

Saint John's University, Collegeville, MN, March 29, 2005:

Einstein: The Sage of Princeton versus the Scientist as a Young Man

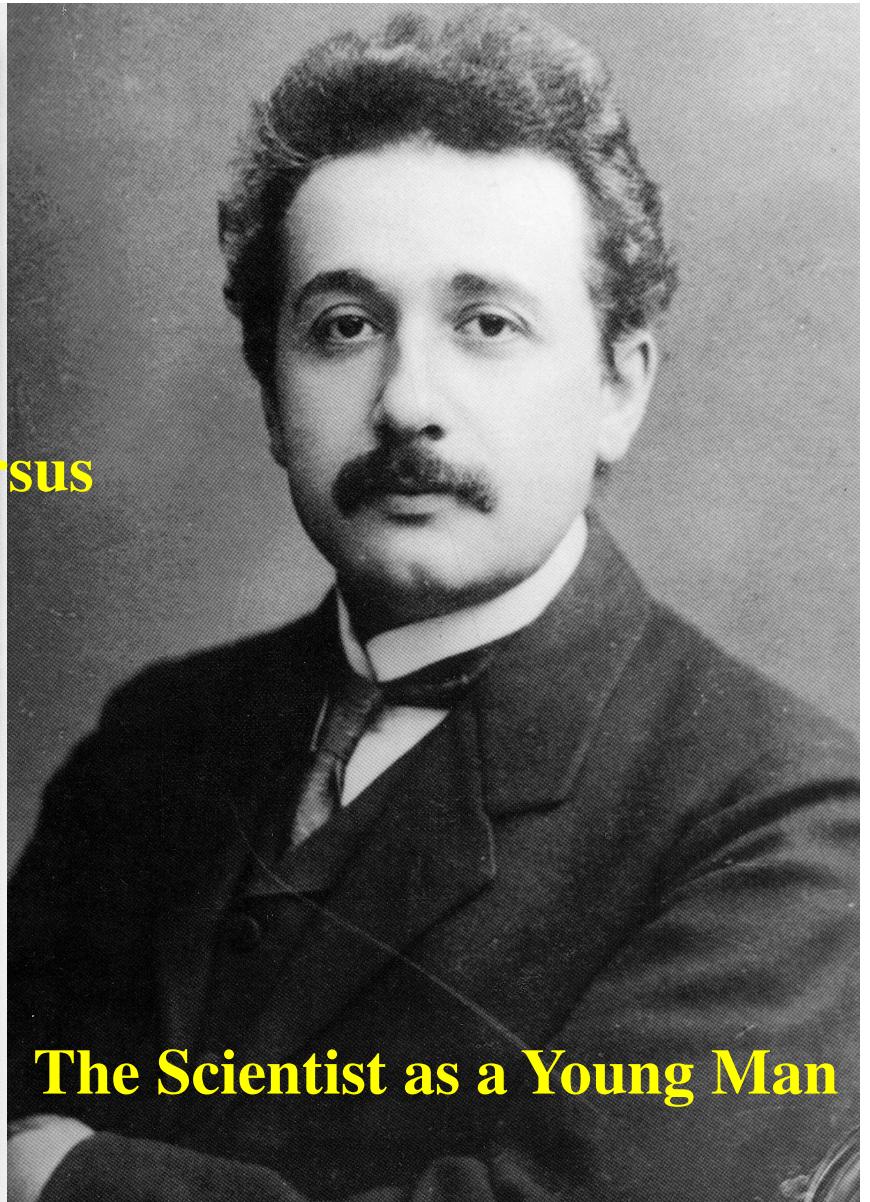
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There is a striking difference between the methodology of the young Einstein and that of the old. I argue that Einstein's switch in the late 1910s from a moderate empiricism to an extreme rationalism should at least in part be understood against the background of his crushing personal and political experiences during the war years in Berlin. As a result of these experiences, Einstein started to put into practice what, drawing on Schopenhauer, he had preached for years, namely to use science as his means of escaping from "the merely personal." Whatever the exact sources of Einstein's about-face, the older man has left us with a highly misleading picture of how the younger man achieved the successes that we still celebrate today. This has had a harmful influence on theoretical physics. If the young Einstein's successes are any guide as to how successful theoretical physics is done, close adherence to general features of the empirical data is much more and mathematical elegance is much less important than the old Einstein wanted us to believe.



versus



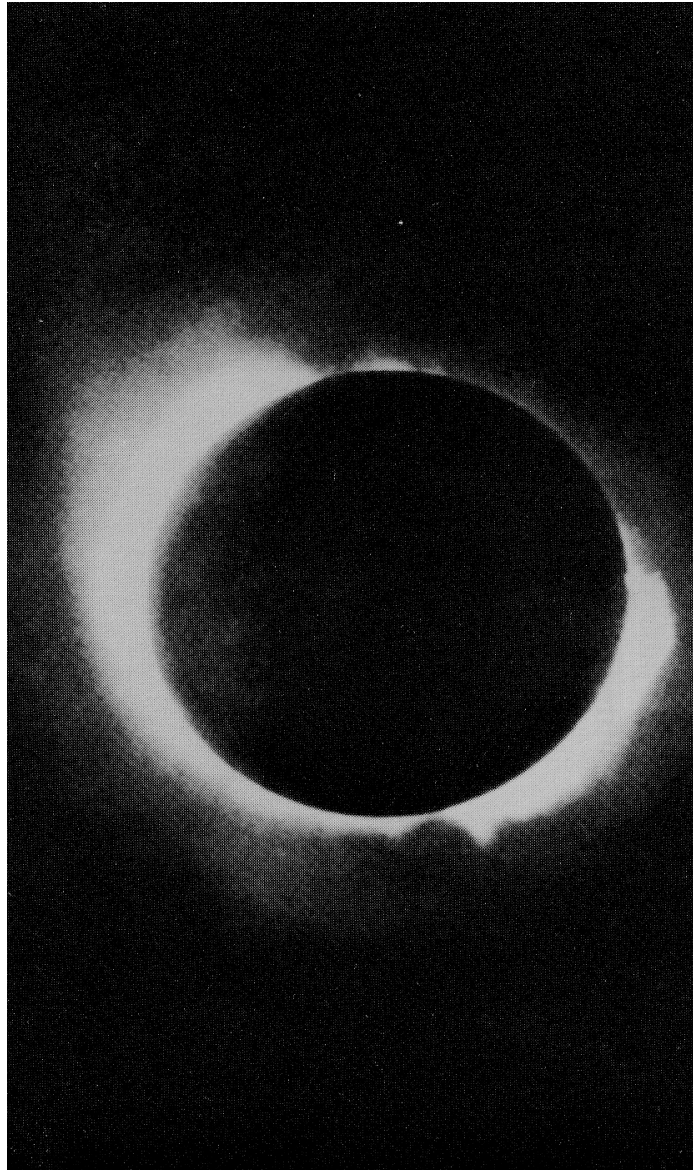
The old Einstein on scientific methodology



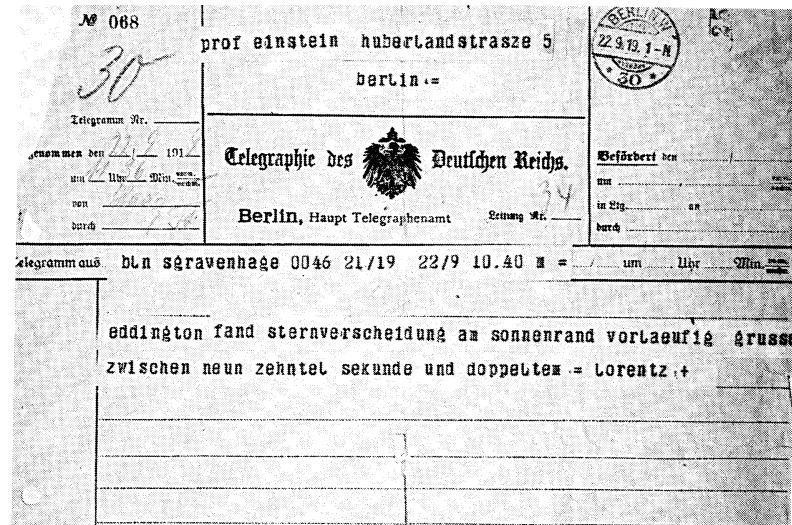
“Our experience hitherto justifies us in believing that nature is the realization of the simplest conceivable mathematical ideas. I am convinced that we can discover by means of purely mathematical constructions the concepts and the laws ... which furnish the key to the understanding of natural phenomena ... Experience remains, of course, the sole criterion of the physical utility of a mathematical construction. But the creative principle resides in mathematics. In a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed [think of Pythagoras and Plato]”

—Herbert Spencer Lecture, Oxford, June 10, 1933

This picture fits with the myth of Einstein's cavalier attitude toward empirical data



The IRS story. Ilse Rosenthal-Schneider was with Einstein when Lorentz's telegram with the results of the British eclipse expedition confirming general relativity was delivered.



Ilse Rosenthal-Schneider: “When I was giving expression to my joy that the results coincided with his calculations, he said, quite unmoved, ‘But I knew that the theory is correct,’ and when I asked, what if there had been no confirmation of his prediction, he countered: ‘Then I would have been sorry for the dear Lord—the theory is correct.’”

The old Einstein on scientific methodology

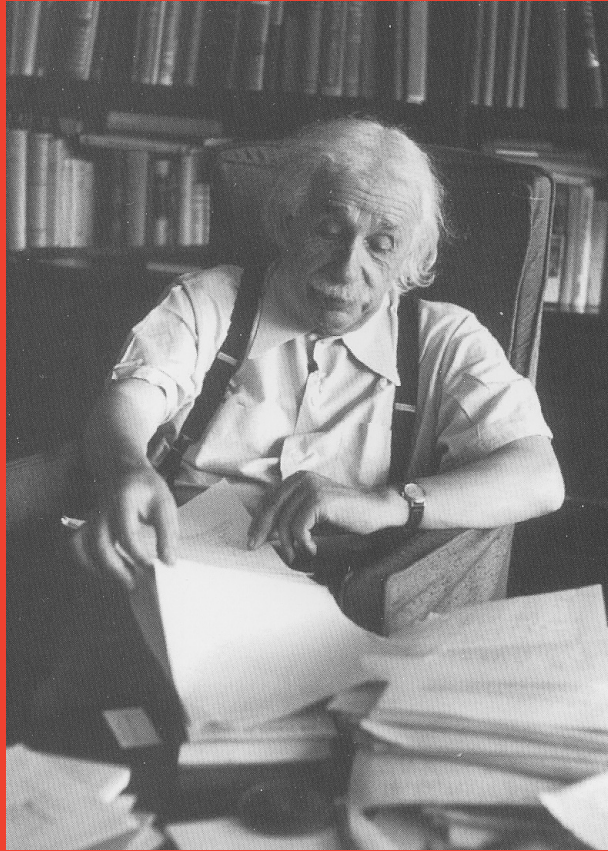
Disclaimer:

“If you want to find out anything from the theoretical physicists about the methods they use, I advise you to stick closely to one principle: do not listen to what they say, look at what they do.”

—Herbert Spencer Lecture, Oxford, June 10, 1933



Autobiographical Notes (“my own obituary”), 1946

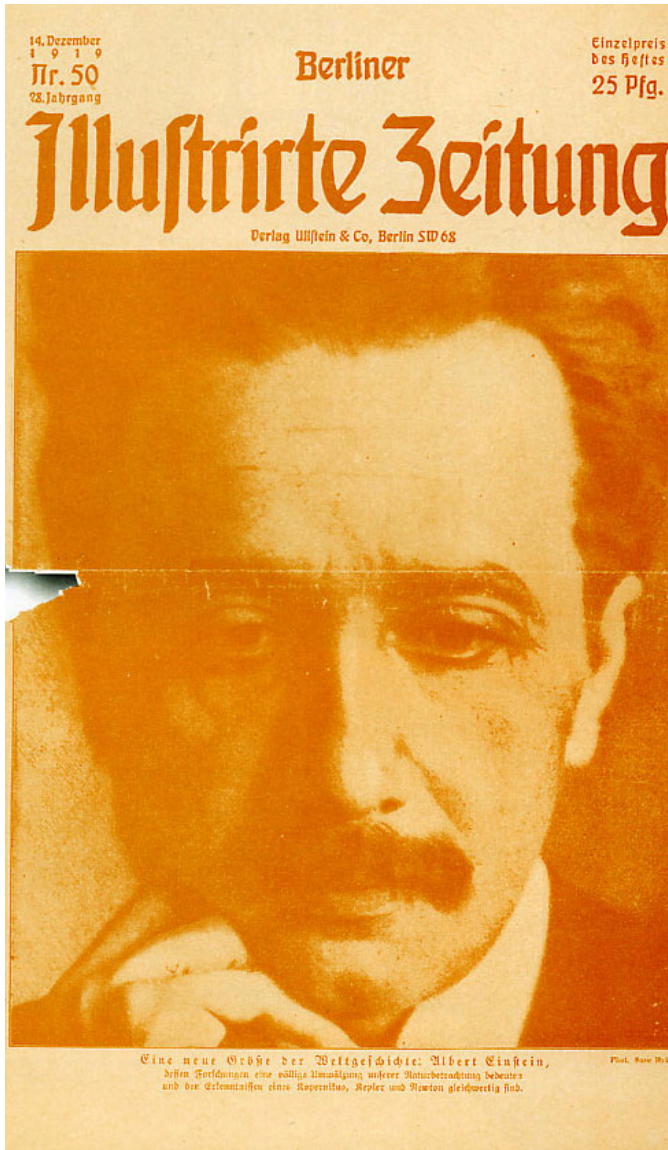


“I am not [...] capable to replace these hints [about scientific methodology] by more precise definitions. I believe, however, that a sharper formulation would be possible. In any case it turns out that among the “augurs” there usually is agreement in judging the “inner perfection” of the theories and even more so concerning the “degree” of “external confirmation.”

The London Times, November 28, 1919

Constructive theories: [Most theories] are constructive. They attempt to build up a picture of the more complex phenomena out of the materials of a relatively simple formal scheme from which they start out. [Example:] kinetic theory of gases ... When we say that we have succeeded in understanding a group of natural processes, we invariably mean that a constructive theory has been found which covers the processes in question.

Principle theories: there exists a second [class of theories], which I will call “principle theories.” These employ the analytic, not the synthetic, method. The elements which form their basis and starting point, are not hypothetically constructed but empirically discovered ones, general characteristics of natural processes, principles that give rise to mathematically formulated criteria which the separate processes or the theoretical representations of them have to satisfy. [Example:] thermodynamics.



Einstein was the master of the “theory of principle” but preferred “constructive theories”

**Arnold Sommerfeld
(1868–1951)**



The London Times, 1919: When we say that we have succeeded in understanding a group of natural processes, we invariably mean that a constructive theory has been found which covers the processes in question.

Einstein to Arnold Sommerfeld, January 14, 1908: The theory of relativity is ultimately as little satisfactory as [...] thermodynamics was before Boltzmann had interpreted the entropy as probability.”



Question: Given Einstein's preference for constructive theories, why bother with principle theories at all?

Comments on discovery of special relativity in autobiographical notes (1946):

“By and by I despaired of the possibility of discovering the true laws by means of constructive efforts based on known facts. The longer and more despairingly I tried, the more I came to the conviction that only the discovery of a universal formal principle could lead us to assured results. The example I saw before me was thermodynamics”

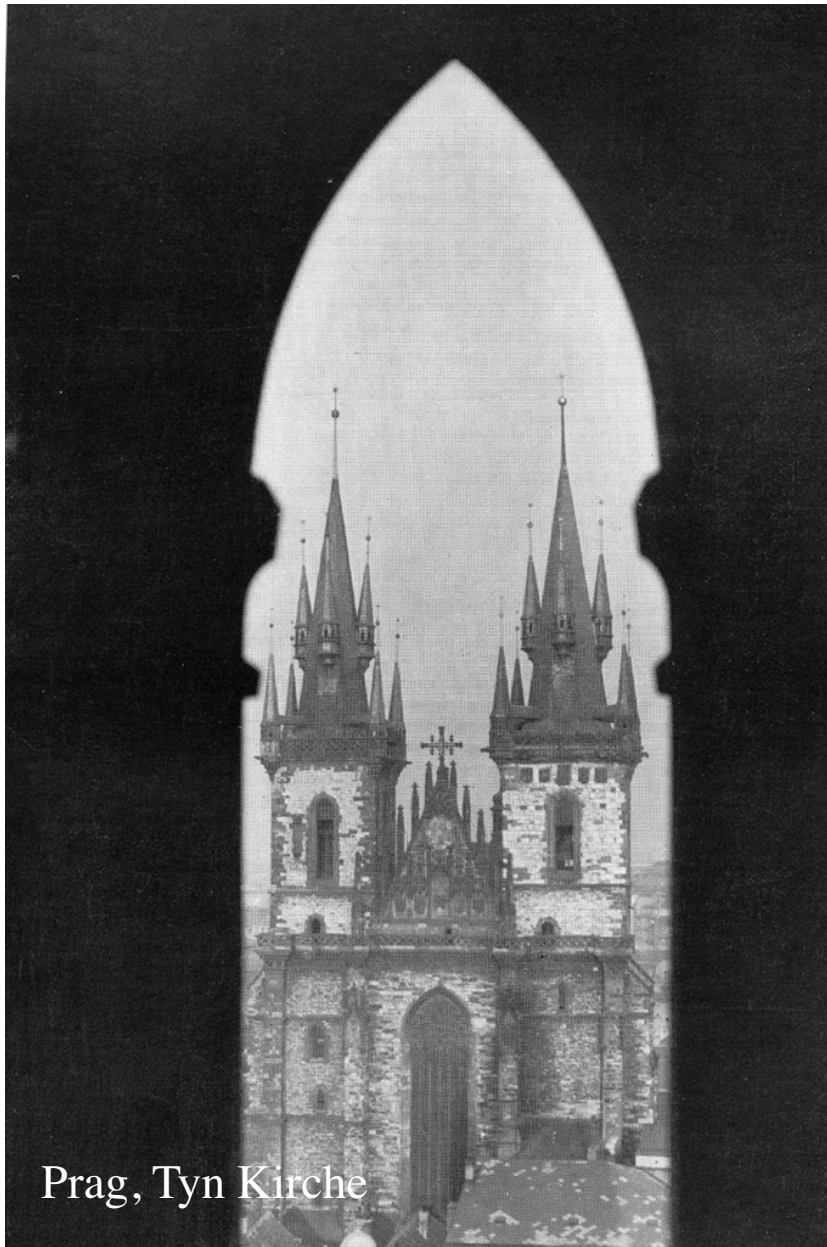
So: Principle theories = physics of desperation.

Maxim: when you have not a clue what a satisfactory model (→ constructive theory) might look like, limit yourself to finding constraints on such models (→ principle theory).

My claim: Einstein made important contributions to quantum theory precisely because (and as long as) he clearly realized he knew essentially nothing about the ultimate nature of the quantum world.

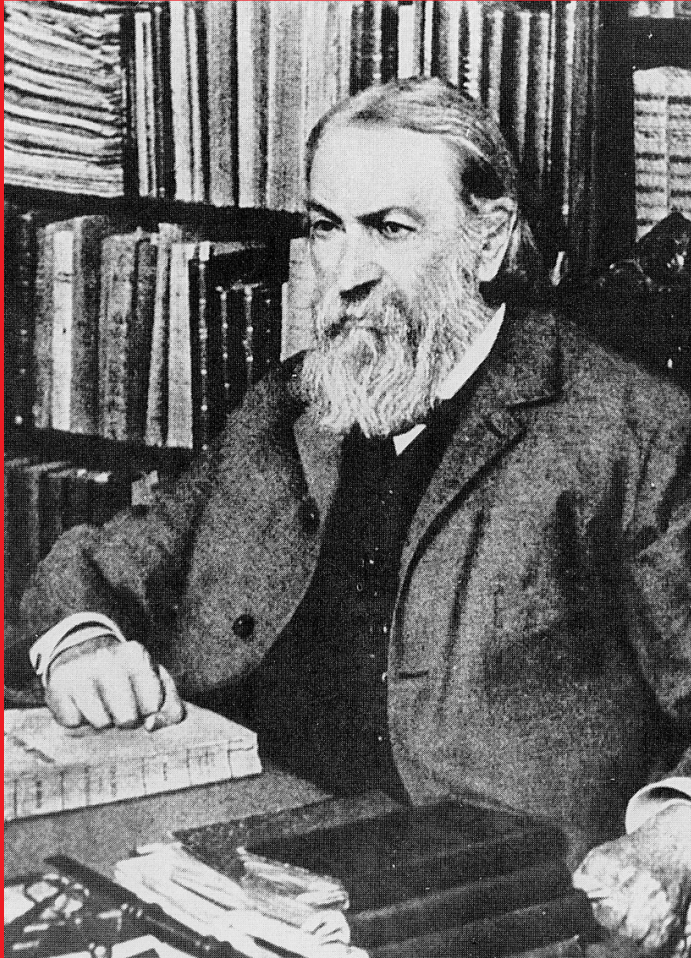
Einstein showing the view from his office in Prague, overlooking the garden of the Bohemian Psychiatric Ward, to his successor, Philipp Frank:

“Those are the madmen who do not occupy themselves with the quantum theory”



Prag, Tyn Kirche

Difference between Einstein's work in quantum and Einstein's work in relativity:



In relativity Einstein gets more and more confident that he knows what a satisfactory model of space-time should look like. Bad influence of **Ernst Mach (1838–1916)**: absolute motion and absolute space need to be exorcised from physics

Stenographed notes of lecture in Princeton, May 9, 1921:

“Whenever we talk about the motion of a body, we always mean by the very concept of motion relative motion [...] These conditions are really quite trivial and don't really have anything to do with relativity theory. As a matter of fact, we can only conceive of motion as relative motion [...] All this goes without saying and does not need any further discussion.”

How did Einstein find his principles?



- **Humdrum way: inductive generalization.** Example: every attempt so far to detect ether drift has failed, so probably all attempts will fail.
- **Magic wand I:** exploit explanatory deficiencies in existing theories. Example: special and general relativity.
- **Magic wand II:** exploit violent clash of different parts of existing theory. Example: light quantum hypothesis, special relativity.

Magic wand I: exploiting explanatory deficiencies in existing theories (or: asking embarrassing why-questions)

Example 1 (1905): the magnet and the conductor



Embarrassing question for Lorentz: Why do these two experiments that according to your theory are completely different, give the exact same result?

Einstein in 1919 (unpublished *Nature* article): “In the formulation of the special theory of relativity, a consideration—not mentioned so far—concerning Faraday’s electromagnetic induction played a leading role ... The idea that we would be dealing here with two fundamentally different situations was unbearable to me [...] The existence of the electric field was therefore a relative one, dependent on the coordinate system used, and only the electric and magnetic field taken *together* could be ascribed some kind of objective reality. This phenomenon of electromagnetic induction forced me to postulate the [...] relativity principle”

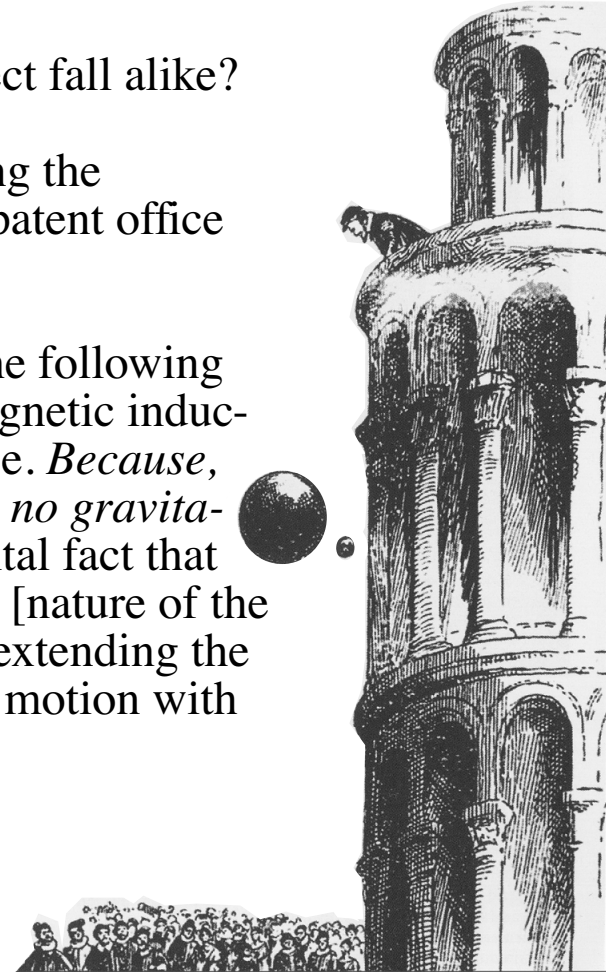
Magic wand I: exploiting explanatory deficiencies in existing theories (or: asking embarrassing why-questions)

Example 2 (1907): the equivalence of gravity and acceleration

Embarrassing question for Newton: Why do all object fall alike?

The next paragraph in that same 1919 article, describing the thought that hit him in 1907 as he was working in the patent office in Berne:

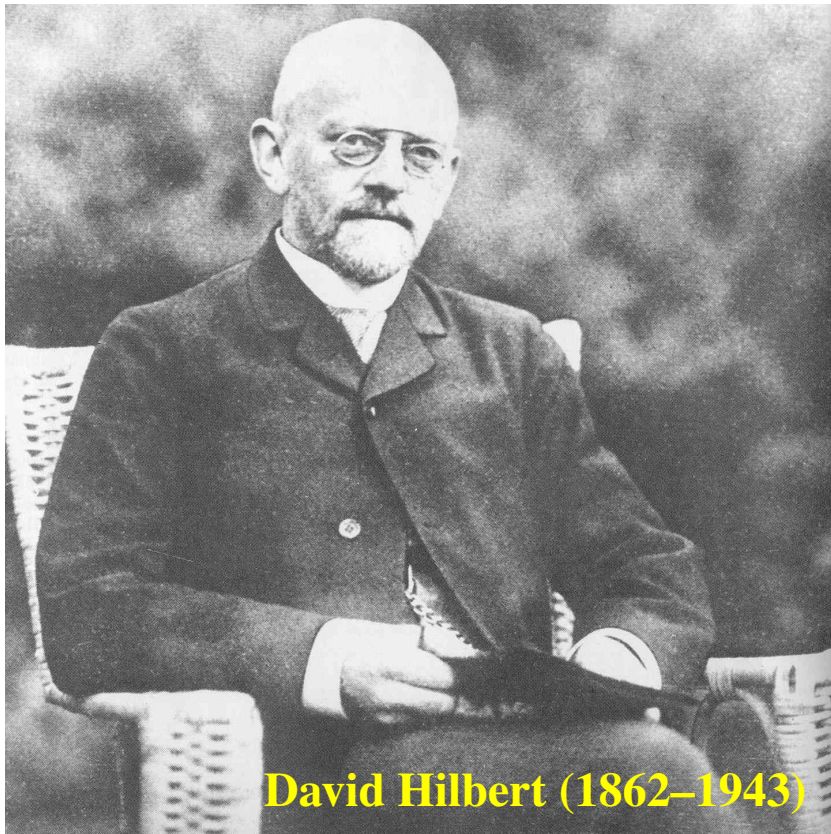
“Then came to me the happiest thought of my life in the following form ... Like the electric field generated by electromagnetic induction, the gravitational field only has a relative existence. *Because, for an observer freely falling from the roof of a house, no gravitational field exists while he is falling* ... The experimental fact that the acceleration due to gravity does not depend on the [nature of the accelerated] material is thus a powerful argument for extending the relativity postulate to systems in non-uniform relative motion with respect to one another.”



Given the successes of principle theories, why switch back to constructive theories?

- Einstein thinks he knows God's blueprint for the universe: classical field theory along the lines of general relativity unifying inertio-gravitational and electro-magnetic fields.

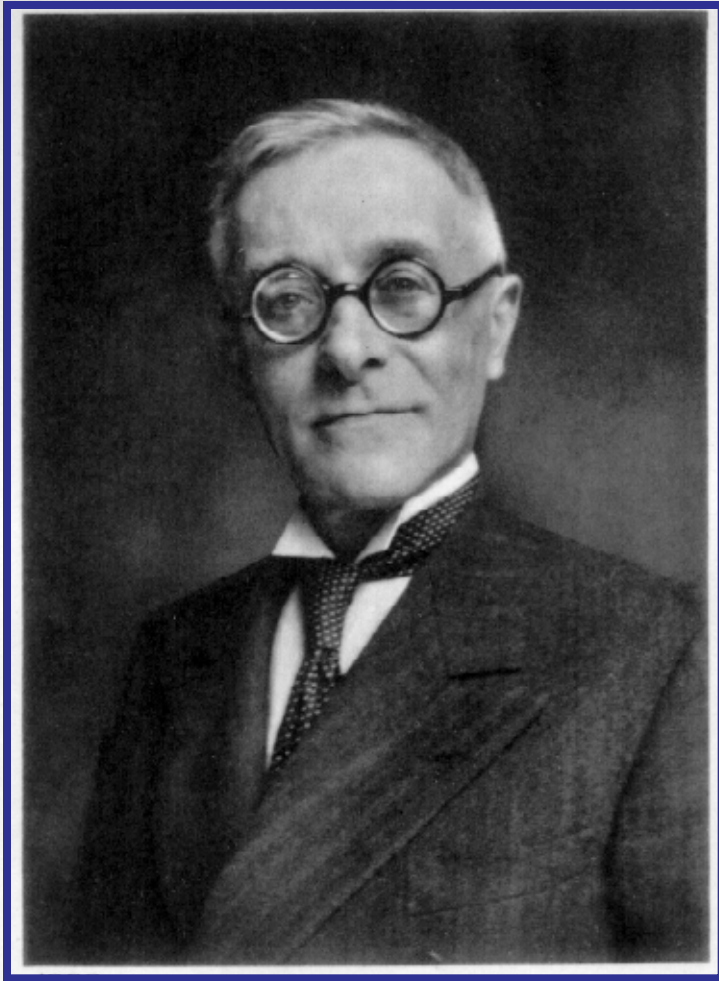
Why reliance on mathematical elegance over adherence to empirical facts in developing constructive theories?



David Hilbert (1862–1943)

- In 1915, The Göttingen mathematician **David Hilbert (1862–1943)** almost beats him to the punch in putting the finishing touches on general relativity by paying attention only to mathematical elegance without stopping to think about what the math means physically.

Einstein's "math envy"



Tullio Levi - Civita

Tullio Levi-Civita (1873–1941)

Einstein to Sommerfeld, October 29, 1912:

“One thing for sure though is that I have never before in my life exerted myself even remotely as much and that I have been infused with great respect for mathematics, the subtler parts of which I until now, in my innocence, considered pure luxury. Compared to this problem, the original theory of relativity is child’s play.”

Einstein to Levi-Civita, August 2, 1917:

“[i]t must be a pleasure to ride through these fields on the steed of real mathematics, while the likes of us must trudge through on foot.”

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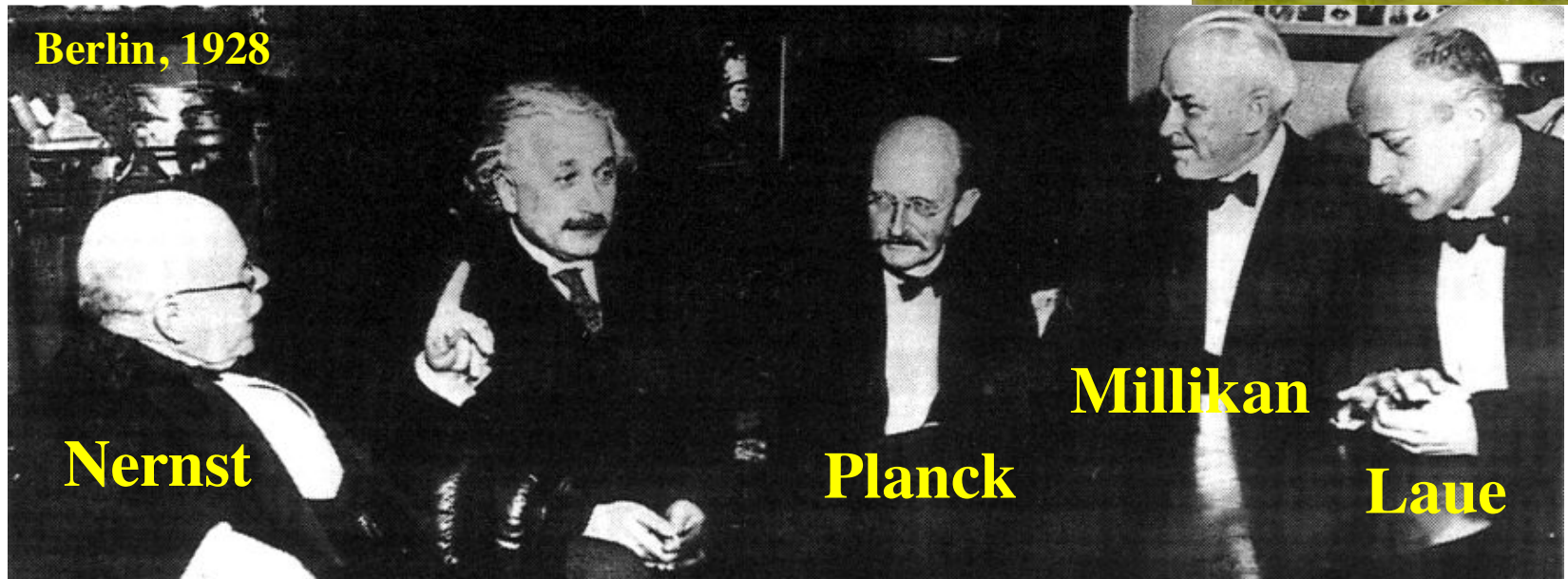
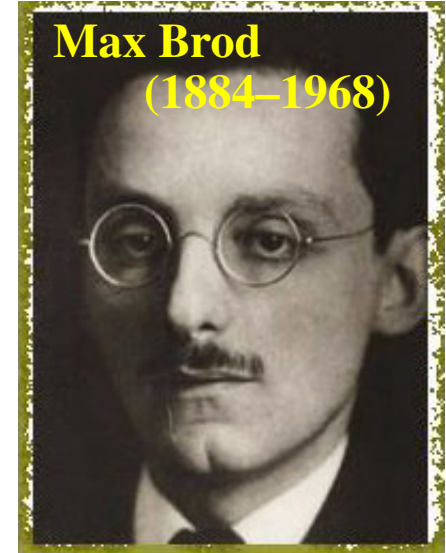
Why reliance on mathematical elegance over adherence to empirical facts in developing constructive theories?

- **After his midlife crisis in 1917–1918 (when he's pushing 40), Einstein starts using physics as his way of escaping from the dreariness of everyday life—of “getting beyond the merely personal” [rest of this talk]**

Physics as a way of “getting beyond the merely personal”

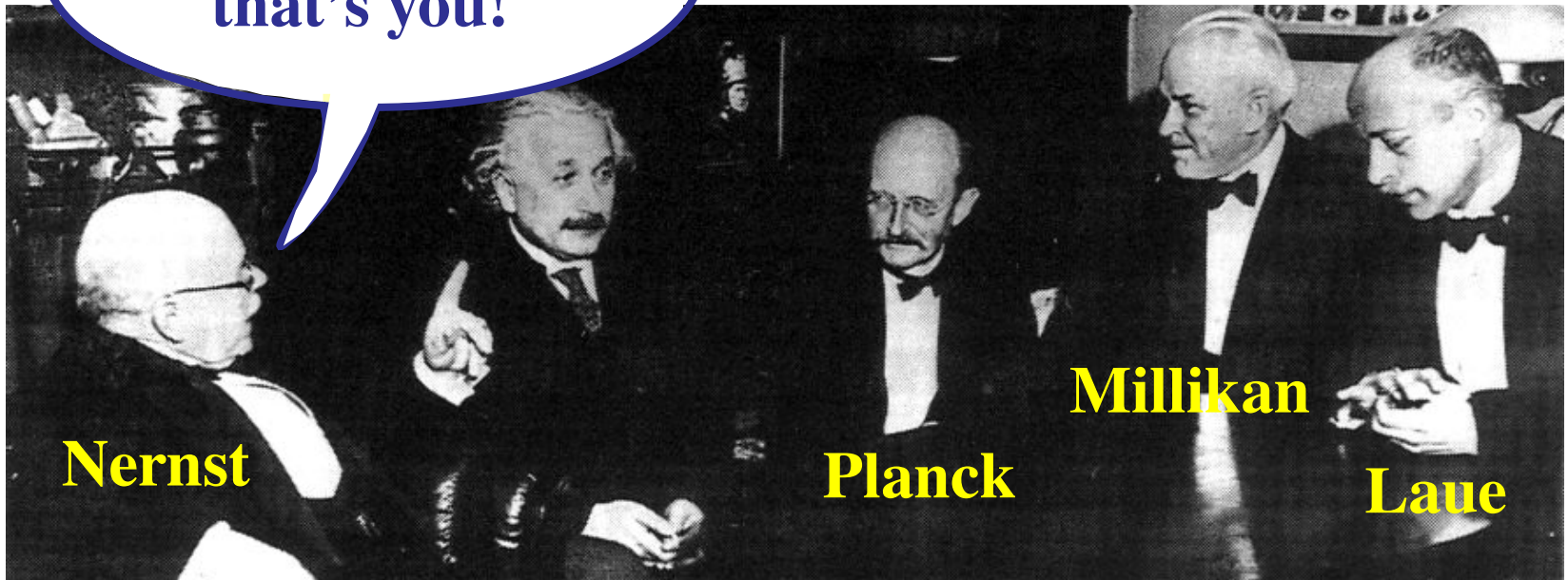
The tranquility with which [Kepler] applied himself to his labors ... was to Tycho almost superhuman. There was something incomprehensible in its absence of emotion, like a breath from a distant region of ice ... He had no heart and therefore had nothing to fear from the world. He was not capable of emotion or love.

—Max Brod, *The Redemption of Tycho Brahe*



Physics as a way of “getting beyond the merely personal”

**This Kepler:
that’s you!**



Physics as a way of “getting beyond the merely personal”



Einstein to Pauline Winteler, May 1897:

“Dear mommy ... I cannot come to visit you at Whitsuntide ... I have already caused much too much [pain] to the dear child [Pauline’s daughter Marie] ... It fills me with a peculiar kind of satisfaction that now I myself have to taste some of the pain that I brought upon the dear girl through my thoughtlessness and ignorance of her delicate nature. Strenuous intellectual work and looking at God’s Nature are the reconciling, fortifying, yet relentlessly strict angels that shall lead me through all of life’s troubles. If only I were able to give some of this to the good child! And yet, what a peculiar way this is to weather the storms of life—in many a lucid moment I appear to myself as an ostrich ... One creates a small little world for oneself, and as lamentably insignificant it may be in comparison with the perpetually changing size of real existence, one feels miraculously great and important, like a mole in his self-dug hole.”

Physics as a way of “getting beyond the merely personal”



Mileva Maric (1875–1948)

Einstein to Mileva, December 17, 1897: It is really a screamingly funny life that I am living here, completely in Schopenhauer’s sense ... I am now very eagerly working on an electrodynamics of moving bodies, which promises to become a capital paper ... Since that bore Kleiner hasn’t answered yet, I’m going to drop in on him ... To think of all the obstacles that these old philistines put in the way ...

Einstein to Mileva, October 3, 1900: You too don’t like the philistine life any longer, don’t you? He who tasted freedom cannot stand the chains any longer. How lucky I am to have found in you a creature who is my equal, who is as strong and independent as I am myself.

Einstein and Mileva: Happy together?



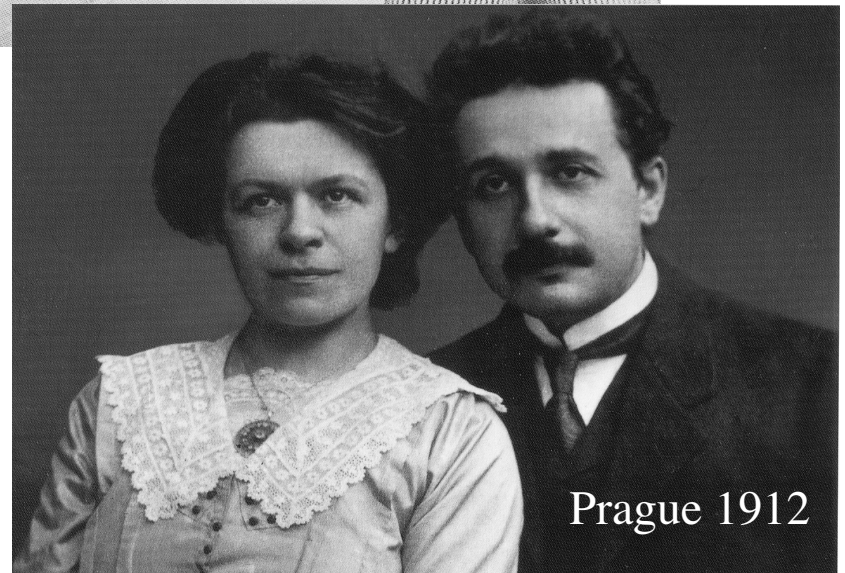
Zurich 1914

Tete
(b. 1910)

Hans-Albert
(b. 1904)

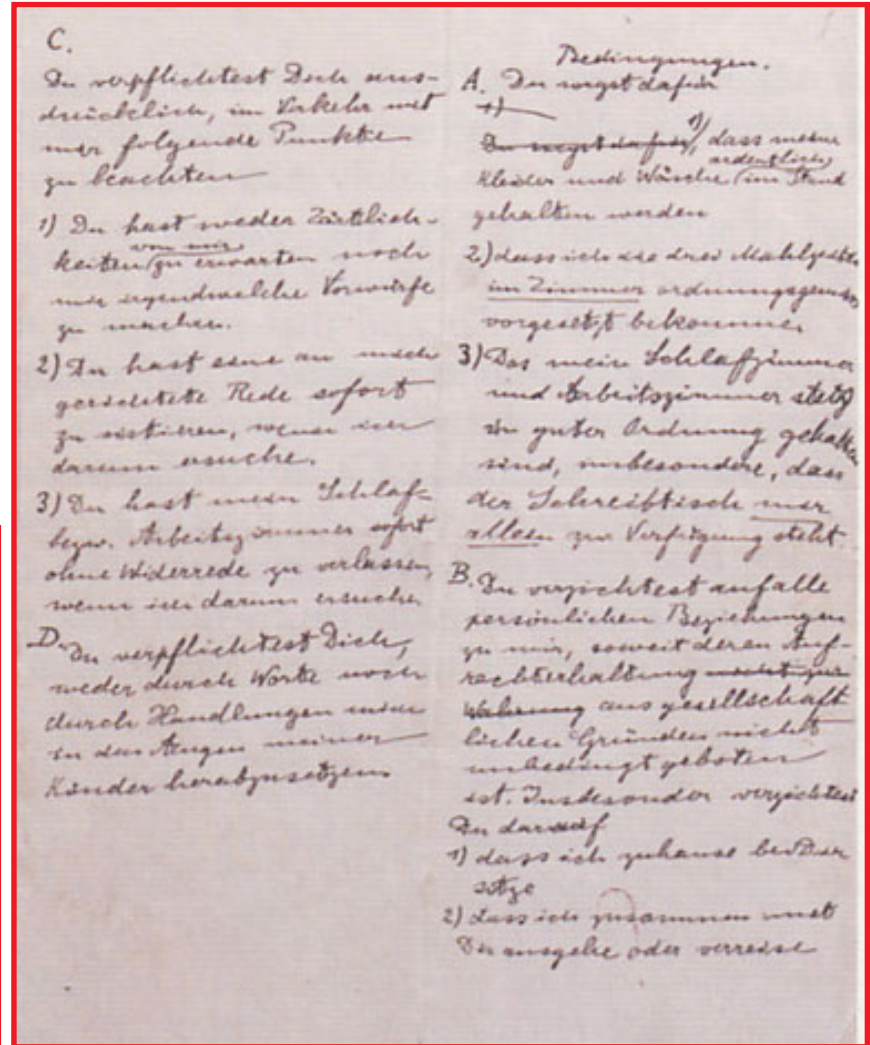
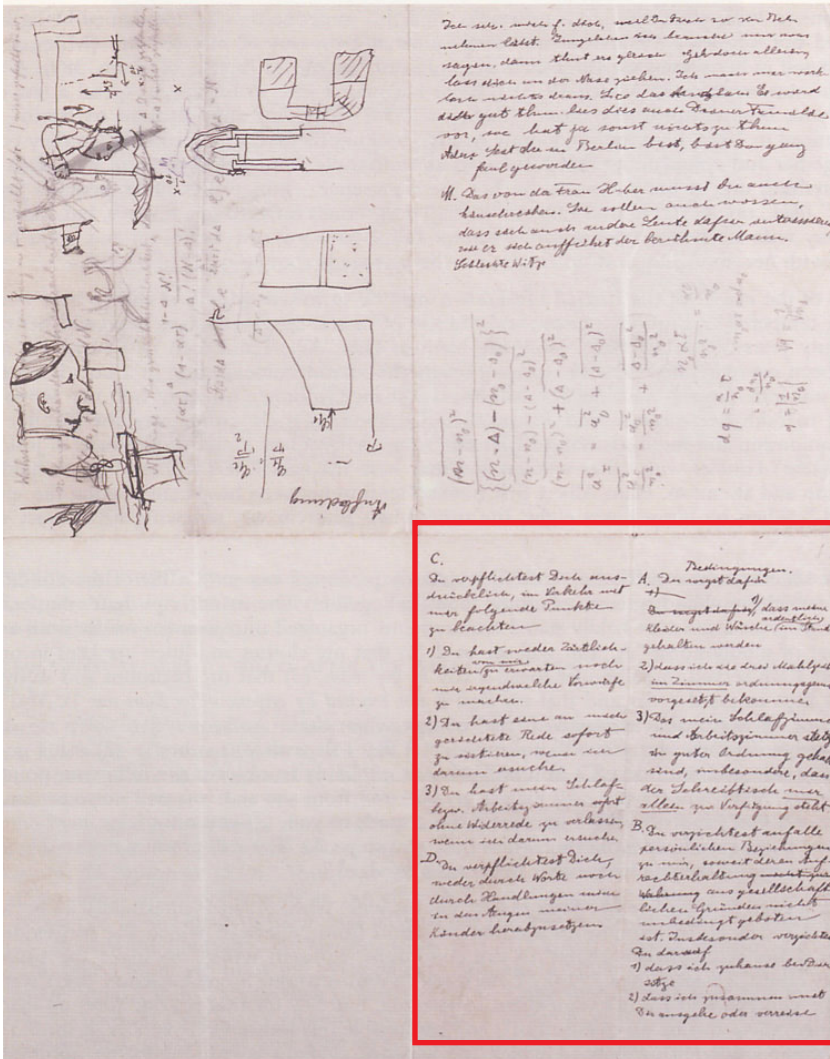


Berne
1904



Prague 1912

Einstein and Mileva: Happy together?



Conditions under which Einstein is prepared to stay married to Mileva, July 1914

A. You make sure:

- 1. that my clothes and laundry are kept in good order and repair.**
- 2. that I receive my three meals regularly in my room.**

B. You abstain from all personal contact with me unless absolutely required for reasons of social decorum.

C. You commit yourself to observing the following points in your dealings with me:

- 1. You are neither to expect intimacy from me nor to reproach me in any way.**
- 2. You are to stop talking to me immediately when I ask you to.**
- 3. You are to leave my bedroom as well as my study immediately and without protest when I ask you to.**

[Some zingers from Mileva:] Read it to your family as well. They have nothing else to do anyway. You should also write down this thing about Frau Haber. They should know that there are others who are interested in what a spectacle he is making of himself, the famous man. [Einstein's comment:] Bad jokes.

Einstein and his 1st+2nd cousin/2nd wife Elsa Einstein-Löwenthal (1876–1936)



Ilse Einstein to Prof. Georg Nicolai (1874–1964), May 22, 1918



alle waren —
 leben notwendig
 men lassen. Ich
 sehr daran gewöhnt
 ter" zu betrachten
 , das liegt in
 ich würde täglich
 wieder daran
 eben, das ist etwas
 unser heutiges
 wie ich eingestellt
 sei, aber nicht ganz sauber. (A. behauptet
 zwar, das seien soziale Vorurteile) A.
 redet mir auf keinen Fall zu, daß er nicht
 die Verantwortung übernehmen will,
 ein solch' junges Ding wie mich an sich
 zu fesseln. So lange ich hier im Hause wäre,
 würde es für mich kein großer Unterschied
 sein (nach A.'s Meinung) ob ich verheiratet

Verreichen Sie bitte Am 22. Mai 18.
Dieser Brief sofort nach dem Lesen!
 Lieber Herr Professor.

Sie sind der einzige Mensch, dem ich
 Folgendes anvertrauen kann und der
 mir eine, der mir ein Rat geben kann
 und darum bitte ich Sie, was ich Ihnen
 schreiben, reiflich zu überlegen und
 mir dann
 Sie erinnern
 Alberts und
 Sie sagten
 wissen Sie
 ich habe bis
 gedacht. Gest
 gestellt, ob
 wolle. Diese
 ausgesproche
 Minuten ei
 meine voll
 besprochen we



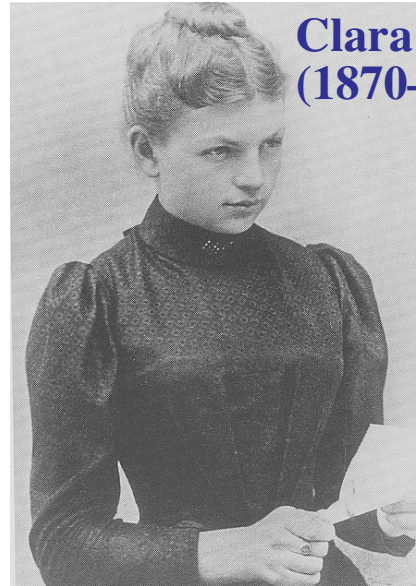
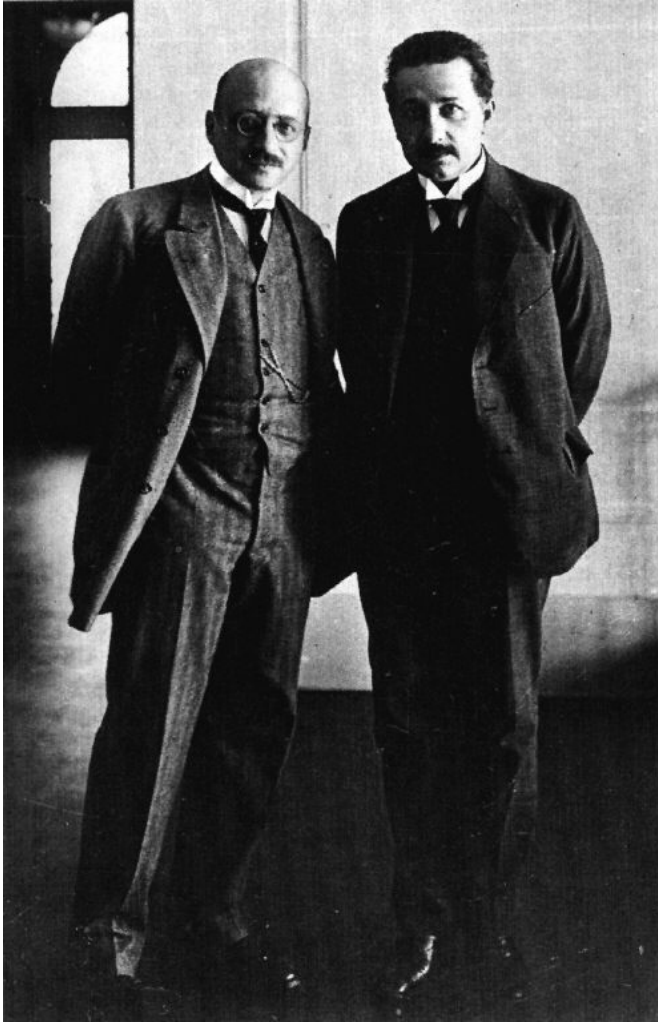
Ilse Einstein to Prof. Georg Nicolai (1874–1964), May 22, 1918

waren —
 Verriichten Sie bitte Am 22. Mai 18.
 diesen Brief sofort nach dem Lesen!
 Lieber Herr Professor.
 Sie sind der einzige Mensch, dem ich
 Folgendes anvertrauen kann und der
 zu betonen habe, dass ich mit Albert leben kann
 was leicht zu verstehen ist, wenn man nur weiß, dass ich die
 wirklich nicht mehr streicht, sondern ich die
 jeder Mensch, der mich liebt, verpflichtet zu sein, mich mit
 zu teilen.
 Albert und Mama werden mich nicht nur
 user, sondern auch als Person, die sprechen und
 ich empfinden, dass es eine Ehe
 über. (A. behauptet sich habe bis gestern wie ein Erbstücker
 und die...)

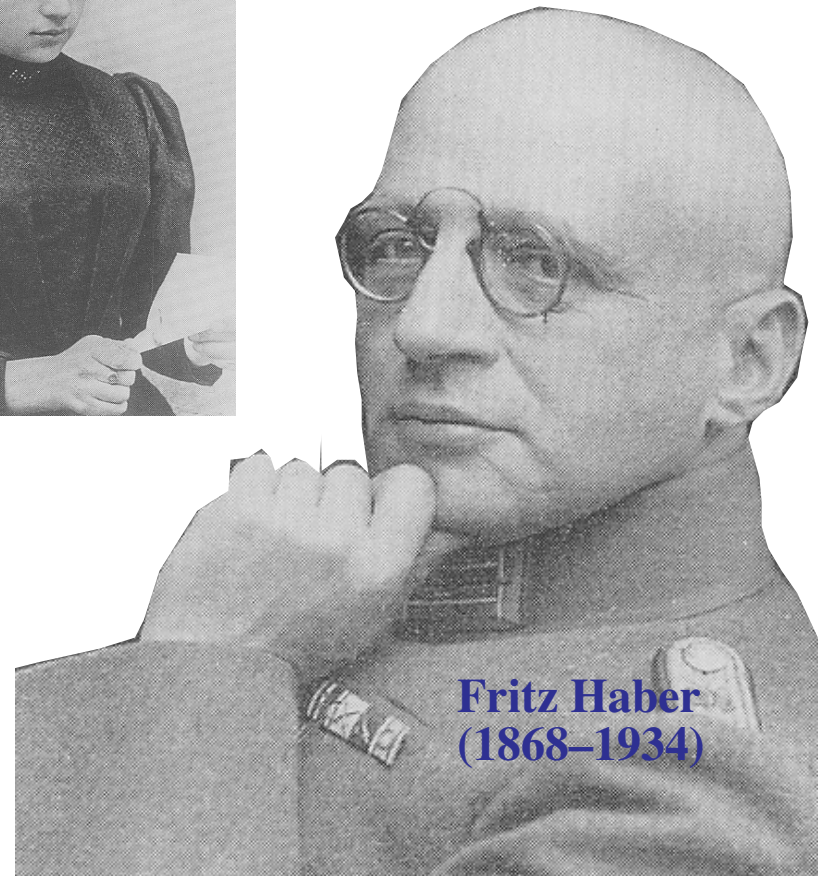
(Please destroy this letter immediately after reading it)

You will recall that we recently talked about Albert’s and mama’s marriage and that you said to me that a marriage between Albert and me would be more appropriate. Until yesterday I’d never given this any serious thought. Yesterday, however, the question suddenly came up whether A. should marry mama or me. Within minutes this question, first brought up half-jokingly, turned into a very serious matter, which had to be examined from all angles and discussed fully. Albert refuses to make a decision. He is prepared to marry either me or mama ... I have never wished or felt any desire to be close to him physically. For him this is a different matter — at least lately. He recently told me how hard it is for him to control himself.

Einstein to Mileva, April 1918: “I am curious to see what will last longer, the world war or our divorce proceedings. Both began essentially at the same time. This matter of ours is actually still the prettier of the two.”



**Clara Haber
(1870–1915)**



**Fritz Haber
(1868–1934)**

Einstein to Mileva, April 1918: “I am curious to see what will last longer, the world war or our divorce proceedings. Both began essentially at the same time. This matter of ours is actually still the prettier of the two.”



Wilhelm II with his uncle King Eduard VII in front of the Brandenburg Gate (1909)



Einstein to Mileva, April 1918: “I am curious to see what will last longer, the world war or our divorce proceedings. Both began essentially at the same time. This matter of ours is actually still the prettier of the two.”

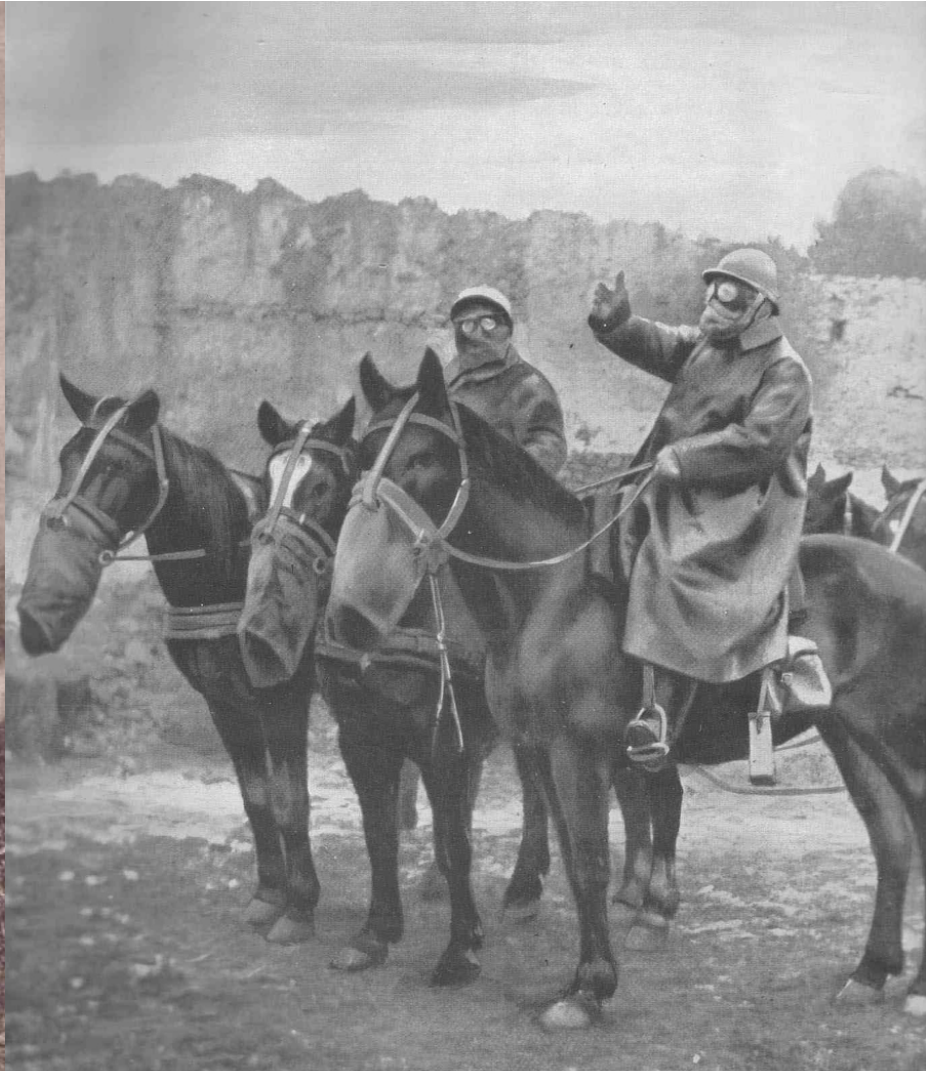


Trench Tourism outside Berlin



No Sunday Picnic!

Einstein to Mileva, April 1918: “I am curious to see what will last longer, the world war or our divorce proceedings. Both began essentially at the same time. This matter of ours is actually still the prettier of the two.”



Einstein to Mileva, April 1918: “I am curious to see what will last longer, the world war or our divorce proceedings. Both began essentially at the same time. This matter of ours is actually still the prettier of the two.”



John Singer Sargent (1856–1935), *Gassed* (1918)

Physics as a way of “getting beyond the merely personal”



Compare Einstein’s Berlin inaugural lecture in 1914 to his speech for Planck’s 60th birthday in 1918

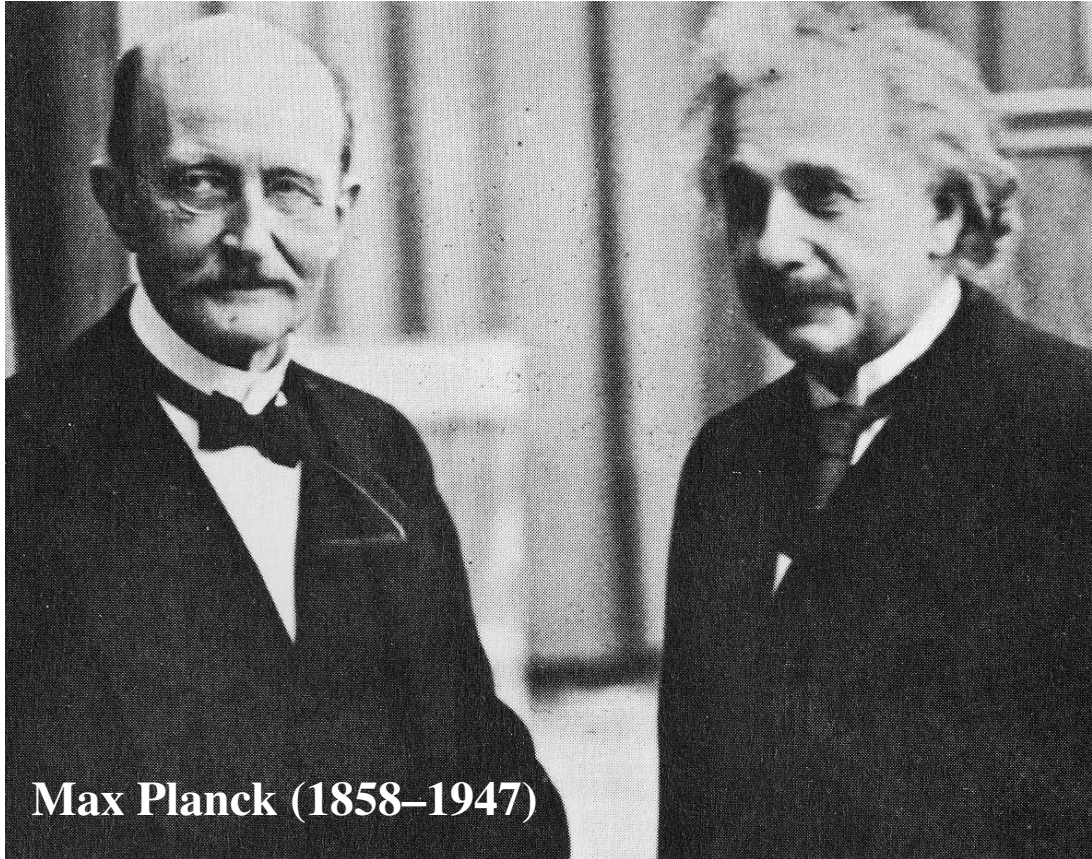
Inaugural lecture, July 2, 1914: The theorist’s method involves [...] general postulates or “principles” from which he can deduce conclusions ... The scientist has to extract these general principles from nature by perceiving in comprehensive complexes of empirical facts certain general features which permit of precise formulation.

Recall:

- **Spencer lecture, 1933:** we can discover [the laws of nature] by means of purely mathematical constructions the concepts and the laws ... the creative principle resides in mathematics ... pure thought can grasp reality.
- **Autobiographical notes, 1946:** I am not ... capable to replace these hints [about scientific methodology] by more precise definitions.

Physics as a way of “getting beyond the merely personal”

Lecture in honor of Max Planck’s 60th birthday, April 26, 1918: “Motivations for doing research”

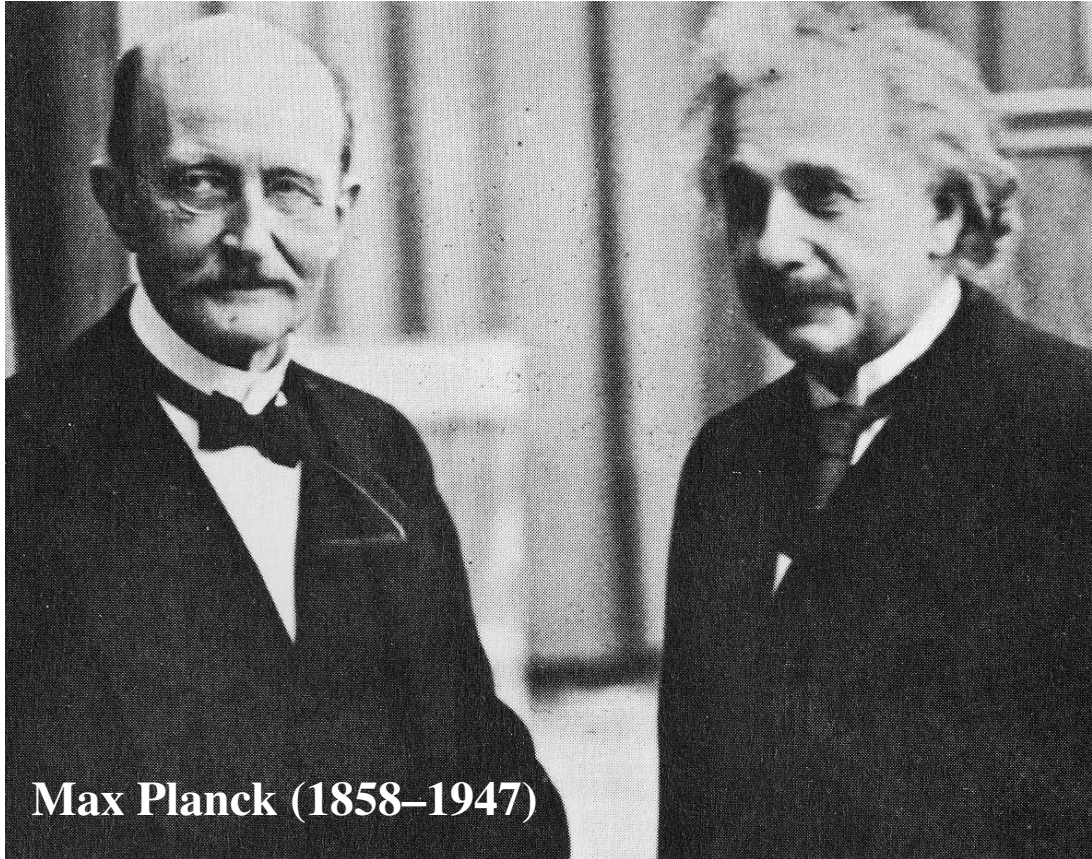


Max Planck (1858–1947)

In the temple of science there are many mansions, and various indeed are they that dwell inside and the motives that have led them there ... Were an Angel of the Lord to come and drive all the people [who are only seeking intellectual challenges or practical applications] out of the temple, the congregation would be seriously depleted, but there would still be some men [...] left inside. Our Planck is one of them, and that is why we love him

Physics as a way of “getting beyond the merely personal”

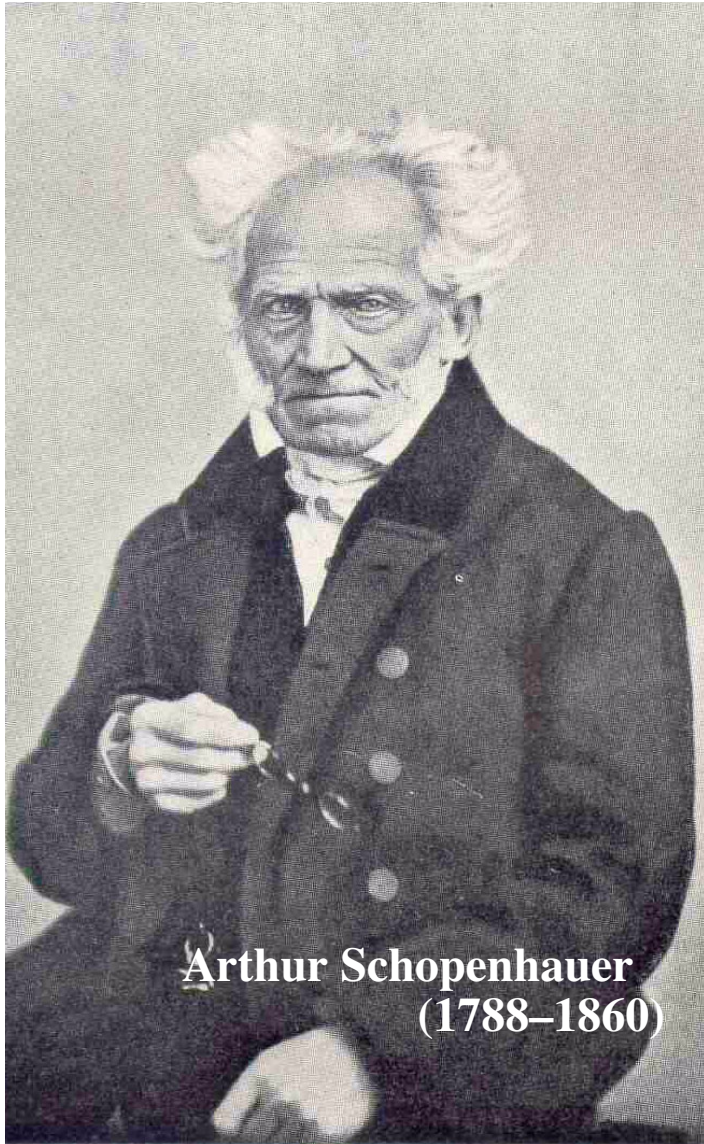
Lecture in honor of Max Planck’s 60th birthday, April 26, 1918: “Motivations for doing research”



Now let us have another look at those who have found favor with the angel. Most of them are somewhat odd, uncommunicative, solitary fellows, really less like each other, in spite of these common characteristics, than the hosts of the rejected. What has brought them to the temple?

Max Planck (1858–1947)

Physics as a way of “getting beyond the merely personal”



Arthur Schopenhauer
(1788–1860)

**Lecture in honor of Max Planck’s 60th birthday,
April 26, 1918: “Motivations for doing research”:**

I believe with Schopenhauer that one of the strongest motives that leads men to art and science is escape from every day life with its painful crudity and hopeless dreariness, from the fetters of one’s own ever shifting desires. A finely tempered nature longs to escape from personal life into the world of objective perception and thought ...

Physics as a way of “getting beyond the merely personal”



“Motivations for doing research” April 26, 1918

... this desire may be compared to the townman’s irresistible longing to escape from his noisy, cramped surroundings into the silence of high mountains, where the eye ranges freely through the still, pure air and fondly traces the restful contours apparently built for eternity.

Caspar David Friedrich (1774–1840),
‘The Wanderer Above The Sea of Mists’
(1818)

Physics as a way of “getting beyond the merely personal”



Einstein's book plate

“Motivations for doing research”

April 26, 1918

With this negative motive goes a positive one. Man tries to make for himself in the fashion that suits him best a simplified and intelligible picture of the world; he then tries to some extent to substitute this cosmos of his for the world of experience, and thus to overcome it. This is what the painter, the poet, the speculative philosopher, and the natural scientist do, each in his own fashion. Each makes this cosmos and its construction the pivot of his emotional life, in order to find in this way the peace and security which he cannot find in the narrow whirlpool of personal experience.

Physics as a way of “getting beyond the merely personal”

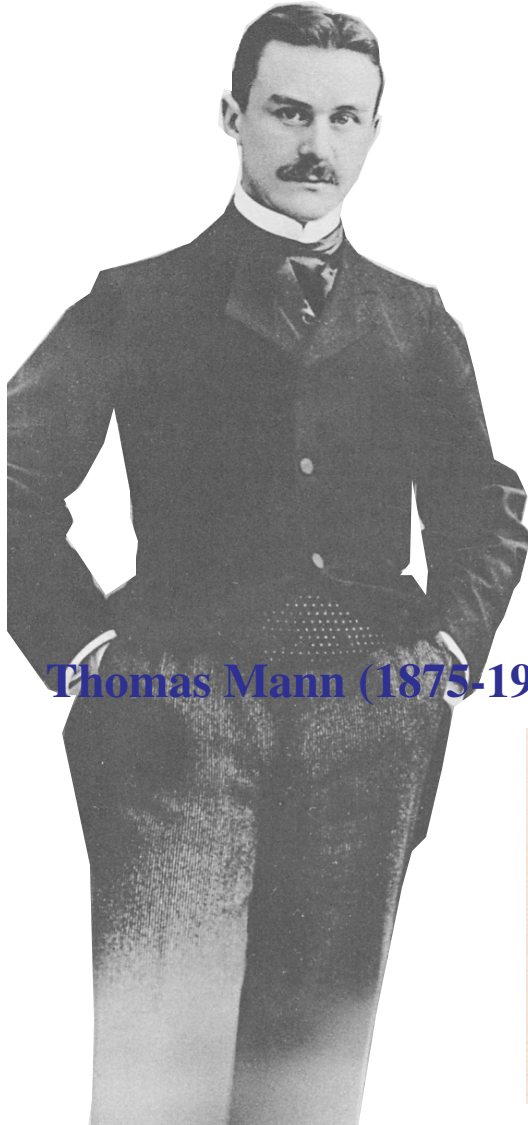


Lecture in honor of Max Planck’s 60th birthday, April 26, 1918: “Motivations for doing research:”

Sounds remarkably similar to Einstein’s “dear mommy”-letter 21 years earlier!

“One creates a small little world for oneself, and as lamentably insignificant it may be in comparison with the perpetually changing size of real existence, one feels miraculously great and important, like a mole in his self-dug hole.”

Schopenhauer cult. Described for instance in Thomas Mann, *Buddenbrooks* (1901) [Nobel prize, 1929]. Cool in 1897, not so cool anymore in 1918.



Thomas Mann (1875-1955)



Conclusion: Schopenhauer corrupted the moderate empiricist Einstein and helped turn him into a radical Platonist.

