

MS EINSTEIN.

Evan Harris Walker

(The Walker Cancer Research Institute, Inc.)

ABSTRACT

What stimulus and what fundamental picture of reality led to the incredible discovery of relativity that catapulted an obscure patent examiner to the highest pinnacle of twentieth century science. Einstein's explanations of its origin have always seemed to leave gaps. More mysterious is the enigmatic figure of his first wife, Mileva Einstein-Marić, a woman of equal education and ambition, a woman who shared his dreams and abilities. Efforts to trace the origins of key source material relevant to the theory place Mileva Marić in the middle of that path. The letters Albert Einstein wrote Mileva Marić show that he regarded her as his collaborator in their joint research. One in three of his letters to her during the development of the theory make reference to this collaboration. We find statements like "I find the collaboration very good", " We will start immediately with Helmholtz's electromagnetic theory", " You must now continue with your investigation", " Professor Weber is very nice to me... I gave him our paper ", and "How happy and proud I will be when the two of us together will have brought our work on the relative motion [the theory of relativity] to a victorious conclusion!" We will examine new material to determine the role Mileva Marić played as the senior partner in this collaboration. It now seems reasonable to conclude from Einstein's own statements that Mileva Einstein-Marić should be recognised as coauthor of the theory of relativity. Supporting this claim Abraham Joffe states he saw the original 1905 manuscripts. They were by-lined "Einstein-Marić".

INTRODUCTION

The essential concepts that inspire theoretical physicists generally assume physical reality to be comprehensible in terms of a fairly limited set of fundamental propositions. Knowing these, we believe that we can develop the basic equations that represent observable phenomena. As a result, we pay particular attention to the ideas that have inspired basic advances in our knowledge of the world, believing that a clear conception of these ideas is essential to a full understanding of physical reality, and also that such a clear conception of the origins of such theories may reveal the path to new concepts, new theories, and an improved fit between our basic equations and experimental findings.

It is for such reasons that the theory of relativity has been so closely examined. Probably no theory has been the subject of such thorough scrutiny. Yet despite that scrutiny, that careful sifting of the facts of its beginnings, none has been quite so elusive as to its origins. Despite all this examination, many physicists still feel that the basic ideas are not in evidence. The equations are clear. The derivations straightforward. But over and over we examine the statements of Albert Einstein as to the basic concepts only to feel that something is missing -- something that would more comfortably tie it into the history of physics, something that would tell us that this or that idea was the one compelling starting point from which all the rest began. The fact that this issue remains a concern among physicists, as evidenced by such investigations as John Stachel's *Physics Today* article attempting to explain puzzling aspects of the theory's origins (May 1987, pp 45-47), gives testimony that something is missing.

Clark, in his massive biography *Einstein: The Life and Times* (World Publishing Co., 1971, pg 74), states, "Today, two-thirds of a century after Einstein posted the manuscript of his paper to *Annalen der Physik*, the dust is still stirred by discussion of what inspired him . . . and by the sometimes contradictory evidence of the paper's genesis." So much of what Einstein gives us as glimpses of his inspiration, on reflection do not seem to be the cues to discovery that should have led him to the theory of relativity. His oft quoted 1895 thought experiment in which he tries to imagine what he would see if he were able to follow a beam of light at its own velocity through space -- if he were able to travel beside the beam of light traveling toward the Great Clock Tower in Bern -- evidences the problem. His thought experiment should have simply had him observing a standing wave if -- if, that is he knew nothing of the remarkable findings of the Michelson-Morley experiment.

The matter becomes even stranger when we read Yoshimasa A. Ono's translation of a 1923 publication by the Japanese physicist, Jun Ishiwara, titled "How I created the theory of Relativity" (*Physics Today*, August 1982, pg 45). What is striking in this article, as A. I. Miller tells us in his May 1987 *Physics Today* letter (pp 9-13), is that in this Kyoto lecture Einstein omits his "oft repeated stress on such key elements of his

thinking toward the special theory of relativity as the symmetries in electromagnetic induction, stellar aberration and his 1895 though experiment of pursuing a beam of light. Instead this passage emphasizes the Michelson-Morley experiment, despite the fact that without exception and from early days to the end, a crucial connection of this sort is not born out by any of the many consistent firsthand accounts Einstein himself gave of this experiment."

The problem becomes even more perplexing when we read Stachel's evidence that Einstein had had access to the critical information about the Michelson-Morley experiment, evidence found in references to technical matters in the correspondence with his first wife, Mileva Marić. Why, throughout his life, does he seem to have so little memory of the Michelson-Morley experiment playing the important role it so surely must have played, and yet in faraway Kyoto, he remembered this connection?

I find I must ask myself the question, "Why do these inconsistencies recur? Is there more to the story? Is there something more basic to be discovered?"

MILEVA MARIĆ

There are other puzzles. There is the fascinating enigma of Mileva Marić, Albert Einstein's first wife. To Einstein's biographers she is made to be so little of nothing that the wonder is that Albert Einstein would have found anything about her to have interested him. Clark gives little more than demeaning glimpses, "This carefree... existence [Einstein had been living] was drastically changed when in January, 1903 Einstein married Mileva Marić. The daughter of a Slav peasant, four years his senior...her dreamy, ponderous nature often curdled her life and her studies. Her contemporaries found Mileva a gloomy, laconic, and distrustful character... hardly the typical Swiss-German house-sprite, the height of whose ambition is a constant war against dust, moths, and dirt... Mileva had the unpardonable Slav tendency to let things slip."

Clark tells us that "the men and women against whom [Einstein] was brushed by the chances of everyday life, were only too ready to admit that relativity was beyond them... with Mileva the situation was different, for was she not a physicist like her husband? Had she not, in fact got just enough 'little learning' to enter the new world he had created if only he would spare the time to explain things? The answer was 'No,' but she would never believe it."

But is this an accurate picture of Mileva Marić? Is it even a believable representation of her? And what of this "little learning" Clark speaks

of? As it happens, Mileva received essentially the same education in physics that Albert received. Both took and completed the same course work at the Swiss Federal Polytechnic Institute (Eidgenössische Polytechnische Schule or ETH) in Zurich -- with the exception of one significant term, 1897-8, during which Mileva studied under prof. Lenard at Heidelberg. It was Lenard who did the experimental research that provided the data on the photoelectric effect for which Albert Einstein would receive the Nobel Prize twenty-five years later. Prof. Lenard received the Nobel Prize for 1905. It was also at Heidelberg that Mileva would have had the chance to learn about the Michelson experiment from professors who had been there when Michelson visited in the early 1880's. Although at times Albert and Mileva both did well at the ETH, Albert failed his first try at the entrance exams for the ETH [1]. In March 1899 he received the "director's reprimand for nondiligence in physics practicum (laboratory). In 1900 he was allowed to graduate with the slightly sub-borderline grade of 4.91 [2]. In 1902 Albert had to withdraw his doctoral thesis. He received his doctorate in 1905. Mileva did not pass in 1900, having received judgementally lower grades on several courses to result in an overall 4.00 average. Mileva's failing grade resulted from her marks on two courses where she received significantly lower grades than Albert. One was in Funktionentheorie -- despite the fact that in later years it is known that she was the one Albert called on to help him in his problems in this area. The other was in Diplomarbeit -- due largely to some sort of personality conflict she encountered working with Prof. Weber. Both Mileva and Albert had checkered academic records, but we must remember that both had significant prejudice to overcome, not the least of which was the great prejudice against women in academia at that time. In Germany, for example women generally could not even enter the universities to receive an advanced degree. The difficulties and prejudices of the time for any woman suggest that any woman going as far as she did, doing as well as she did, must have been exceptional. Even today there are few women who go into physics. At the time Mileva entered the ETH there had only been one woman per decade to enter physics there. Contrary to Clark, Mileva had had much more than some 'little learning.' She had her full equal share with Albert, and between them they had enough to overturn the world of science.

But it is not until we read the letters between Albert Einstein and Mileva Marić written at the time that the theory of relativity was under development, that we understand the extent to which the great Einstein papers of 1905 owe their existence not just to Albert but to Mileva Marić as well. Only recently, with the publication at long last of their letters in The Collected Papers of Albert Einstein by Princeton University Press, with John Stachel as editor, have we had the opportunity to discover that this great work was the result of a marvelous collaboration.

One of the most direct statements addressed to the question is to be found in Document 94 in The Collected Works of Albert Einstein. There, in

a letter written by Albert Einstein to his then-fiancée, Mileva Marić, on March 27, 1901, we find the statement, "How happy and proud I will be when the two of us together will have brought our work on the relative motion to a victorious conclusion!" The statement is clear and leaves little to the imagination. In the February 1989 issue of *Physics Today* I stated that "For me this statement is the proof of something I had suspected ever since Ronald Clark's *Einstein: The Life and Times* appeared in 1971." I pointed out that with the educational background she had obtained at such a price as women at that time had to pay, "I cannot help but see Mileva and Albert Einstein working as a team, hoping together to achieve the kind of husband-and-wife recognition that had come to Marie and Pierre Curie." I pointed out that "Mileva Einstein and Marie Curie were in fact good friends, sufficiently close that the two families went on holiday together in the Swiss Alps." (This was in 1913, some years after the death of Pierre Curie.) I added, "I cannot imagine these ... people together, considering Mileva's own drive to obtain an education in physics, without the idea of some shared fame [with Albert] coming to her mind."

If Mileva had entertained such an idea, however, there is one obstacle that could not have been easily overcome. One cannot watch theoretical physics the way one could see the two Curies year after year at work on the chemical separation of radium from tons of pitchblende. Besides, with Albert's career already in peril, Mileva undoubtedly would have seen the wisdom of building the reputation of her husband at her own expense, if need be, so that he could obtain a university post. But, I noted there, once he obtained such a post and such recognition, the lack of that shared dream could have come home to strain their marriage.

Albert Einstein and Mileva finally separated in the summer of 1914. Their years together saw Einstein's greatest achievements: His physics was filled with daring concepts of space and time distorted, of gravitation being only a distortion of the space-time metric, of photons that truly were packets of energy -- not just a mathematical device, as Max Planck thought, but a reality. And his work was filled with the immediate implications of the most recent and detailed findings of the current physics. But after his marriage to Mileva ended, his physics became more conservative. He added the cosmological constant to his equations so they would predict the physics everyone expected for the universe, and as a consequence missed predicting the Big Bang. He became not the leader of avant-garde physicists, but in time the odd man out in his position against the new quantum mechanics. But more than all of this, he seemed never to be able to enjoy his own success the way other physicists have theirs. He spent the rest of his life working almost as if he had to prove himself. I cannot help but feel that the background material, the literature searches, the critical data and, most importantly, those most basic capricious ideas that were the turning points of relativity theory came from Mileva, while much of the overall formalism of the theory was set up by Albert. The mathematics and the proofs were probably shared.

When they separated, perhaps, there was nothing more she could do with whatever ideas still haunted her mind. And Albert, for all his ability, came to depend on continually sifting through all the old ideas, forever searching for originality to come out of slight changes in his equations.

In February 1919 the marriage of Albert and Mileva ended in an "amiable" divorce. Mileva received custody of the children, child support and alimony. And in an added clause of the divorce decree, Albert Einstein agreed to pay Mileva every krona of any future Nobel Prize he might be awarded. He could keep the glory, but she had the prize. It seems to me that to Mileva, justly or unjustly, she saw this as her proper reward for the part she had played in developing the theory of relativity and the theory of the photoelectric effect.

EVIDENCE

This kind of opinion, this statement of my own suspicions was at least adequate to open an investigation of the question of Mileva Marić's contribution to the theory of relativity, but it was of course not a definitive handling of the question. It was only a first statement of the question. In the April 1988 issue of Physics Today (pg 124) K. Suchy had commented on Albert Einstein's statement to Mileva in the letter mentioned earlier, "How happy and proud I will be when the two of us together will have brought our work on relative motion to a successful conclusion." John Stachel wrote in his "Einstein and the Ether Drift Experiments" (Physics Today, May 1987, pg 45), "this comment raises the intriguing question of the nature of Marić's role in their collaboration." These statements were the opening door that I needed for my letter to Physics Today proposing that we consider seriously the possibility that Mileva Marić had made significant contributions to the development of the theory of relativity, and perhaps to Einstein's other early works. That letter, published in the February 1989 issue of Physics Today, did not, however, deal with the many questions needed to prove such contentions. Since my brief letter in Physics Today did not give me the opportunity to point out any of the detailed evidence, John Stachel, who was asked by the editor of Physics Today to rebut my letter, was in a position to take strong exception to my thesis. He stated:

To rescue Einstein-Marić [her name by Swiss custom after her marriage] from the obscurity to which she has been consigned so long and unjustly, it is not necessary to deprecate Einstein's intellectual abilities. Rather, one must try to understand the role of each in the other's life on the basis of a careful study of all the available evidence, taking into account all relevant factors in their relationship, including its psychological, sociological and intel-

lectual aspects.

These, of course are fine sentiments, but sentiments that Stachel has not taken the least effort to fulfill, nor has anyone else till recently. Stachel added:

Einstein certainly will not emerge from such scrutiny as a plaster saint, but there is no evidence to indicate that he will emerge as an intellectual plagiarist. On the basis of their early correspondence, I think it is clear that she played a crucial role in his emotional life -- as he did in hers. But up to now, at least, there has been no evidence that she played a similarly crucial role in his intellectual development or scientific accomplishments.

Indeed, there is at least one significant piece of contrary evidence. Aside from one comment on a course she took [note the course Stachel refers to here is that most significant course she took from Lenard at Heidelberg], none of Marić's letters to Einstein touches on any substantive point in physics, while his to her are chock-full of substantive comments on books and articles on physics he has read, as well as on his own theoretical ideas and experimental proposals. It is true that only ten of Marić's letters to Einstein have come to light, compared with 43 of his. But one could not select ten of Einstein's letters to Marić that would be as devoid of references to physics as are hers to him.

In this Stachel is entirely wrong. Eleven of Albert Einstein's letters to Mileva have no reference to science at all (see Documents 40, 41, 43, 68, 70, 72, 73, 106, 134, and 137 as listed in The Collected Papers of Albert Einstein, Vol. 1). Another eight letters (Documents 45, 50, 69, 107, 112, 114, 119, and 126) have only a single brief reference to science in each. These include statements like "My broodings about radiation are starting to get on somewhat firmer ground" in Document 45, and in Document 50, "When I was reading Helmholtz for the first time, it seemed inconceivable that you are not with me." These are references that are no longer than can be found in four of Mileva's ten letters to him (Documents 36, 53, 123, and 124) which includes the statement:

Oh, it was really neat at the lecture of Prof. Lenard yesterday, he is talking now about the kinetic theory of heat of gases; so, it turned out that the molecules of O move with a velocity of over 400 m per second, then the good Prof. calculated, set up eq., differen., integrated, substituted and it finally turned out that even though mole-

cules do move with this velocity, they travel a distance of only 1/100 of a hairbreath. (Document 36)

These facts mean that we cannot judge Mileva's contribution based on the very limited number of her letters that have survived [3]. Instead we must examine Einstein's letters to her in order to determine what her letters likely contained, and what her contribution was. It happens that we can tell by looking at his responses to her letters that many of her lost letters make reference to her scientific work, to her comments on science, and to their collaborative efforts. I find statements in thirteen of his 43 letters to her where reference is made to her research or to an ongoing collaborative effort. These include the following:

Document 50 - Meanwhile, I have already studied quite a bit of Helmholtz ... out of fear of you & also for my own pleasure, let me immediately add that I will reread the whole stuff with you. When I was reading Helmholtz for the first time it seemed inconceivable that you are not with me & now its not much better. I find the collaboration very good & curative...

Document 57 - And we will start immediately with Helmholtz's electromagnetic theory of light, which 1) out of fear 2) because I did not have it, I still have not read.

Document 74 - For the investigation of the Thomson effect I have again resorted to another method, which has some similarities with yours for the determination of the dependence of k on T & which indeed presupposes such an investigation. If only we could already start tomorrow.

Document 75 - I am also looking forward very much to our new work (Arbeiten). You must now continue with your investigation.

Document 79 - Michele has already noticed that I like you, because, even though I didn't tell him almost anything about you, he said, when I told him that I must go to Zurich again: "He surely wants to go to his (woman) colleague, what else would draw him to Zurich?" I replied, "But unfortunately she is not yet there." ...When we [Albert and Mileva] come to Zurich, we shall seek to get empirical material on the subject through Kleiner. If a law of nature emerges from this, we will send it to Wiedermann's Annalen. [4]

Document 93 - However, compounds of great "internal" energy

do show band-like absorption spectra. What is the story with the specific heat of glass considering its composition. It would have to have a small molecular heat, compared with its molecular number. See whether you can find something about that!...One kisses equally well as a little doctor and professor. Did you also send a paper to Wenger?

Document 94 - How happy and proud I will be when the two of us together will have brought our work on the relative motion [the theory of relativity] to a victorious conclusion!

Document 96 - Michele arrived with wife and child from Trieste the day before yesterday. ... Yesterday evening I talked shop with him with great interest for almost 4 hours. We talked about the fundamental separation of luminiferous ether and matter, the definition of absolute rest, molecular forces, surface phenomena, dissociation. He is very interested in our investigations...

Document 101 - As for science, I've got an extremely lucky idea, which will make it possible to apply our theory of molecular forces to gases as well.

Document 102 - 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. ... I am very curious whether our conservative molecular forces will hold good for gases as well. We shall get quite a precise test of our view. (This work was published in Annalen der Physik 4 (1901) with the title "Folgerungen aus den Capillaritätsercheinungen" under Albert's name only).

Document 107 - The local Prof. Weber is very nice to me... I gave him our paper.

Document 111 - Imagine how lovely it will be when we will again be able to work together totally undisturbed ... You will be amply compensated...Weber also once did theoretical work on the motion of heat in metal cylinders. See whether you couldn't somehow use the table on this basis...

Document 127 - From this it follows, according to our theory of molecular forces, that there must exist an approximate proportionality between our constants Σc_a and the molecular volumes of the liquids.

In these letters Albert seems to be quite consistent in referring to

"our" theory whenever he discusses either the theory of molecular forces or the work on relative motion. Such references to "our" work do not seem to occur where Albert discusses other scientific ideas. These two theories, at least, appear to have been collaborative efforts.

It might also be mentioned that at least during this period of his life Albert never discusses any scientific matters in his letters to other women. His letters to Marie Winteler, Rosa Winteler and Julia Niggi, for example contain nothing in the way of treatises on technical matters. Nor is there such material in his letters to people like Helene Kaufler, Otto Wiener, Wilhelm Ostwald, or even in his correspondence with Conrad Habicht. There is only an oblique reference to scientific matters in his correspondence with his long time friend Jost Winteler, concerning the fact that he had had a controversy with some German professors. Even here there is no mention of the scientific nature of the controversy. Only in his correspondence with Marcel Grossmann, with whom he later coauthored his first paper on the general theory of relativity do we find him sharing his scientific ideas in a letter -- and then it is only one short paragraph. In none of these letters do we find Albert Einstein ever making any reference to "our" work or to a collaboration with any one.

Stachel's Physics Today rebuttal to my letter published on the Mileva Marić controversy, also takes exception to my statement that "their years together saw Einstein's greatest achievements..." In his rebuttal Stachel abbreviated this quote so as to divert attention from the main point of my statement which was not that Einstein made no further contributions, but that his physics after that time was no longer "filled with daring concepts." This is a well known fact to most physicists, yet Stachel argued that "about a year after his separation ... Einstein surmounted the major conceptual difficulties that had prevented him for two years from completing the general theory of relativity ..." adding that "within about two years of the separation, he made one of his major contributions to the quantum theory by introducing the concept of transition probabilities between quantum states." But in both cases we are dealing with the completion of work already well developed. Einstein's 1915 paper on general relativity was presaged by work on the general theory as early as 1907 (see Hoffman's Albert Einstein, Creator and Rebel, Viking Press, N.Y. pg 109). By 1911 (pg 111) the deflection of starlight by the sun had been calculated. In 1912 the Einsteins returned to Zurich where their old friend Marcel Grossmann began helping to formulate general relativity in terms of tensor calculus. By 1914, experimenters were already looking for the predicted deflection of starlight. On April 6, 1914 Einstein moved with his family to Berlin (Clark, pg 173) as the director of the Kaiser Wilhelm Institute for Physics, with a professorship at the University of Berlin and a chair in the academy of Sciences. There he completed the 1915 paper on the general theory. Mileva left Berlin for Zurich in the summer of 1914. "Erklärung der Perihelbewegung des Merkur aus der allgemeinen Rela-

tivitätstheorie" was published in 1915; "Die Grundlage der allgemeinen Relativitätstheorie" was printed in Annalen der Physik in 1916. Similarly, the work in transition probabilities goes back to the time when Mileva and Albert were working together.

But again I should perhaps emphasize that I have only argued that Mileva's presence during this time aided materially the formulation and development of these works, not that any of these later works should be considered hers. That the character of his work changed after their separation is a fact that has long been noted by the scientific community, even though the absence of Mileva as such has not been cited as the cause of this change.

Stachel has also taken considerable exception to my statement that Einstein "pursued his interest in relativity for years with no knowledge of the Michelson-Morley experiment or (until quite late [relative to the publication date of the special theory]) of the work Hendrik A. Lorentz had done." It is hardly surprising that he would have taken exception to this, since it is the whole purpose of Stachel's Physics Today article (May 1987, pp 45-47) to show that these early letters between Einstein and Marić disprove Einstein's own statements to the contrary. In The Collected Papers of Albert Einstein, Vol. 1 pg 330, Footnote 4, we have Einstein's statement to Carl Seelig of February 19, 1955 that when he wrote "Zur Elektrodynamik bewegter Körper" in 1905, he knew "nur Lorentz bedeutendes Werk von 1895, aber nicht Lorentz' spätere Arbeit." On this subject Clark (pp 96-97) gives us the following:

"When I asked him how he had learned of the Michelson-Morley experiment," says R. S. Shankland, who visited Einstein on February 4, 1950, from the Case Institute of Technology, while preparing a historical account of the experiment, "he told me he had become aware of it through the writings of H. A. Lorentz, but only after 1905 had it come to his attention ... Yet when Shankland again visited Princeton on October 24, 1952, Einstein was not so certain. "This is not so easy," Shankland quotes him as saying. "I am not sure when I first heard of the Michelson experiment. I was not conscious that it had influenced me directly during the seven years that relativity had been my life. I guess I just took it for granted that it was true." He then realized (so he told me) that he had also been conscious of Michelson's result before 1905 partly through his reading of the papers of Lorentz and more because he had assumed this result of Michelson to be true.

In 1954, for Michael Polanyi's The Art of Knowing, Einstein approved the statement that "the Michelson-Morley experiment had a negligible effect

on the discovery of relativity." A supplementary note written by a former professor of mine, Dr.N. Balazs, who was working with Einstein in Princeton in the summer of 1953, and who questioned him on the subject for Polanyi, gives us this insight:

The Michelson-Morley experiment had no role in the foundation of the theory. He got acquainted with it while reading Lorentz' paper about the theory of this experiment (he, of course, does not remember exactly when, though prior to his paper), but it had no further influence on Einstein's consideration and the theory of relativity was not founded to explain its outcome at all.

Here, clearly, Einstein professes only the vaguest of contacts with these ideas that would appear to be crucial to the development of the special theory of relativity. And yet I must wonder first how Einstein could have derived the theory in the form in which we have it (1) without any knowledge of the Michelson-Morley experiment and (2) without Lorentz' expression for the transformation laws from the beginning. The derivation of the transformation laws that are given in the 1905 Einstein paper begin with a concept that is in some ways a schematic for the Michelson-Morley experiment. The calculation follows what one would do to determine the essential relationship between the reference frames and the light radiation in the two coordinate systems along the parallel and perpendicular directions. This immediately gives us the Lorentz transformations - and some such confirmation would have been vital to have served as the basis for the rest of the derivations needed to complete the 1905 paper. It is hard to imagine that such a basis for the work did not exist, and even more difficult to imagine that Einstein would not have remembered distinctly when and where he first saw that this incredibly simple derivation yielded the Lorentz transformations. All this becomes much easier to understand if it were Mileva who had acquired these important pieces of information, or brought these facts into play at the right time.

The purpose of Stachel's Physics Today article is to resolve exactly this peculiar puzzle, a paradox examined over and over by Albert Einstein's many biographers. Stachel cites the correspondence between Albert Einstein and Mileva Marić to prove that Einstein probably knew of the Michelson-Morley work as early as 1899 and of the earlier Lorentz work by the end of 1901. But a careful reading of these letters shows only that Marić and Einstein between them likely knew of these works. Stachel writes (Physics Today, May 1987, pg 45), "While there is no mention of Albert A. Michelson in any of the letters in Volume 1 ... there is strong indirect evidence. Einstein's first comments on the subject... appear in a remarkable letter" to Mileva Marić dated August 1899 (Document 52):

I returned the Helmholtz volume and am at present studying

in depth Hertz's propagation of electric force. The reason for it was that [I] didn't understand Helmholtz's treatise on the principle of least action in electrodynamics. I am more and more convinced that the electrodynamics of moving bodies, as presented today is not correct, and that it should be possible to present it in a simpler way. The introduction of the term "ether" into the theories of electricity led to the notion of a medium of whose motion one can speak without being able, I believe, to associate a physical meaning with this statement. I think that the electric forces can be directly defined only for empty space, [which is] also emphasized by Hertz. ... Electrodynamics would then be the theory of the motion of moving electricities and magnetisms in empty space.

There are several points to make about this excerpt. First, why did Albert mention that he had returned the Helmholtz volume? The answer is to be found in his prior August 1899 letter (Document 50), in which he says, "I have already studied quite a bit of Helmholtz...out of fear of you." Mileva and Albert had a continuing practice of extensively sharing their physics texts with each other. Stachel makes a point of how the above passage (from Document 52) seems similar to those of Lorentz. He states that there is no mention of Lorentz in any surviving letter of Einstein's until December 1901 when Albert states that he intends to study what Lorentz and Paul Drude have written on the subject." But we hear of Drude much earlier. In a note to Mileva of April 16, 1898 (Document 41), Albert says, "I found the apartment locked and nobody home...I beg you therefore not to be angry with me for abducting Drude in my hour of need, so as to be able to study a little." This is Drude's 1894 *Physik des Aethers auf electromagnetische Grundlage*. On September 10, 1899 he writes to her (Document 54), "I can have the municipal library send me books by Helmholtz, Boltzmann & Mach ... I give you my solemn promise that I'll go over everything with you." On April 15, 1901 he writes to Mileva asking her "Could you send me Kirchoff's Heat?"

All of this points to the conclusion that the two were closely sharing the available material, and even suggests that Marić selected some of the material that Einstein reviewed. All of the references to material in The Collected Papers of Albert Einstein that Stachel quotes to show that Einstein should have known of the Michelson-Morley experiment and been familiar with Lorentz's work, references to Wien, Lorentz, Drude and Hertz, are taken from his letters to Mileva Marić, and not from any of the other 99 documents in The Collected Papers of Albert Einstein. The fact that we now know that Mileva and Albert between them had available the crucial information about the Michelson-Morley experiment and information about Lorentz's work taken together with the fact that Einstein later professed little knowledge of these sources, suggests strongly the conclusion that

it was Mileva who brought the salient facts to the task of creating the theory of relativity. If it had been Mileva who showed Albert these facts about the Michelson-Morley experimental results at the inception of the work, his later vagueness on the source of something otherwise so crucial would be understandable. We could then easily understand his statement to Shankland, "I am not sure when I first heard of the Michelson experiment. I was not conscious that it had influenced me directly..." for the influence would not have been direct. It would seem reasonable, therefore, to postulate that Mileva Marić was the source of the crucial pieces of information about the Michelson-Morley experiment, that through her influence the ideas inherent in that experiment guided the derivation of the transformation laws and that information from her concerning the Lorentz expressions for the transformation laws helped assure Einstein that they were on the correct path.

If so, then it would seem Mileva Marić deserved to be a coauthor, and her name should have appeared on the original 1905 paper "Zur Elektrodynamik bewegter Körper" in Annalen der Physik. And in fact it did. Subsequent to the appearance of my letter in the February 1989 issue of Physics Today, I received a letter from Dr. Troemel-Ploetz of the Franklin and Marshall College German Language Department pointing out the following statement in one of the references cited by the editors of The Collected Papers of Albert Einstein (pg 405), the biography of Mileva Einstein, titled: Im Schatten Albert Einsteins: Das tragische Leben der Mileva Einstein-Marić by Desanka Truhović-Gjurić (Paul Haupt Berne, Bern Switzerland, 1988,). Translated from the German, the passage reads:

The outstanding Russian physicist Abraham F. Joffe (1880-1960), director of the Applied Physics Institute, later the Institute for Semiconductors in the Academy of Sciences of the USSR, called attention to the fact in his "Remembrances of Albert Einstein" that Einstein's three epoch making articles of 1905 were marked in the original "Einstein-Marić. Joffe as an assistant to Röntgen, who belonged to the board of trustees of the Annalen, had seen the originals that the editor had forwarded for review. To this work Röntgen pulled in his summa cum laude student Joffe who had the opportunity thereby to see the manuscripts that are no longer available today. (pg 97)

Joffe's credentials are such that his assertion alone would seem to be sufficient testimony to establish a claim for Mileva Marić. That claim is enormously strengthened by Einstein's own statements to the same effect made in his letters to her. Nevertheless, there remains a certain doubt. Is it not just possible that Joffe simply did not remember accurately what he had seen on that manuscript so many years earlier?

There is a subtle but most significant piece of evidence in Joffe's statement as found in his original "Remembrances of Albert Einstein." There Joffe uses the name "Эйнштейн-Марити", that is, in Latin letters, Einstein-Marity. Supprisingly, he does not use the Russian Cyrillic form of her maiden name, "Маритч" as he should have were he transliterating her name from her native Serbo-Cyrilic, where it has the form "Маритѣ", the form in which Mileva herself used her name when she lived in Serbia. Nor is this the form he should have given had he been transliterating from the Croatian, "Marić", which is the form of her name used on her Swiss records, in all Western biographies and references on the subject, and even in the biography by her fellow countryman, Desanka Trbuhović-Gjurić. However, in the Trbuhović-Gjurić biography of Mileva Marić, there are three plates in the book that reproduce her name as she used it herself in Switzerland after her marriage: "Einstein-Marity". This is a Hungarian-ized form of her name. It is the form of her name that appears on her tombstone in Zurich. It is also how she signed her name on her marriage certificate in 1903. If Joffe remembered that form of her name, it would have had to be because he had seen something that Mileva had signed herself, something that she signed "Einstein-Marity", that became in the Russian "Эйнштейн-Марити". This, taken with all the rest, is compelling evidence that Joffe did see the original 1905 papers, and that the name there was "Einstein-Marity"!

Clark tells us that in 1943 the Book and Author Committee of the Fourth War Loan drive asked Albert Einstein to donate his original paper of 1905 to be sold to support the war effort. Since Einstein no longer had the original, he made a hand written copy on which he wrote, "The following pages are a copy of my first paper concerning the theory of relativity. I made this copy in November 1943. The original manuscript not [sic] longer exists having been discarded by me after its publication." (pg 570)

CONCLUSIONS

What have we proved? Considering only the firsthand statements made by Albert Einstein himself, there is sufficient evidence to prove that by today's standards Mileva Marić should be accorded coauthorship. Whatever the customs at the turn of the century, by today's standards one does not enter into a scientific collaboration over a period of time that encompasses the full development of the work, acknowledging the benefits of that collaboration (Document 50), using the products of that person's efforts (Document 74), encouraging continuing collaboration (Document 94), while making promises that "you will be amply compensated" (Document 111) without including that individual as a coauthor. There is reason to speculate that Mileva's contribution was even greater than this. There is reason to believe that hers could have been the primary contribution.

That remains an open question. But Einstein's words alone show us that Mileva Marić was coauthor of the special theory of relativity.

Where does all this take us? When I started, I said, "we pay particular attention to the ideas that have inspired basic advances in our knowledge of the world, believing that...a clear conception of the origins of such theories may reveal the path to new concepts, new theories." What future concepts might the vantage of Mileva Einstein-Marić lend to present efforts to understand nature? It would seem that our present situation in physics is so removed from the situation during her time with Albert that there would be little of bearing to be found there. But physics still finds itself much further from a fully satisfactory formulation of natural laws than we might wish to acknowledge. On several of the most basic issues, physics has been at a standstill for a long time - in particular, the problem of the synthesis of general relativity and quantum mechanics. In her biography of Mileva, Desanka Trbuhović-Gjurić tells us that Mileva, speaking of her time, felt that "physics had come to a recognizable standstill." [pg 127] In this regard Mileva was particularly interested in the question, "What happens really in a space in which forces are effective, and how is it possible [in view of this] for the matter in the human brain to think and feel?" [pg 128] It is a curious blending of ideas, a blending that has something in common with some current ideas about physics, ideas in which some have felt that a resolution of the deepest questions in physics cannot be achieved without coming to grips with the problem of the nature of mind and consciousness.

Footnotes

1. Einstein subsequently obtained a diploma after a year at the Swiss Cantonal School of Aargau. This made him eligible for entrance to the ETH without having to pass the entrance examinations.
2. Marks below 5.00 were probably customarily below the passing grade. I have a photostatic copy of the grades for July 26, 1901 showing that the grades of 4.65 and 4.75 were failing grades; only grades of 5.00 or higher were passing.
3. I find eighteen clear references in Einstein's letters to Marić that refer to recent letters from her. Fifteen of these references carry dates such that they could not have been one of the ten letters from Mileva that we now have. Judging by Albert's four complaints when he has not received a letter from Mileva after such a short period as four or even three days (Documents 58 - "It's already the 4th day...[and she] has not uttered a single word..." Document 126 - "Three days have passed without my having received a letter...") her custom must have been to write him about as frequently as he wrote to her rather than the paucity that ten letters in many months of separation over the five year period involved might otherwise suggest.
4. The first two sentences are included to make clear that the "we" refers to Mileva and Albert, not Michele and Albert.

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