Interview with Alex Wellerstein

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Alex Wellerstein is an Assistant Professor of Science and Technology Studies at the Stevens Institute of Technology. He is interested in cold war technology and government secrecy and blogs his research at Restricted Data: The Nuclear Secrecy Blog. I interviewed him in April 2014 to learn about Leo Szilard and others' attempts to prepare for the advent of nuclear weapons, as part of MIRI's investigation into early efforts to avert predicted problems.

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How exactly did Szilard intend for his patent on the chain reaction to help? (Doesn't a patent usually make something more public? Did he expect German scientists to avoid studying nuclear weapons because they are patented?)

Szilard came out of a generation of physicists where patenting had just started to be an important way for the scientists to assert control over their work, and had become a means of making sure that any commercial benefits the work produced would be re-invested back into science. Szilard was already a prolific patent filer for this reason, perhaps even more so than the average physicist in the 1930s.

That being said, secret patents were unusual at the time. What Szilard appears to have been doing was drawing the idea to the attention of the British authorities in particular. Filing a patent like this and declaring it as needing to be secret was his way of demonstrating that the idea could be made into a concrete technology and forcing it to go through the kinds of channels that a military patent might be put through -- a place where you are guaranteed that security people and technical people are going to be scrutinizing it closely. He was hoping they would take interest in it enough to start funding a project to investigate whether it might actually work -- but they weren't.

Was the patent filed in such a way as to be secret until the war office took it, or how did Szilard expect patenting it to even look like it was helpful for making it secret?

My understanding regarding the patent is that when he filed it he explicitly requested it be kept secret. The patent law in question allows the inventor to assign weapons patents to the UK Crown and to have them kept secret. (Section 30 of the UK Patents and Designs Act of 1907:
http://www.legislation.gov.uk/ukpga/1907/29/pdfs/ukpga_19070029_en.pdf)

Was the patent useful in the end? How?

I don't think the patent ended up being very useful in the end, except so much as it helped keep Szilard interested in the topic, which put him in a good position once fission was discovered. I don't think it did anything for him or really did much for getting authorities interested in the topic. The “unknowns” were bigger than the “knowns.”

Given that there was a future risk of Germany having nuclear weapons, were Szilard's actions obvious ones to take? Were they reasonable? Should he have done anything else, in retrospect?

Szilard's approach was always to try and get official (Allied) interest (either the UK or USA), and to secretly pursue this work. So his patenting activities were always secret for this reason. He didn't think a patent would stop the Germans at all — just that it would get the "good guys" interested in the topic.

If Szilard had managed to interest the military with his patent, and get funding for such research, would the research he wanted to do have been useful? E.g. Would it have found fission earlier? Or was it on the wrong track because he was imagining a metastability related chain reaction?

Szilard's research plan involved shooting neutrons at a lot of materials and seeing if any of them created a chain reaction. It wasn’t a terrible idea, but he didn’t really know how the chain reaction would work, and wasn’t imagining fission would be the mechanism. Because Szilard wasn't thinking about fission, he was starting on the wrong end of the periodic table (he wanted to start with iridium, element 77, some 15 elements from uranium, element 92). I don't know how he would have done if his research was funded; he was not an especially clever experimentalist — he was better with ideas and theory. It is worth noting that by 1935, Fermi had already found that slowed (moderated) neutrons produced interesting radioactive byproducts in uranium. Neither he, nor Szilard, nor pretty much anybody else until Hahn and Meitner, realized that fission was going on, or that neutrons might be a by-product of uranium bombardment by neutrons. To me this is just a nice indication of how big of a cognitive jump fission was from what they were looking for or expecting — they expected nuclear transmutations to be on the order of a proton here or a neutron there, not a complete rupture of the nucleus.

I understand Szilard was concerned about German nuclear weapons when he took out the patent (is that correct?). Do you have any idea how far in the future he would have expected that threat? (e.g. did he think they might already be working on it, or that it was decades away?)

I don't think he was as concerned about the Germans in 1933-1934 as he was in 1939. He knew the Germans were bad — he had fled Germany when Hitler took power, just

before things got really bad for the Jews — but it wasn't obvious that world war was going to be the consequence. Again, given how speculative the patent was, I'm not sure how concrete a threat he thought it was. I don't think he thought anyone was working on his idea. Szilard prided himself on being ahead of his time, of thinking about the *next* big thing.

It sounds like other scientists broadly disagreed with Szilard about the promise of a chain reaction until about 1939. Is that right? Did some agree with him? Why did they mainly disagree?

The reason they weren't interested in it is an important one. It isn't that they were fools or unimaginative. It's that the patent requires the presumption of a nuclear phenomena that in 1934-1935 was not known to exist. This is the part that people often get very confused about: Szilard wasn't filing a patent on nuclear fission bombs or nuclear fission reactors. What he was filing was a patent that said, "if there is a nuclear phenomena that is triggered by one neutron and produces more than one neutron subsequently, then you could create a neutron-based nuclear chain reaction that would release a lot of energy and produce a lot of neutrons."

But he didn't know what the nuclear phenomena would be. Nuclear fission wasn't discovered until late 1938/early 1939. What Szilard was imagining wasn't fission — he was imagining something more like artificial radioactivity, where a neutron makes an unradioactive atom radioactive. In his scheme, a neutron would make an atom radioactive, which would make it release another neutron, or maybe two, which would then continue the reaction. This is more or less what he had in mind, though his patent describes many elaborations regarding substances that would work in tandem, hypothetical dineutrons and tetraneutrons, and linear (as opposed to exponential) reactions. These reactions would be low-energy, some of them wouldn't release energy at all, and the dineutrons aren't stable. There was a lot of confusion in his work on this topic — he had the germ of a good idea, but he also had a lot of bad and wrong ideas. And absolutely none of his speculations were supported by experiment.

So in 1934-1935, Szilard was — perhaps accurately — interpreted as kind of a crank. He was trying to drum up attention (and money) for a problem that wasn't at all clear it existed. That the British authorities humored him enough to make the patent secret is perhaps a demonstration of their patience.

But once nuclear fission was announced, Szilard was primed better than any other to realize that this nuclear reaction might actually be the candidate reaction he was looking for, since he had already been thinking about this problem for five years. He was able to quickly see which of his ideas had been good ones, and which had been bad ones.

However, even once fission was discovered/announced, it wasn't obvious it could be *weaponized*. There were plenty of quite brilliant scientists — like Enrico Fermi — who

thought in 1939 that the fear of fission-based bombs was still to speculative to worry much about, but it was just realistic enough a possibility, especially on the eve of war, that he found some limited success in convincing them to self-censor and to look seriously into the issue.

I find Szilard a tricky character, historically. He's half-crank and half-visionary. Maybe the definition of a visionary is a crank who later turns out to be correct? I don't think there was any good reason in 1934 to think that Szilard's idea was a workable one. However, once you add nuclear fission to the picture, it suddenly becomes quite obvious and brilliant. In retrospective, it is easy to see Szilard's patent application as visionary, but only if you filter out all of the wrong and confused parts of it.

How did Szilard's thinking about the problem on his own for years prepare him to respond after fission was discovered? How much did Szilard being ready to act help anything? (Was all that forethought worth it?)

When Szilard heard the announcement of fission he, in his recollection, immediately realized it could be a candidate for an exponential, neutron-based nuclear chain reaction. What he needed to know to be sure was whether the number of neutrons produced per fission reaction was more than one on average. He cabled numerous scientists and asked them to not publish on this possibility or the possibility of chain reactions. In the meantime he set up a small experimental apparatus to see if indeed "secondary" neutrons were produced from fission reactions — they were. His self-censorship campaign had a modest amount of success (he convinced US, UK, and Danish scientists not to publish on chain reactions) but he could not convince the French scientist Frederic Joliot. Joliot published the number of secondary neutrons detected (he found that uranium gave off 3.5 neutrons on average, which is 1 larger than the currently accepted number of 2.5) and commented that chain reactions seemed possible.

Even though the self-censorship regime failed, it primed the other physicists for thinking about weapons and power possibilities, and created the first serious system of publication review (for security purposes) amongst physicists. This continued to be in effect when the government started to look into fission problems and eventually transitioned into part of the secrecy regime of the Manhattan Project.

Did Szilard do other things to forward his side's nuclear technology around this time? I know about the Einstein-Szilard letter.

In terms of forwarding Allied interests in nuclear matters, his self-censorship campaign and his work to get official attention culminated in the Einstein-Szilard letter. He then worked with the Advisory Committee on Uranium, and later was part of the Metallurgical Laboratory at the University of Chicago. He helped build the first nuclear reactor, with Fermi, in 1941-1942. So he stayed active.

Is it true that the Einstein-Szilard letter was very influential?

The Einstein-Szilard letter's importance is in my view somewhat debatable. It was quite limited in its actual scope. FDR was already being steered towards coordinating work on fission -- his advisor, Alexander Sachs, had been aware of fission's possibilities. Sachs used the letter as the final excuse to get FDR's attention on the matter. What FDR did was authorize a very modest coordination of fission work under the auspices of the National Bureau of Standards. It was absorbed into Vannevar Bush's National Defense Research Committee (NDRC) in 1940. I suspect that had the Advisory Committee on Uranium not been created in 1939, a similar committee would have sprung up organically within another part of the government (e.g. the Naval Research Laboratory, which was already looking into these matters, and certainly by the time the NDRC was created). The work of the committee was not to work towards building an atomic bomb — it was simply to finance experiments that would help determine whether atomic bombs or atomic reactors were feasible for the current war. By 1941 or so, the US conclusion was that nuclear reactors were probably feasible but bombs were probably too difficult to demand the effort that would be required.

The real turning point in the US program had nothing to do with the Advisory Committee at all. In 1941, scientists in the UK (in a similar committee) had concluded that atomic bombs might not be very hard for the US to build at all (but too hard for the UK), and had sent a report to the US explaining this. The chair of the US Advisory Committee did not share the report. An emissary from the UK eventually came over to see what had happened to the report, and instead spent his time convincing several important US scientist-administrators, most notably Vannevar Bush, of the report's conclusions. Bush then staged something of a coup to wrest control of fission research from the original Advisory Committee and to accelerate the research program. By late 1942 it was decided that they should move the program into a production phase and the Army Corps of Engineers was brought in — this is when it became the Manhattan Engineer District, and thus the Manhattan Project, and became a bomb-making program.

So the point here is that the impetus for the Manhattan Project did not really come from the Advisory Committee and thus really didn't come from the Einstein-Szilard letter. It came from a completely different source — the British. If the Einstein-Szilard letter had never been sent, and the Advisory Committee had never been created, I doubt it would have affected anything much at all in the timeline of whether and when the atomic bomb was made, simply because it wasn't that influential on the timeline at all. Of course, this is speculative — there may have been other useful aspects of the Advisory Committee (e.g. it did involve getting several scientists involved who might have gotten tied up with other war work had they not been told about the uranium question). But I think it is worth emphasizing that it was not really the start of the Manhattan Project at all, and it

was not a bomb-producing program in 1939. The bomb-producing program did not really start until late 1942.

And a meta-question: are the answers to these questions fairly certain and well-known amongst scholars on the topic, or controversial and hard to be confident of?

Most historical accounts present Szilard as an unambiguous visionary and the Einstein letter as the starting point of the Manhattan Project. My approach attempts to be a bit more historical about these matters, looking at them in the context of their own time and not "smoothing" the narrative by removing the errors, hiccups, missteps, and so on. Amongst serious historians of science and serious historians of physics I do not think my account would be terribly controversial, though my interpretations are stronger than one usually finds in the historical narratives.

The problem is that much of the scholarship in this field is easily drawn into the drama of emphasizing the role of Einstein, Szilard, the individual scientists, etc. It's more fun to have Szilard be this great visionary who changed the direction of history and so forth. And he's a fun character to write about. So it is easy to make him take center stage. The fact that he also later became an opponent of the bomb and the arms race makes it an appealing narrative as well — the scientist who regrets his actions, etc. The fact that Einstein is always so front-and-center despite his really quite minimal role in this story (and the quite minimal role of his science in it as well — E=mc^2 matters a lot less to atomic bomb production than people generally realize) is further testament to the power of a good yarn.

But if you start drilling down into the narrative, beyond the more pop-history accounts, you find that Szilard's patent and his letter just weren't as influential in the long run. I think Szilard's most important role here is his self-censorship campaign, which did get the scientists thinking concretely about secrecy and security and did result in the creation of what became very long-term institutions of secrecy. I think it is fair to say that among serious historians of this topic, the real emphasis is on the importance of the *institutions* that were being created — both Szilard's secrecy institution and the importance of someone like Vannevar Bush, who was probably the most important single person with regards to getting the Manhattan Project started, since he was the only person who really had the power and will to move the program from a small experimental investigation into a full bomb-production program. Where more popular accounts of the bomb focus on individual ideas or people making the key contributions, the more scholarly, academic accounts focus on how the big systems of production that got the actual results were created.

Would you mind telling me more (or directing me somewhere to read) about the secrecy institutions, or any other important institutions that were

created? Do you know if these things were intended to last a long time, or if that was just a side effect of dealing with near-term problems?

Spencer Weart's "Scientists with a Secret" is a nice article about Szilard's secrecy system and the publication screening system that came with it. The evolution from this to the Manhattan Project is described in the first few chapters of my dissertation and will eventually be put into book form. The main trajectory is that the secrecy started as "self-censorship" (individuals) and then something like "community censorship" (physics journals). It transitioned under the NDRC/OSRD period into "civilian secrecy" — government secrecy but under entirely civilian auspices. When the Army took over it became "military secrecy" of the sort we are familiar with. The transition between "self-censorship" and "military secrecy" was gradual between 1939 and 1943, and reflected increasing institutionalization of the bomb program itself as it moved through its various stages.

The people who were erecting the self-censorship, civilian secrecy, etc. thought it would be temporary. Even the military planners expected most of the secrecy to be ended shortly after the war. That the bomb secrets became "perpetual" secrets was not something considered to be a feasible policy for postwar control, but that's what ended up happening for a variety of reasons.

When Vannevar Bush moved the program into bomb-production, do you know how likely it seemed then that bombs could be made in a small number of years?

In late 1942 when Bush made the final push for a bomb production project, he thought it would cost $400 million and that "bomb production should start about the end of 1944 or the beginning of 1945." The actual cost was $2 billion (so 5X the Bush estimate) and the bombs were not produced until mid-July 1945. So he was quite wrong on the expense but not too wrong on the timing (the latter of which is something of a coincidence, because they didn't end up doing it quite as Bush thought they would). He asked for the money under the assumption that the likelihood of success was very high at that point (he wouldn't have pushed for it if it wasn't).

On Szilard's regret, I read that he expected attacking the Japanese with nuclear weapons to produce an arms race, and so petitioned against it. Do you know an arms race was actually a big concern of his, or if it's just easy to emphasize it later when it turned out to be correct? Do you know if not attacking them is considered likely to have actually helped with this?

Scientists like Szilard, Niels Bohr, and Vannevar Bush did explicitly worry about a nuclear "arms race" during World War II. Here they truly were visionary, seeing very clearly what kind of dynamic it would create for one country to suddenly have a new weapon, and how this would drive others to acquire the same weapons. Bush lobbied the

Secretary of War, Henry Stimson, very hard during the war to embrace a system of "international control" of the bomb for after the war. Basically this would involve creating the institutions of non-proliferation before anyone else even had the bomb and would involve the US getting rid of its bombs. Bush thought that secrecy and independent development would lead to a very dangerous situation — that of unannounced nuclear nations.

Here are excerpts from what Bush wrote Truman in late September 1945:

> Down one path lies a secret arms race on atomic energy; down the other international collaboration and possibly ultimate control. Both paths are thorny, but we live in a new world and have to choose. ... It is impossible to maintain full scientific secrecy in this country without altering much of our usual way of life. ... It should be emphasized that the move does not involve 'giving away the secret of the atomic bomb.' That secret resides principally in the details of construction of the bombs themselves, and in the manufacturing processes. What is given and what is received is scientific knowledge. Under an attempted closed system, and scientific espionage, it is probable that Russia would benefit to a considerable degree by our scientific progress, and we would benefit little by hers. Moreover, we cannot keep scientific secrets from Russia without also keeping them from the major portion of American scientists. In this sense it is doubtful if the move actually involves giving away anything at all. It may also be argued that the move involves giving away the gun on our hip as we carry on difficult negotiations. Actually there is no powder in the gun, for it could not be drawn, and this is certainly known. ... A secret race on atomic bombs can lead to a very unhappy world.

The idea of "international control" was very common, even among military men, in the early postwar. It was not until things started going very sour with the USSR that people abandoned it, and eventually thought it a bizarre notion. For the scientists who worked on the bomb, a scenario where multiple countries were secretly developing their own nuclear weapons was the worst of all possible worlds.

Do you know of any other historical cases where a person or group may have predicted a problem many years in advance, and done anything useful about it?

On other cases of imagining things in advance — at the end of WWII it was predicted by many that "push-button" war (e.g. with nuclear-tipped rockets) would be something to deal with in the near future. But little was done about it in any sense other than investing in the technology. They also knew that a hydrogen bomb might be feasible; some pursued it, though most did not.