

The International Year of Physics

Einstein: His Impact on
Accelerators; His Impact on the
World

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Contents

I. His Impact on Accelerators

1. Special Relativity
2. Brownian Motion
3. Photo-Electric Effect
4. A and B Coefficients
5. General Relativity

II. His Impact on the World

6. Family Life
7. World Peace: Pacifist, Atomic Bomb, Arms Control
8. Humanitarian: Social Justice, Anti-Racism, Civil Rights

III. Reprise

9. Some Reflections

References

Hundreds of books. Just a few:

Clark, Ronald, “Einstein: The Life and Times” (1971)

Jerome, Fred, “The Einstein Files” (2002)

Einstein, Albert, “Out of my Later Years” (1956)

Calaprice, Alice, “The Quotable Einstein” (1996)

Pais, Abraham, “Subtle is the Lord” (1994)

And just this year a number more.



“The state has become a modern idol whose suggestive power few men are able to escape.”

~~“If we knew what we are~~

doing it would not be called research, would it?”

1. Special Relativity (1905)

Lev Landau complimented Gersh Budker with the nickname “engineer of relativity”

- a) Betatron (1940) [mv vs p] and the change of circulation frequency with energy limiting the top energy of a cyclotron. Nevertheless the 184” cyclotron is initiated (1941). Thomas cyclotron (1938), FM (1945), FFAG spiral ridge cyclotrons (1954)
- b) Synchrotrons (and the need for relativistic dynamics) (1953)
- c) Time dilation for decaying species (muons) (1969)

2. Brownian Motion (1905)

Einstein's thesis and six papers prior to 1905 were on fluctuation phenomena. Here he presented arguments that convinced the world of the reality of atoms. So, we can reasonably consider that all fluctuation phenomena go back to Einstein.

- Incoherent radiation (only due to the fluctuations in beam current) (1947)
- Gas scattering and intra-beam scattering (1963)
- Stochastic cooling (1972); Optical stochastic cooling (1993)
- The limit on muon cooling (1981)

3. Photo-Electric Effect (1905)

$$E = h\nu - W$$

The realization that photons are “real”; they carry energy and have momentum.

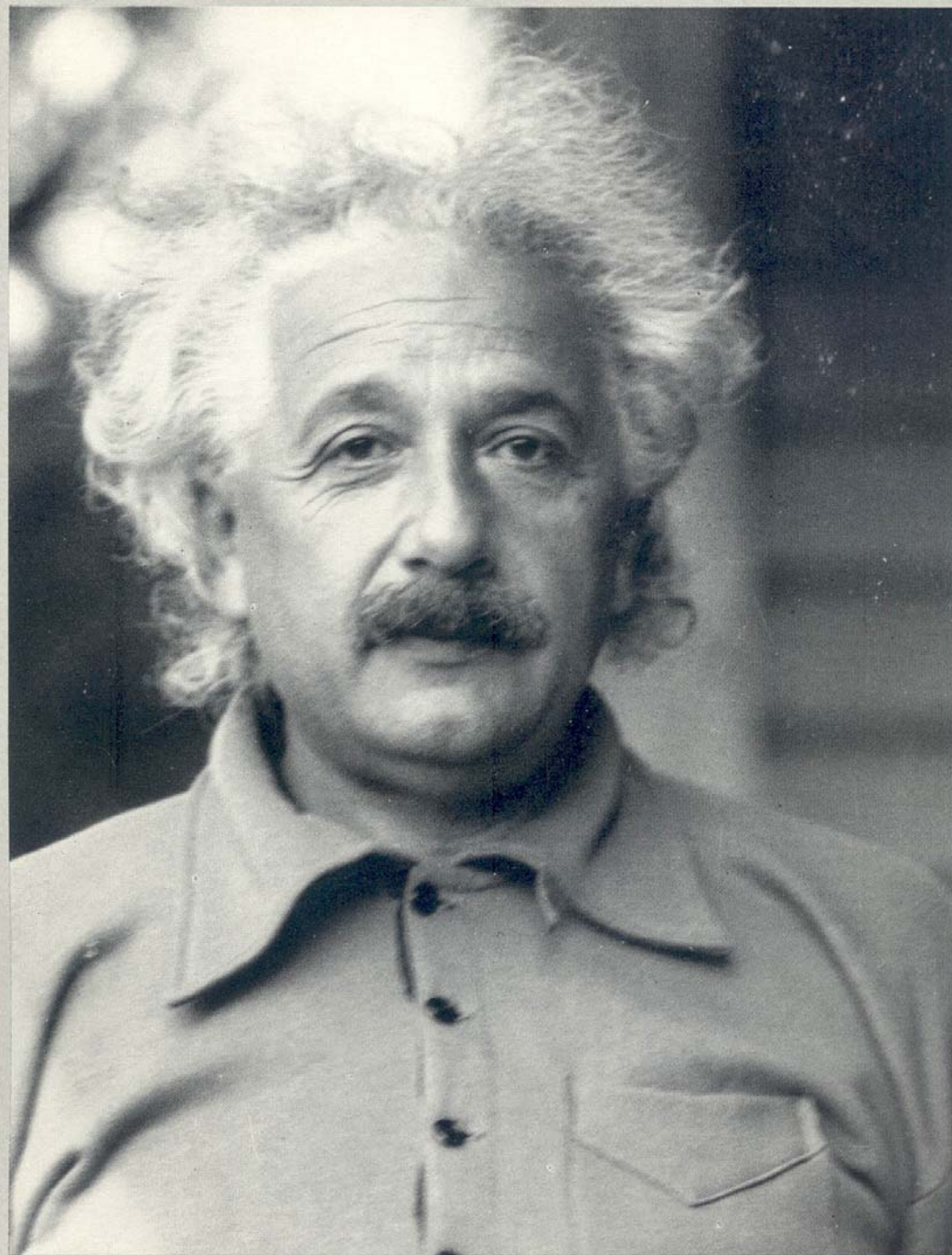
This was, of the 1905 papers, the most radical.

Planck, in 1913, advocating that Einstein become the director of the Kaiser Wilhelm Institute for Physics, in Berlin, in his very positive letter wrote, “...his theory of light quanta cannot really be held against him, for every innovation entails risk”

(And this was 8 years later! It wasn't until the Compton Effect, in 1922, that everyone accepted the photon concept.)

3. Photo-Electric Effect (1905)(Cont.)

- a) Radiation effect on betatron and synchrotron motion (radiation damping and ultimate emittance) (1955)
- b) Laser cooling (1990)
- c) Photo-cathodes (1995)
- d) Many particle detectors.....



“Everything that is really great and inspiring is created by the individual who can labor in freedom.”

“The Lord God is subtle, but malicious he is not”

4. A and B Coefficients (1916)

Let N_a be the number of atoms in lower level a.

Let N_b be the number of atoms in upper level b.

Let $\omega_{ba} = (E_b - E_a)/\hbar$, be the transition frequency.

Let dN_{ab}/dt be the transition rate.

Let $\rho(\omega_{ba})$ = energy density of radiation per unit angular frequency range.

Then:

$$dN_{ab}/dt = A N_b + B N_b \rho(\omega_{ba})$$

and, as Einstein showed: $A = (\hbar \omega_{ba}^3 / \pi^2 c^3) B$

There is a direct relation between spontaneous and stimulated emission

4. A and B Coefficients (1916) (Cont.)

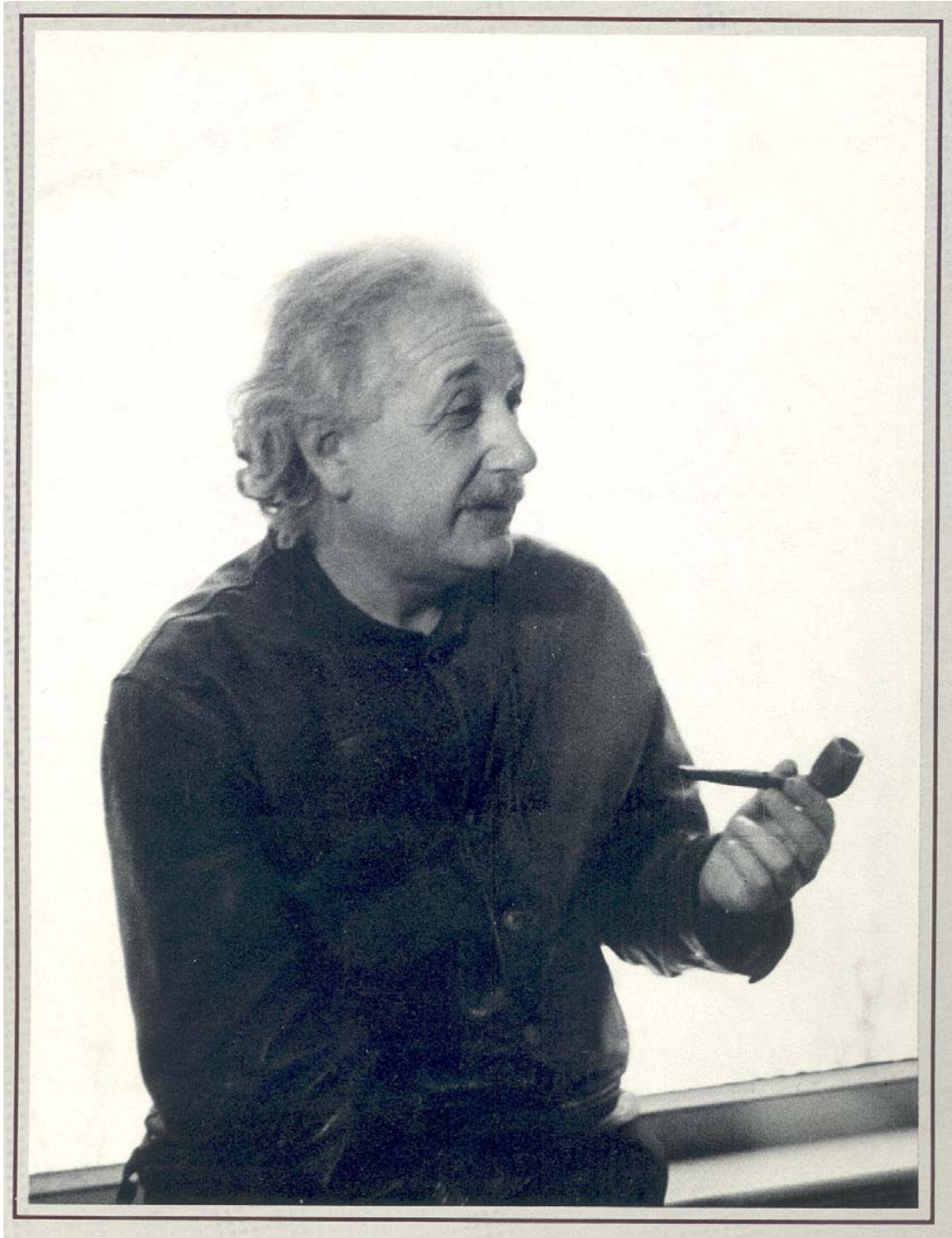
The very concept behind the laser and, hence, any use of lasers, such as in:

- Laser alignment (1960s)
- Laser cooling (1990)
- Laser acceleration (1979)

The Madey Theorem (1971) (The gain spectrum is the derivative of the spontaneous emission spectrum; i.e., there is a relation between stimulated and spontaneous emission, which is just the Einstein concept.)

5. General Relativity (1916)

- a) Larry Jones and I did an analysis in 1956, using general relativity, of why storage rings would work despite gravity!
- b) John Bell and J. Leinaas analysis of the ultimate polarization in a storage ring (1983). An accelerated electron sees the vacuum photons as a gas at a temperature
- $$T = \frac{\hbar a}{2\pi k}$$
- (Hawking, Unruh radiation), where k is Boltzmann's constant, and a is the acceleration. The electron is shaken up by these photons and that limits the polarization to less than 100%.
- c) Jie Wei's derivation of beam frame equations (1993).
- d) Some suggested experiments to use accelerated particles to study general relativity. (Nothing has come of these ideas.)(1990s)



“Wisdom is not a product of schooling, but of the life-long attempt to acquire it”

“It is a precarious undertaking to say anything reliable about aims and intentions.”

6. Family Life

Married Mileva Maric in 1903 (although they had a child prior to that, which they gave up for adoption, and all records are lost) Perhaps, there are lots of little Einsteins running around. Later they had two sons; the first born on May 14, 1904.

Mileva suffered from depression: **“If I could only give you some of my happiness so you would never be sad and pensive again”**. (1901)

Their marriage was not good. **“The situation in my house is ghostlier than ever: icy silence”**. (1913)

Separated in 1914 (and he was pleased to have quiet and peace while working out general relativity).

6. Family Life (Cont.)

Divorced in 1919 (and he agreed to give Mileva the Nobel Prize money when he won it: 30,000 kroner).

He started an affair with what was to be his second wife, Elsa, in 1912. (Note: He separated in 1914.)

Married cousin Elsa in 1919 (she had two daughters 20 and 18). Elsa died in 1936. Einstein never re-married although he lived until 1955. (Remark made soon after, and, unfortunately, typical, **“I have settled down splendidly here....”**)

6. Family Life (Cont.)

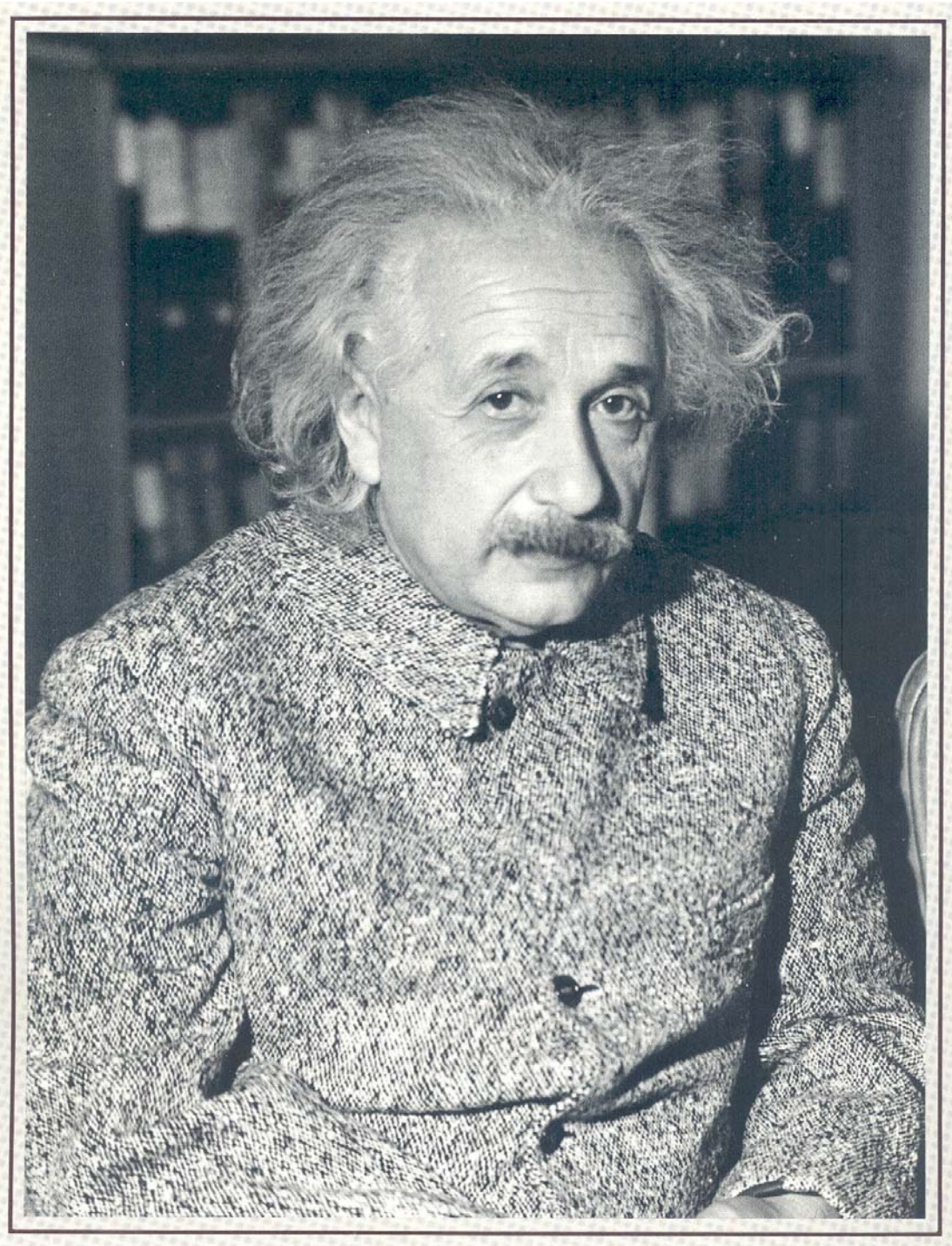
Einstein quotes on marriage:

“ALL marriages are dangerous”

“Marriage is but slavery made to appear civilized”

“Marriage is the unsuccessful attempt to make something lasting out of an incident”

“I have survived two wars, two wives, and Hitler”



"All means prove but a blunt instrument, if they have not behind them a living spirit."

"There is nothing divine about morality; it is a purely human affair"

"Gravity can not be held responsible for people falling in love"

7. World Peace: Pacifist, Atomic Bomb, Arms Control

“I made one great mistake in my life - when I signed the letter to President Roosevelt recommending that atomic bombs be made...”
(1954) (Note: Not referring to the cosmological constant.)

- a. Manifesto of the 93 and Manifesto to Europeans (1914)
- b. Pacifist during WWI. (His salary support, however, was from those who supported German militarization.) His pacifism caused him problems in Germany both during and after the war.
- c. The “two percent” solution to war (1930). (Refuse to fight; flood the jails.)

7. World Peace: Pacifist, Atomic Bomb, Arms Control (Cont.)

- d. His revulsion towards Nazism caused him to give up pacifism. (A pro-Nazi paper, in 1930, put 50,000 Marks on his head. Einstein replied, **“I didn’t know I was worth so much”**)

- e. On Oct 1940 he became a US citizen. He was delighted and offered to even give up his cherished sailboat if that was required. In July, he had been denied clearance (he didn’t know that in Oct). Thus he was never privy to the work at Los Alamos. (His FBI file was 1,800 pages long.) He worked on naval problems during WWII. George Gamow was the go-between. Einstein remained in Princeton, but on Fridays did naval work. Mostly he reviewed the proposals of others.

7. World Peace: Pacifist, Atomic Bomb, Arms Control (Cont.)

f. However, through conversations with Otto Stern he knew, in general terms, what was going on in Los Alamos, and in December 1944 he wrote a long letter to Niels Bohr advocating **“internationalization of military power”**

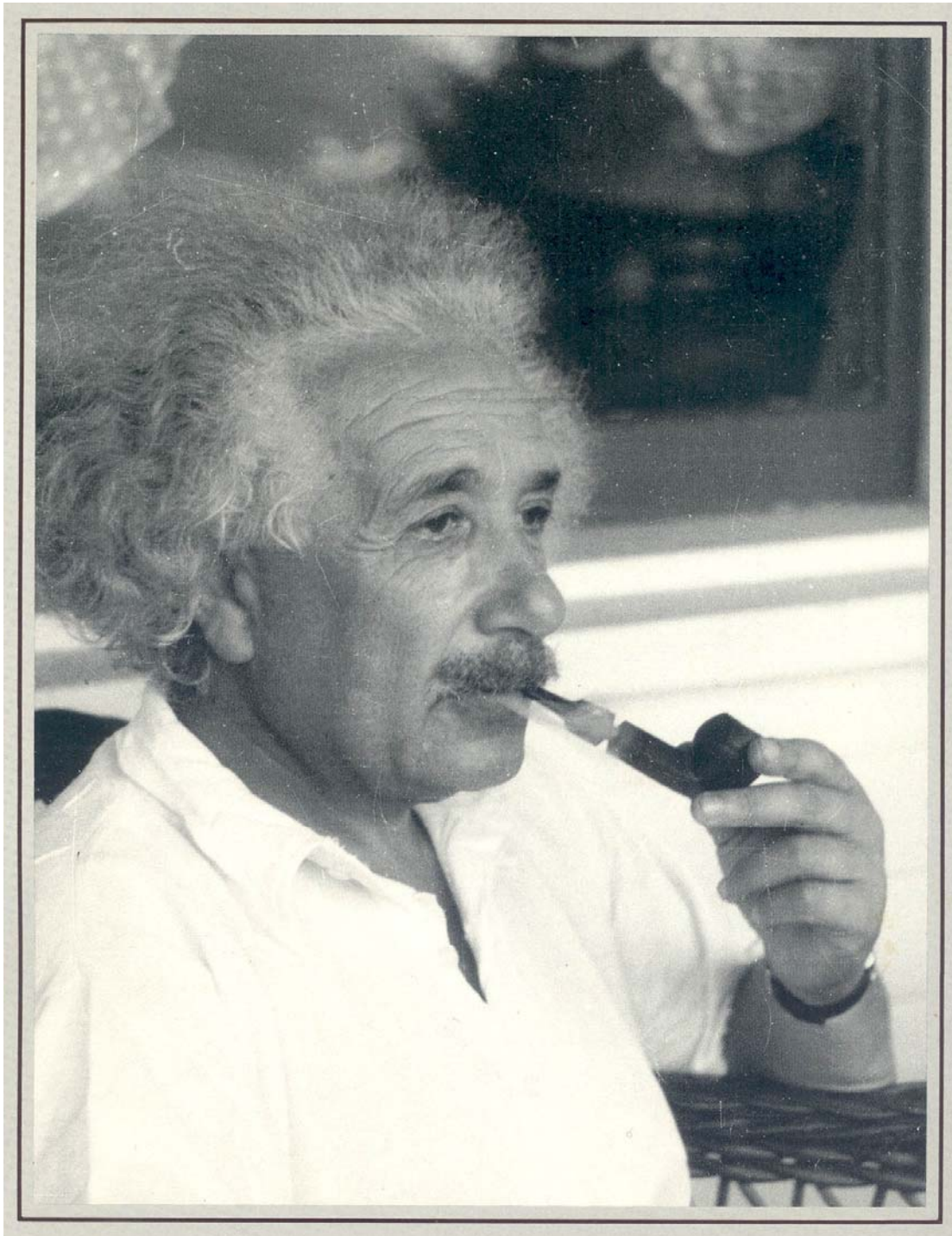
g. Einstein joined Szilard in urging President Roosevelt not to use the A-bomb on people, but his letter was found un-opened on Roosevelt’s desk after Roosevelt’s death.

h. Einstein asserted that he never had worked for the military. (Clearly not true and the generous view is he completely forgot -- pushed to the back of his mind -- his naval work during WWII.)

7. World Peace: Pacifist, Atomic Bomb, Arms Control (Cont.)

- i. In 1946 Einstein became the first chairman of The Emergency Committee of Atomic Scientists. (Members such as Linus Pauling, Hans Bethe, Vicki Weiskopf.) This was the start of the Federation of American Scientists.

- j. The Bertrand Russell-Albert Einstein Declaration (concern that nuclear weapons would be used in any world war and a call for the repudiation of war as a means of settling disputes) was initiated by Russell in Feb, 1955. Einstein worked on it through April 11 (He died on April 18) This Declaration was the start of Pugwash.



“We must overcome the horrible obstacles of national frontiers.”

“My life is divided between equations and politics”

8. Humanitarian: Social Justice, Anti-Racism, Civil Rights

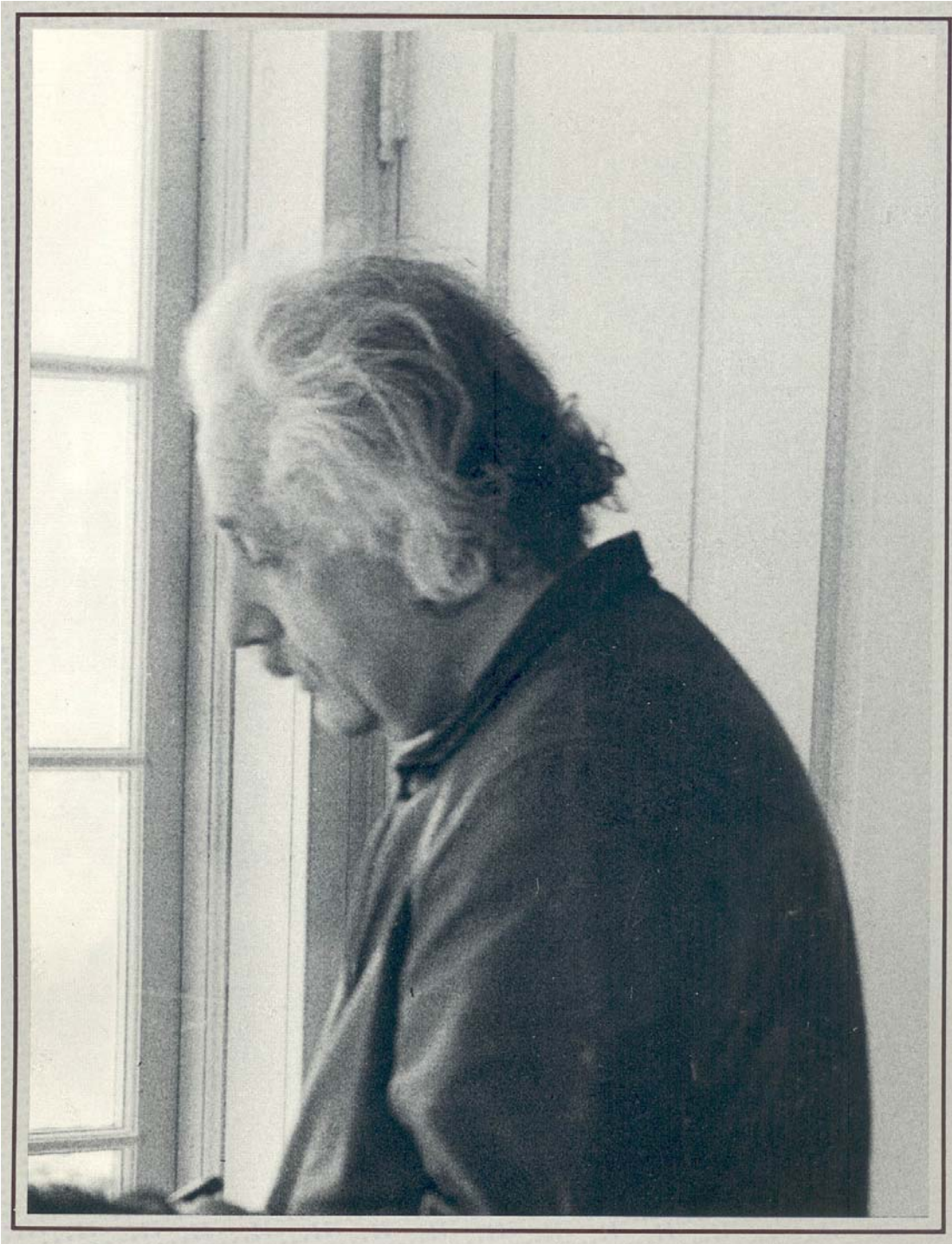
a. Even as early as 1922, visa problems getting into the USA.
(Not naive at all.)

b. In 1953, an open letter, published in the New York Times:
“However, this refusal to testify must not be based on the Fifth Amendment, but on the assertion that it is shameful for a blameless citizen to submit to such an inquisition...” The claim that it is wrong to obey the law, when it is a bad law, brought strong reaction.

c. Published only after his death: **“I want to suggest that the practices of those ignoramuses who use their public positions of power to tyrannize professional intellectuals must not be accepted..”**

8. Humanitarian: Social Justice, Anti-Racism, Civil Rights (Cont.)

- d. In reaction to McCarthy, and the denial of clearance to J. Robert Oppenheimer, in 1954, “If I were a young man again....I would not try to become a scientist or a scholar or a teacher, I would rather choose to be a plumber or peddler, in the hope of finding that modest degree of independence still available under present circumstances.”
- e. “Curiosity is a delicate little plant which, aside from stimulation, stands mainly in need of freedom”
- f. “Gandhi, the greatest political genius of our time”



“One can organize to apply a discovery already made, but not to make one.”

“Concern for man himself must always constitute the chief objective of all technological effort”

9. Some Reflections

Einstein was often, in his physics and in his politics, at odds with the thinking of the time and, also, ahead of his time. Consider:

I need not talk of his physics; that is obvious.

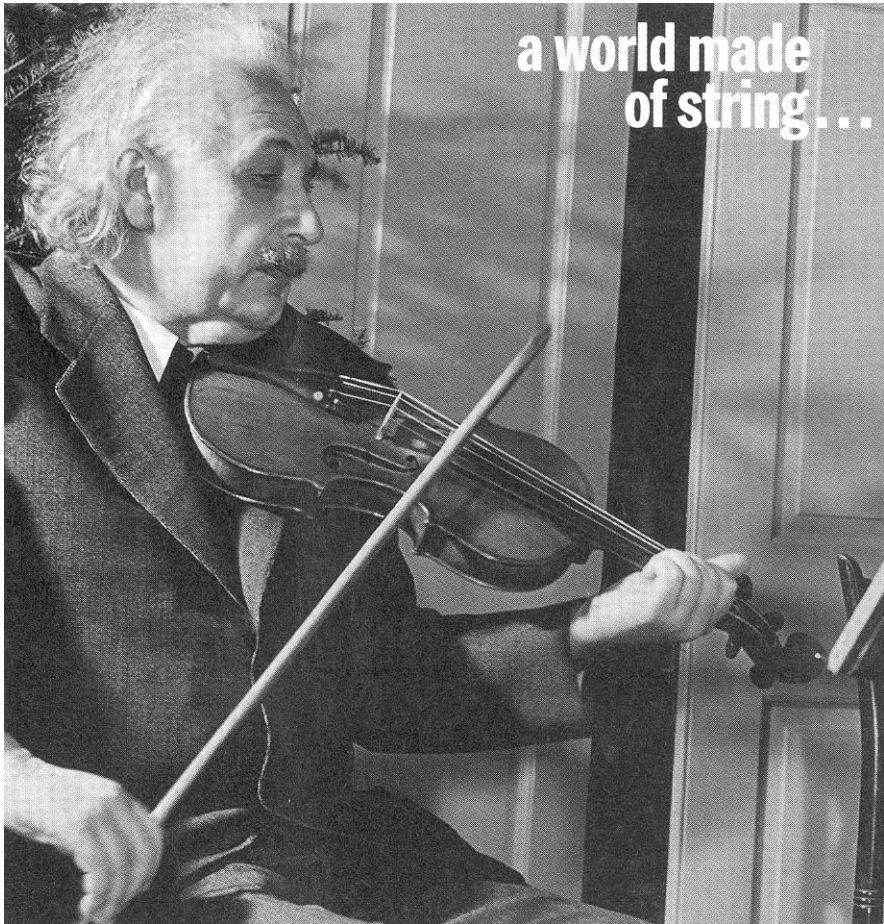
Think for a moment of how he was a pacifist in Germany during WWI, advocated no more wars in 1930 (the 2% solution), was for internationalization of the A-bomb in 1944 (letter to Bohr), was against using the A-bomb on people in 1945 (letter to Roosevelt), was for education about the A-bomb in 1946 (the creation of FAS) and advocated not using war to settle disputes in 1955 (the Russell-Einstein manifesto and subsequent creation of Pugwash).

9. Some Reflections (Cont)

If only Einstein were alive ! He would surely have opinion on, and be making statements about, (to name just a few):

Stem cell research, Missile defense, Intelligent design, Energy Sources, Global warming, Forest management and endangered species, Environmental health, The design of new nuclear weapons (“bunker breakers”), Teen-age pregnancy, Education in science, Human rights, The Iraq war....

The public, respecting him -- and hence respecting science -- might just listen, which would be a vast change from the situation today where no living scientist has the respect Einstein once had, and scientists are considered as one more interest group, and science is typically ignored in public debate and hardly figures in the making of policy.



"If you want to live a happy life, tie it to a goal, not to people or things"

"A table, a chair, a bowl of fruit and a violin.... what else does a man need to be happy!"