorial Society.

The sixth scientific paper and the first one in 1905, submitted in March of that year was, *Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt, On a Heuristic Point of View Concerning the Production and Transformation of Light*. [36] This is the photoelectric paper, whereby light consists of photons or particles of a given quantum of energy. This was a landmark paper and one that would later win him the Nobel Prize in 1922. [37]. Clearly, the work that Mileva had done at Heidelberg University, with Professor Lenard, was instrumental in forming the photoelectric paper. It allowed Einstein to calculate the relationship between the fundamental value of a photon. [3] However, as to be expected, many critics have insisted that Mileva took no part in any of Einstein's work. However, Mileva had even prepared letters to Max Planck about this work, and so apparently she was involved. [3]

In May of that year, Einstein submits his seventh paper to *Annalen der Physik*. *Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen, On the Movement of Small Particles Suspended in Stationary Liquids Required by the Molecular-Kinetic Theory of Heat*. [38] This is a seminal work concerning the Brownian motion of molecules. Again, a subject with which Albert's wife had corresponded. [1]

Then merely, one month later in June of 1905, Einstein submits his eighth scientific paper. This is also a landmark work, published in the *Annalen der Physik*, *Zur Elektrodynamik bewegter Körper, On the Electrodynamics of Moving Bodies*, [39] This is essentially, the Special Theory of Relativity. At the end of the paper, there is acknowledgement. "In conclusion, let me note that my friend and colleague M. Besso steadfastly stood by me in my work on the problem here discussed and that I am indebted to him for many a valuable suggestion." (Document 23, Page 171) [40] Clearly, there is no mention of Mileva in this submission but only his friend Besso. Again a woman's place in the early 20th-century was by her husband's side. [41]

Then, in September of 1905, Einstein publishes his ninth paper in *Annalen der Physik*, *Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?, Does the Inertia of a Body Depend upon its Energy Content?* In this paper, he derived the fact that mass was equivalent to energy, and vice versa. Producing a reworking of an earlier Henri Poincaré equation [42], which has become the most famous equation in history. The indelible: $E = mc^2$.

The waiting game

The revolution in physics that was in place and ready to happen would not happen right away. In fact, it would take years for someone to read and understand these papers, especially the ones published in 1905. Einstein continued tirelessly to work on his ideas while at the patent office. He was promoted in late 1904 to a 2nd class clerk position. He found the job ideal, for it gave him time to think about his theories.

According to some authors, case in point is the work of Hans C. Ohanian. In his book, *Einstein's Mistakes: The Human Failings of Genius*. He suggests that by the end of 1905, "Mileva had lost all interest in physics; she had become Einstein's wife and cook and the mother of his children, but not his collaborator." [23] Well at that time, there was only one child, Hans Albert and so if Ohanian is wrong about the number of children he is most likely wrong about many things. In letters from Mileva to Helene, there is evidence that physics was still a subject that made her passionate. However, she was saddened that she felt excluded from academic life. [3] As Stachel et al., points that some letters from that period show Mileva excited and happy about their lives together, and there is no reason to suspect anything had changed at that time. [40]

Although some letters from Mileva to her good friend Helene during early 1907 and mid–1908 have not survived. It was a crucial period, and they would provide some insight into her state of mind and some of the events that had transpired. However, all those letters have been lost. [20]

Max Planck

Several years of being a patent clerk, Einstein's work was finally starting to get noticed. All the while he continued to publish more and more papers. Then Professor Max Planck began to build upon Albert's work. As Isaacson writes, "By the beginning of 1908, even as such academic stars as Max Planck and Wilhelm Wien were writing to ask for his insights. Einstein had tempered his aspirations to be a university professor. Instead, he had begun, believe it or not, to seek work as a high school teacher." [12] By now Albert is also discussing his ideas with his friend Marcel Grossmann but still shared some physics discussions with Mileva. [43] Towards the end of 1908, Einstein is considered a leading physicist and is appointed lecturer at the University of Bern.

Academia

In 1909, Einstein gave a lecture on electrodynamics and the relativity principle at the University of Zürich. After which, Alfred Kleiner recommended Einstein to the faculty, in a newly created professorship in theoretical physics. [12] It is during this period that Mileva prepares notes for Albert's Physics lectures as Einstein is very busy, and she very much enjoyed being involved in the physics. In fact, she even writes letters to other physicists on Albert's behalf. [3]

Then in July of 1910, their second son is born in Zürich. His name is Eduard, and they nickname him Tete, for petit. It is a very busy time for the Einsteins as Albert's career explodes into success upon success. Together, in the evenings they work on his papers and lectures together. Albert still works at the same table as his wife while at home. [3] Yet some writers still insist she is merely a housewife. What an exceptionally skilled housewife she is indeed.

Academic notoriety

Einstein had been in Zürich less than six months when he received an invitation to consider a more prestigious job: a full professorship at the University of Prague. In March 1910, just before relocating to Prague, Hendrik Antoon Lorentz³ invited the Einsteins to visit at the little Dutch town of Leiden. Mileva accompanied Albert, and they stayed with Lorentz and his wife. Mileva was besotted with the invitation.

In April of 1911 Einstein became a full professor at Charles–Ferdinand University in Prague. He was also given Austrian citizenship in the Austro–Hungarian empire. Later that year, he attended the famous Solvay Conference at the end of October 1911, together with all the greats in physics of the day. [12] It meant Einstein had been recognised as a leading theorist, and his life would never be the same.

Growing apart

Einstein was a celebrity and travelled around Europe giving lectures and enjoying his new found fame. All the while his wife stayed in a city that she hated most, Prague. Mileva was depressed for not being part of the scientific academia she had dreamt. Spending most days alone with the children, the Serbian woman became gloomy and quite depressed. Albert started to resent his wife's demands for attention for he was far too busy to occupy himself with family life. [16]



Fig. 6 Tete, Mileva and Hans Albert.
Circa 1912. Credit, Tesla Memorial Society.

³ The Lorentz transformation equations were used in Einstein's Special theory of Relativity paper in 1905.

The marriage had become unstable, for Albert wanted the freedom to take every opportunity. On a trip to Berlin in 1912, during the Easter holidays, he traveled alone. It was at that time that Albert became reacquainted with a cousin whom he had known as a child. Her name was Elsa Löwenthal, and she was also three years his senior. [12] Some authors suggest that Albert and Elsa began an affair at that time. [44]

Full circle

In July 1912, Einstein moved back to Zürich to take up the post, Professor of Physics for the Zürich ETH. He had come full circle now. Mileva was thrilled and believed that returning to Zürich could help save their marriage, and also her sanity. The children seemed happy to be out of Prague. Walter Isaacson reiterates about when Albert sent a postcard to a friend, with the following inscription, “Great joy about it among us old folks and the two bear cubs.” [12]

However it was not to be, Mileva’s depression deepened, and her health started to decline. An illness developed; it was rheumatism. This made it very difficult for her to go outside, especially in the icy winter. At times, she was almost paralyzed by both mental and physical pain. [16]

Sadly in the year 1914, Mileva and Albert separated. Einstein relocated to the city of Berlin and took the post of Professor of Physics at the University of Berlin while Mileva and the children remained in Zürich. The couple would become estranged, and Mileva would have no involvement in his life from this period onward. The only discussion was to be about the children and their eventual divorce. Einstein remains in that post until 1932. Then in 1917 he was appointed Director, Kaiser Wilhelm Institute, Berlin. [12] Any collaboration of the Einsteins, both emotionally and intellectually was most certainly over.

Divorce

On the 31st January 1918 Einstein writes to Mileva in a letter and offers her his inevitable Nobel prize money in exchange for a divorce settlement, in which he would admit adultery. “The capital would be deposited in Switzerland and placed in safe-keeping for the children.” (Doc. 449, page 456) [45] What is intriguing about this story as Hans C. Ohanian points out is, “After he (Einstein) had received the prize money, he gave half to Mileva (in two installments, separated by several years), but he never gave her the other half.” [23] There are two questions here that beg to be answered. Firstly, why the Nobel prize money and not regular family support, which would be the usual thing to do? Secondly, why only half the money? It implies that half the money was for half the work, as a sort of bribe to get a divorce. So Albert could move on to a more exciting life without Mileva and the children tying him down. In any case, it is a very strange agreement.

Eleven months later, they divorced on 14th February 1919, after having lived apart for five years.

Albert would then marry his cousin Elsa Löwenthal, whom he had reignited a romance with some years before. Einstein would have very little to do with Mileva for the rest of his life.

6 Antagonists and Protagonists of the Collaboration Hypothesis

Apparently, most of Einstein’s papers between 1902 and 1905 were the product of the work he performed from 1899 onwards. This period of 1899 to 1905 is a significant time and if any collaboration occurred between Mileva and Albert it most certainly would have been during that period.

Esterson

There are many critics of the idea that the two worked together, in spite of the references to “our work,” and “our investigation.” The most prolific antagonist to the idea that the Einsteins collaborated is Allen Esterson. In fact, Esterson’s leading publications have been to oppose the idea that Mileva had in any way contributed to Albert’s work. Interestingly, Esterson has also been critical of the work of Sigmund Freud, and most of his publications have been in psychology journals. While articles, supposedly refuting Mileva’s contribution, mostly reside on Esterson’s website. [25] Although Esterson has a B.Sc., his criticisms seem to be that of a non-specialist in that he questions historical facts as opposed to ones based on physics. Esterson is merely a critic and has not published any substantive work, but directly criticises the work of others. His main criticism of Mileva is that she failed, or so we are led to believe, a single subject. All her other studies were elegant. Even if she did fail that single topic that would not be an indication of her worthlessness. Case in point, Einstein failed to enter the Zürich ETH on his first try, yet this did not prevent him from being one of the greatest physicists.

Stachel

John Stachel, Ph.D., is an American physicist and philosopher of science. He became the first editor of the Einstein Papers Project. He was editor of the first two volumes of *The Collected Papers of Albert Einstein*. He has been very critical of the Mileva collaboration hypothesis while his criticism surrounds the physics issues, and so his remarks appear to be mainly that of a specialist. However, he seems also to delve into semantics as well, interpreting Einstein’s use of pronoun as meaning something entirely different than one would think.

There are many other critics of Mileva’s involvement, but Esterson and Stachel provide a good cross section of academic criticism regarding the issues involved.

The Maschinchen

There is also the story of the construction of a device, called the Maschinchen, or little machine. Hilary Rose in a book called, *Love, Power, and Knowledge: Towards a Feminist Transformation of the Sciences*, states the following. “Mileva, through the collaboration with a mutual friend, Paul Habicht, constructed an innovatory device for measuring electrical currents.” [46] It was an electrostatic generator. Esterson criticised this account and affirmed it is based on an article in Troemel-Ploetz’s translation of a passage from Truhović-Gjurić’s work, which is supposedly devoid of any source reference. [25] However, as illustrated in this paper, Mileva helped Albert with his work and so why would this be any different.

Michelson-Morley experiment

Evan Harris Walker Ph.D. (1935 – 2006), was a physicist and one of the most prolific writers who suggested that the basic ideas of relativity came from Mileva. Walker had published a little over a hundred papers in reputable scientific journals and held over a dozen patents. He was viewed a radical. Stachel was one of his biggest critics, followed more recently by Esterson. In a letter to *Physics World* in February 1989, Walker writes a lengthy piece entitled, *Did Einstein Espouse His Spouse’s Ideas*. He goes on to criticise an early biography of Einstein written by Ronald W. Clark. [47] [44] In that book Clark suggests that Mileva had, “little learning”. It was considered an authoritative biography at that time. Apparently, Walker knew that Mileva had virtually the same education as Einstein, and it started him on the search for the truth.

In another *Physics World* Edition, Stachel replies with a scathing attack, suggesting that Walker’s claims are merely worthy of a Hollywood screenplay. However, in a counter response, Walker writes a letter entitled, *Mileva Marić’s Relativistic Role*, in which he illustrates something quite profound. [48] Einstein emphatically claimed for most of his life that he was unaware of the Michelson–Morley experiment⁴, when he was writing the Special Relativity paper. Walker points out that, Stachel suggested that letters between Albert and Mileva showed they did know of the experiment. However, Walker suggests that, on careful reading of the letters it is clear that between them they had the knowledge but Einstein was unaware of the details, even though he used the Lorentz transformation equations. This clearly illustrated that there was part of the work that only Mileva had access too. This point has never been successfully disputed, and is one of the main aspects of Walker’s work that still holds today. [48]

Mileva corrected Albert’s maths

Dr Desanka Truhović-Gjurić (1897-1982), a Serbian author, wrote a biographical work in 1969 in her native language, entitled, *Im Schatten Albert Einsteins. Das tragische Leben der Mileva Einstein-Marić. In the Shadow of Albert Einstein: The Tragic Life of Mileva Einstein-Marić*. [41] The author said that when Einstein addressed a group of Zagreb intellectuals he stated, “I need my wife as she solves all the mathematical problems for me.” [41] The book was republished in German in 1983 and received a wider audience. Her work included Letters of Milos Maric, father of Mileva, from Bern and Koložvar to Mileva and the Historian Tihomir Ostojic. The book has received considerable criticism, but it is easy to criticize such a work, 20, 30, 40 or 50 years after it was published. The early date of the first edition undoubtedly, adds some weight to its authenticity as it is closer to the source time.

Senta Troemel-Ploetz, a German linguist, says that, “while Einstein’s ideas may have been his own, but Mileva did the mathematics in many cases”. [49] Troemel-Ploetz goes on to argue that the letters Mileva wrote to Albert, although many are missing, are not about physics but are emotional letters. This does not mean she was not involved in the physics and mathematics, it just means Mileva preferred to write in an emotional context. Troemel-Ploetz goes on to cite third-hand reports that Mileva was the workhorse in the relationship. However, Highfield and Carter describe this claim as Serbian home-town folklore, and the subsequent title of the Serbian Marie Curie was unfitting. [14]

In a book by Charles S Chiu and Edith Borchardt, entitled, *Women in the Shadows*, the authors reiterate an important comment by Stachel. [50] They state, “The mathematics involved does not go beyond elementary calculus, and it seems unlikely that Maric contributed unique mathematical expertise...; one may speculate that she might have suggested method of proving individual results and/or checked calculations.” [50] What is interesting here is that the mathematics in the photoelectric paper and special relativity paper, do not go beyond elementary calculus and are indeed quite simple for someone trained in physics. However, it is not the mathematical simplicity that makes those papers monumental; it is the applied physics that does. So Stachel’s original argument only reinforces the idea that Mileva did do some of the mathematics. [13]

Einstein-Marity

Dr Desanka Truhović-Gjurić also writes about a controversial piece that was written by the Soviet physicist Abraham Joffe, in an article entitled, *In Remembrance of Albert Einstein*. The item was published in 1955. It was an obituary for Einstein in a leading Russian journal of physics. [15] Joffe is quoted as saying that he saw the original three submission papers of 1905 and said they were signed, “Einstein–Marity.” Marity is another form of Marić. However, the name was removed from the final publications.

⁴ The experiment was an interferometer that shown essentially that light moving in the proposed luminiferous ether could not be detected. It led Hendrik Lorentz to develop the transformation equations.

In response to this, many authors have claimed that the matter was a legal one, and this quote is taken out of context. Alberto A. Martínez in his book, *Science Secrets: The Truth about Darwin's Finches, Einstein's Wife, and Other Myths*, writes, "Joffe did not claim that Marić co-authored or collaborated in any of Einstein's papers." [51] It is believed by most, including Esterson, Stachel and others, that the original submission papers have the name of the wife and husband, as part of Swiss custom. However, as the PBS Ombudsman points out in a rebuttal to Esterson and Stachel that Albert never signed his name as Einstein–Marity, in any of his previously published papers. Furthermore, "Swiss law permits the male, the female, or both, to use a double last name, but this must be declared before the marriage. Moreover, it was Mileva, not Albert, who opted for the last name usage, Einstein–Marity." [28] This indicates that the initial submission of three of the significant papers of 1905 were submitted by Mileva, or at the very least both the Einsteins.

Letters and the original early papers

It is unfortunate that many of Mileva's letters to Albert are missing. It is also a tragedy that Einstein's initial drafts of all papers up to the end of 1905 are also missing. It seems that many of these early documents, held by Albert, have indeed gone astray or have been destroyed. Einstein would have known the value of those letters and first draft document, for he knew the value of the work. So why didn't he take efforts to keep them safe? Some have speculated that he destroyed them on purpose to cover up the scientific collaboration. However, I will not cite conspiracy theories, but merely mention it as a possibility. It is equally likely he lost them or threw them away, in my view this seems apter.

7 Notation used in Einstein's papers

If we examine the notation employed in Einstein's early papers, particularly up to and including 1902–1905, we see a standard form of notation. This form is characterised by heavy dependence on the use of Sigma notation, preceding the associated integral notation. For the early equations is based on statistical analysis of physical behaviour. This type of descriptive mathematical treatment, as opposed to an implied treatment, is prevalent in old papers, but so prominent in the Special Relativity paper of 1905.

Although the mathematical treatment of special relativity does not require integration and thus, there is no need for sigma notation. However, the mathematical procedures of all papers prior to the 1905, preceding, *Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt, On a Heuristic Point of View Concerning the Production and Transformation of Light*, have descriptive step-by-step treatments. However, after this paper there is a trend towards an implied mathematical progression. This means that individual steps are assumed and thus implied.

In contrast, papers concerning the special theory of relativity, published later although some sigma notation is used, it is to a lesser extent and comprises a different form; namely, the implied form.

8 What are Collaboration and Co-authorship?

In the days of Einstein, scientific authorship was much simpler and was specifically traceable to particular individuals. As physics has grown more complex, joint or multiple authored journal articles have increased. What constitutes authorship has become more of an issue (Syrett & Rudner, 1996).

Collaboration & co-authorship

In order to determine if Mileva was a collaborator and or a co-author, we need to define explicitly what both of these roles entail. The Standard Collins English Dictionary defines the term collaboration as: "the act of working with another or others on a joint project or something created by working jointly with another or others". [52]

However, scientific collaboration is more specific and is treated in a different manner, qualitatively. Moreover a collaborator and a co-author are not mutually inclusive, and so one could be classified as either or both, dependent on the contribution made.

In a publication from the Washington University in St. Louis, entitled, *Policy for Authorship on Scientific and Scholarly Publications*, which was approved by the Executive Committee on Research in 2009. Defined authorship in the following way. "An author is considered to be an individual who has made substantial intellectual contributions to a scientific investigation." [53]

The document further suggests that all authors of a scientific paper should meet the following criteria, "Scholarship: Contribute significantly to the conception, design, execution, and/or analysis and interpretation of data. Authorship: Participate in drafting, reviewing, and/or revising the manuscript for intellectual content. Approval: Approve the manuscript to be published." [53]

In this context, we can now see collaboration is much broader while co-authorship is more specific. So we are now in a position, based on all the material outlined above, to categorize Mileva's potential involvement.

9 Concluding Remarks

Apparently, from the early essay written by a young Albert Einstein in 1895 which his uncle Jakob received, concerning the propagation of light through the ether, provides insight into Einstein's passion. [19] Clearly, he had been consumed by these ideas long before university and also before meeting Mileva. However, Einstein's work before the Zürich ETH was immature. It would take many years of study and discussion, and the intervention of Mileva in his life, before Einstein would contribute to the world of physics.

On April 10th 2004, Physics World ran a poll in response to the airing of the PBS Documentary, *Einstein's Wife*. [4] Interestingly, 70% of the people surveyed believed that Mileva contributed to his work. Is this an indictment of the facts or merely good filmmaking? [54]

Had the ETH in Zürich not failed Mileva with the exam on the theory of functions, perhaps her path would have taken a different twist. Was it Einstein that prevented Mileva from a career in physics, or was it the tertiary institution's belief that women should merely be auditors of education and not participators of it? It has also been suggested that the Zürich ETH examination board, who knew that Albert and Mileva were lovers and would be married, failed Mileva as only the husband in such a case required a degree. [41] After all Mileva had been one of the first women to undertake a theoretical physics degree in Europe in the late 19th-century. So it is naïve to consider than sexism by a stoic institution did not come into play. It is not only naïve but just ignorant.

Granted Marie Skłodowska-Curie gained her Ph.D., in 1903 and won the Nobel Prize in Physics in the same year; then, won it again in Chemistry in 1911. She is the only person to date to have won the Noble Prize twice, which is an incredible achievement for a woman at the beginning of the 20th Century. [55] However, Mileva and Marie were very different people from very different backgrounds. Moreover, one person's ability cannot be measured by another's success.

In the history of physics, indeed science, in general, we are often confronted with paradoxes. In this instance, I am referring to Stigler's law of eponymy. [56] In its strongest and simplest form it states, "No scientific discovery is named after its original discoverer." In fact, one could also invoke Boyer's Law, which states just, "Mathematical formulas and theorems are usually not named after their original discoverers." [57] Surely in Einstein's case, this would be true. For Henry Lorentz's formula ended up defining the Special Theory of Relativity, and so too did Poincare's equation that Einstein redeveloped in his mass-energy equivalence paper. Boyer's Law seems to sit well with Einstein, as much as anyone else. So why shouldn't Stigler's law of eponymy be equally plausible, concerning Mileva Marić-Einstein? Failing these suggestive statistical behaviours, perhaps we should merely invoke Occam's razor, or the law of parsimony, which states that among competing hypotheses, the one with the fewest assumptions should be selected. [58] It seems simplest to consider, the Einsteins lived and worked together, day to day, and shared everything, including their ideas.

Clearly, Albert Einstein was a genius, there is no doubt about that, but it can also be said that, no man is an island. Being a genius does not mean he did not have collaborators. In fact, he collaborated later with his good friend Marcel Grossmann for the General Theory of Relativity papers [43]. Later he also officially worked with other scientists of the time. Albert was a victim of his place, and time, his spacetime. Women belonged to their husbands and had little in the way of individual voices. It was only the very strong woman who could claim that something to belong to her, while almost all were put in their place and just accepted it. The oppressed usually are unaware of being such, until change shows them otherwise.

Mileva Marić-Einstein passed away on the 4th day of August 1948, after suffering a stroke that paralyzed the left part of her body. According to Milan Popović, just before the seventy-three-year-old Mileva passed away, "she kept repeating a single word, *No*". [20] What she meant by this we will never know. However, what we do know is that much of the evidence is worthy of serious consideration. A court may say that this evidence is circumstantial, but cases are won for less.

I study Einstein's work and am continued amazed and besotted by each of his most significant papers. So much so, that all my academic study is concerned with the special and general theories of relativity. I am not an Einstein bagger nor a feminist in activist form. In fact, I admire Einstein, and I do not judge the mistakes he made as a person, for we have all made our own. This investigation is merely an academic one to uncover a truth, and whatever it may be I am prepared to accept it. However, I will not accept an institutionalised idea of what happened in those years, of the Einsteins, only because the mainstream deems it so.

There are so many instances that illustrate that Mileva was involved both as a collaborator and a co-author of the early papers. I would suggest that Mileva Marić-Einstein was a collaborator to all papers before the end of 1905. Moreover, most likely a co-author of one, possibly two, significant works. The first she may have co-authored is the document of 1901, *Folgerungen aus den Kapillaritätserscheinungen, Conclusions Drawn from the Phenomena of Capillarity* [27]. While the second paper is the 1905 which seems more likely being, *Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt, On a Heuristic Point of View Concerning the Production and Transformation of Light*. [36]

However, I cannot see that Mileva co-authored the special theory of relativity paper, as we can see a shift in Einstein's thinking and a change to a simpler mathematical form in that work. However, this

unrecognised Serbian woman would have certainly been a collaborator and assistant on earlier work on special relativity, but it was limited.

Most poignantly, Einstein received the Nobel Prize for the photoelectric paper of 1905, and so this puts the recognition of that work on a very different footing. Perhaps we will never know the full extent of Mileva's involvement but most certainly it would change the public perception of Albert Einstein. However, that said, it would not lessen the genius of a great physicist but merely provide solutions to many unanswered questions.

It would seem assigning honorary co-authorship would be an appropriate course of action in one, or perhaps two, cases as outlined above. However, this should only be considered after a proper and extensive inquiry, by an academic society, or institution has evaluated all evidence.

Clearly, there was much more to Mileva Marić, and most assuredly that is why Albert Einstein was attracted to her in the first place.

10 References

- [1] Renn J. & Schulmann R. [Eds.], *Albert Einstein/Mileva Maric: The Love Letters*, Princeton University Press, 2000.
- [2] Stachel J., Cassidy D.C., & Schulmann R., *The Collected Papers of Albert Einstein, Volume 1: The Early Years, 1879-1902*, Princeton University Press, 1987.
- [3] Krstić D., *Mileva & Albert Einstein: their love and scientific collaboration*, Radovljica: Didakta, 2004.
- [4] N. Woolmington, Director, *Einstein's Wife*. [Film]. Australian Broadcasting Corporation (ABC), Melsa Films, & Oregon Public Broadcasting, 2003.
- [5] Pintor R. L. & Gratschew M., *Voter Turnout in Western Europe since 1945: A Regional Report*, International Institute for Democracy and Electoral Assistance (International IDEA), 2004.
- [6] Rosser S. V. [Ed.], *Women, Science, and Myth*, Santa Barbara: ABC-CLIO, 2008.
- [7] Byers N., "Overview on women's education in England and the United States 1600 - 1900," 4th Dec. 1999. [Online]. Available: <http://cwp.library.ucla.edu/articles/WL.html>. [Accessed 8th Mar. 2015].
- [8] Tomczak M., "Mileva Maric, an unfulfilled career in science," [Online]. Available: http://www.es.flinders.edu.au/~mattom/science+society/Mileva_Maric.pdf. [Accessed 5th Mar 2015].
- [9] O'Connor J.J. & Robertson E.F., "Winifred Edgerton Merrill," May 2001. [Online]. Available: <http://www-history.mcs.st-andrews.ac.uk/Biographies/Merrill.html>. [Accessed 7th Mar. 2015].
- [10] Rosser S. V., *The Science Glass Ceiling*, New York: Routledge, 2004.
- [11] Leslie S.J. et al., "Expectations of brilliance underlie gender distributions across academic disciplines," *Science*, vol. 347, pp. 234-235, 2015.
- [12] Isaacson W., *Einstein - His Life and Universe*, London: Simon & Schuster, 2008.
- [13] Stachel J., "The Scientific Relationship of Albert Einstein and Mileva Maric," in *Symposium on Creative Couples and Gender Complementarity: Cross-disciplinary Perspectives*, 1991.
- [14] Highfield R. & Carter P., *The Private Lives of Albert Einstein*, Faber and Faber, 1993.
- [15] Truhovic-Gjuric D., *Mileva Maric-Einstein*, Bern: Haup, 1982.
- [16] Calaprice A. & Lipscombe T., *Albert Einstein: a biography*, Westport: Greenwood Press, 2005.
- [17] Bernstein J. & Gingerich O. (Ed.), *Albert Einstein: And the Frontiers of Physics (Oxford Portraits in Science)*, New York: Oxford University Press, 1995.
- [18] Dukas H & Hoffman B. (Eds.), *Albert Einstein, the Human Side: New Glimpses from His Archives*, Princeton University Press, 1981.
- [19] Stachel J., Cassidy D.C., & Schulmann R. (eds.), "Über die Untersuchung des Aetherzustandes im magnetischen, On the Investigation of the State of the Ether in a Magnetic," in *The Collected Papers of Albert Einstein, Volume 1: The Early Years, 1879-1902*, vol. Vol. 1, Princeton University Press, 1987.
- [20] Popović M. (ed.), *In Albert's Shadow: The Life and Letters of Mileva Maric, Einstein's First Wife*, Johns Hopkins University Press, 2003.
- [21] Schilpp P.A. (Ed. & Trans.), *Albert Einstein, Philosopher-Scientist: The Library of Living Philosophers Volume VII*, Open Court; 3rd editio, 1998.
- [22] "The Nobel Prize in Physics 1905 - Philipp Lenard - Facts," 2014. [Online]. Available: http://www.nobelprize.org/nobel_prizes/physics/laureates/1905/lenard-facts.html. [Accessed 3rd Mar 2015].
- [23] Ohanian H.C., *Einstein's Mistakes: The Human Failings of Genius*, W. W. Norton & Company, 2009.
- [24] Walker E.H., "Ms. Einstein," in *Annual Meeting Abstracts for 1990, 1990*.
- [25] Esterson A., "Articles on MILEVA MARIĆ, FREUD and DARWIN," [Online]. Available: <http://www.esterson.org/>. [Accessed 5th Mar. 2015].
- [26] "Prussian Academy of Sciences," 2015. [Online]. Available: <http://memim.com/prussian-academy-of-sciences.html>. [Accessed 14th March 2015].
- [27] Einstein A., "Folgerungen aus den Kapillaritätserscheinungen, (Conclusions Drawn from the Phenomena of Capillarity)," *Annalen der Physik*, vol. 4, no. (ser. 4), p. 513-523, 1901.
- [28] Getler M., "Einstein's Wife: The Relative Motion of 'Facts'," 15th December 2006. [Online]. Available: http://www.pbs.org/ombudsman/2006/12/einsteins_wife_the_relative_mo.html. [Accessed 14th March 2015].
- [29] Weinstein G., "Did Mileva Marić assist Einstein in writing his 1905 path breaking papers?," arXiv:1204.3551 [physics.hist-ph], 2012.
- [30] Zackheim M., *Einstein's Daughter: The Search for Lieser*, Riverhead, 1999.

- [31] Einstein A., "Thermodynamische Theorie der Potentialdifferenz zwischen Metallen und vollständig dissoziierten Lösungen ihrer Salze, und eine elektrische Methode zur Erforschung der Molekularkräfte, On the Thermodynamic Theory of the Difference in Potentials between Met," *Annalen der Physik*, vol. 8, no. (ser. 4), p. 798–814, April 1902.
- [32] Einstein A., "Kinetische Theorie des Wärme Gleichgewichtes und des zweiten Hauptsatzes der Thermodynamik, Kinetic Theory of Thermal Equilibrium and of the Second Law of Thermodynamics," *Annalen der Physik*, vol. 9, no. (ser. 4), p. 417–433, June 1902.
- [33] "Eine Theorie der Grundlagen der Thermodynamik, A Theory of the Foundations of Thermodynamics," *Annalen der Physik*, vol. 11, no. (ser. 4), p. 170–187, January 1903.
- [34] Einstein A., "Allgemeine molekulare Theorie der Wärme, On the General Molecular Theory of Heat," *Annalen der Physik*, vol. 14, no. (ser. 4), p. 354–362, March 1904.
- [35] Einstein A., *Eine neue Bestimmung der Moleküldimensionen, A New Determination of Molecular Dimensions*, Bern: Buchdruckerei K. J. Wyss, 1905.
- [36] Einstein A., "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt, On a Heuristic Point of View Concerning the Production and Transformation of Light," *Annalen der Physik*, vol. 17, no. (ser. 4), p. 132–148, March 1905.
- [37] "Albert Einstein - Facts," [Online]. Available: http://www.nobelprize.org/nobel_prizes/physics/laureates/1921/einstein-facts.html. [Accessed 3rd Mar. 2015].
- [38] Einstein A., "Über die von der molekular kinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen, On the Movement of Small Particles Suspended in Stationary Liquids Required by the Molecular-Kinetic Theory of Heat," *Annalen der Physik*, vol. 17, no. (ser. 4), p. 549–560, 1905.
- [39] Einstein A., "Zur Elektrodynamik bewegter Körper, (On the Electrodynamics of Moving Bodies)," *Annalen der Physik*, vol. 17, no. (ser. 4), p. 891–921, 1905.
- [40] Stachel J., Cassidy D.C., Renn J., & Schulmann R. (Eds.), *The Collected Papers of Albert Einstein, Volume 2: The Swiss Years: Writings, 1900-1909.*, Princeton University Press, 1990.
- [41] Truhović-Gjurić D., *Im Schatten Albert Einsteins. Das tragische Leben der Mileva Einstein-Marić*, In the Shadow of Albert Einstein: The Tragic Life of Mileva Einstein-Marić, 1969.
- [42] Auffray J.P., "Dual origin of $E=mc^2$," arXiv:physics/0608289 [physics.gen-ph].
- [43] Sauer T., "Marcel Grossmann and his contribution to the general theory of relativity," arXiv:1312.4068 [physics.hist-ph], 2013.
- [44] Clark R.W., *Einstein: The Life and Times*, New York: Avon Books, 1971.
- [45] Hentschel A.M. (Trans.) & Hentschel K. (Cons.), *Volume 8: The Berlin Years: Correspondence, 1914-1918 (English translation supplement)*, Princeton University Press, 1998.
- [46] Rose H., *Love, Power, and Knowledge: Towards a Feminist Transformation of the Sciences*, Indiana University Press, 1994.
- [47] Walker E.H., "Walker writer a length piece entitled, Did Einstein Espouse His Spouse's Ideas," *Physics World*, p. 9, February 1989.
- [48] Walker E.H., "Mileva Marić's Relativistic Role," *Physics World*, vol. 44, no. 2, p. 122, 1991.
- [49] Troemel-Ploetz S., "Mileva Einstein-Marić: The woman who did Einstein's mathematics," *Index on Censorship - Breaking The Silence*, vol. 19, no. 9, pp. 33-36, 1990.
- [50] Chiu C.S. & Borchardt E., *Women in the Shadows: Mileva Einstein-Marić, Margarete Jeanne Trakl, Lise Meitner, Milena Jesenska, and Margarete Schuette-Lihotzk*, Peter Lang Publishing Inc, 2008.
- [51] Martínez A.A., *Science Secrets: The Truth about Darwin's Finches, Einstein's Wife, and Other Myths*, Pittsburgh: University of Pittsburgh Press, 2011.
- [52] "Collins English Dictionary - 9th Revised edition," 2007.
- [53] "Policy for Authorship on Scientific and Scholarly Publications," 15th Dec. 2009. [Online]. Available: <http://wustl.edu/policies/authorship.html>. [Accessed 8th Mar. 2015].
- [54] Martínez A.A., "Arguing with Einstein's wife," 10th April 2004. [Online]. Available: <http://physicsworld.com/cws/article/print/2004/apr/10/arguing-about-einsteins-wife>. [Accessed 14th March 2015].
- [55] "Marie Curie - Biographical," [Online]. Available: http://www.nobelprize.org/nobel_prizes/physics/laureates/1903/marie-curie-bio.html. [Accessed 9th March 2014].
- [56] Gieryn, T. F., ed., *Science and Social Structure: A Festschrift for Robert K. Merton (New York Academy of Science Transactions)*, Mishawaka, USA.: Better World Books, 1980.
- [57] Kennedy H.C., "Who Discovered Boyer's Law?," *The American Mathematical Monthly*, vol. 79, pp. 66-67, Jan. 1972.
- [58] Thorburn W.M., "Occam's razor," *Mind* vol. 24, p. 287—288, 1915.