"Immediately after the explosion I fell asleep"

An interview with Wolfgang K. H. Panofsky

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INHALT

"IMMEDIATELY AFTER THE EXPLOSION I FELL ASLEEP"

An interview with Wolfgang K. H. Panofsky
With questions from Michael Schaaf and Hartwig Spitzer
Hamburg, 6 July 2006

When did you decide to study physics?

Well, actually that was sort of a silly situation. I came to the United States in 1934 and my father[1] made the arrangement for teaching a course in art history at Princeton University in exchange for free tuition for his children. We were enrolled at Princeton University while I was only fifteen. I had not finished the *Gymnasium*[2] in Hamburg and I knew very little English. It was simply natural for me to start science and engineering, not because I was that terribly interested but because it was something I didn't need much English to undertake. I was always interested as a child in building things with my hands, but in the *Gymnasium* here in Hamburg they taught no physics until I left.

Until when?

Until I was fifteen, until the Untersekunda.[3] No *Naturwissenschaft*[4] at all! It was all history and classical education. So I started studying physics as sort of a path of least resistance in Princeton. But then I got very interested and Princeton gave the opportunity to write an experimental paper as an undergraduate student. So I started working. There was a cyclotron operating and so I started doing some radioactivity measurements on the cyclotron and one thing led to another. And then there were some very good people. I studied quantum mechanics under Wheeler[5] and I got very good grades, then I graduated in physics. At Princeton I wrote a thesis on radioactivity measurements – and then one on the theory of the vibration of a piano string using Fourier analysis. You see, a piano, to the first approximation, doesn't work at all because when you hit it that point becomes the centre of oscillation but at the same time the hammer immobilizes the point at which you strike it – a piano works only in second order. It doesn't work in first order. Anyway, then I went to Caltech for graduate study. Caltech had a very rigorous curriculum on problem oriented things and I wrote my thesis on precision x-ray measurements. Then the war started and I started doing military research.

We are now already well into the 1930s.

My parents were totally uninterested in physics. My father and mother called the two children always "die Klempner."[6]

When you were still in Hamburg, how did you experience the transformation of power to the National Socialists? Was there a change in the behaviour of the friends at school or the teachers?

Oh, yes, it was terrible! Firstly, all the Johanneum[7] people were fairly decent. But when the Nazis came – that started already in 1933 – when the teachers came into the class room they would say "Heil Hitler!" at the beginning of each class. The students in the beginning thought it was very funny and we would try to annoy the teachers by continuously greeting them with "Heil Hitler!", so they never got their arms down. But then I was a *Nicht-Arier*[8] and we were banned from any athletics because that implied physical contact with 'Aryans' and that was considered to be improper. So, the Jews were asked to form their own sports association, which did athletics and played soccer independently.

Was that part of the school program?

No, that was at the "Sportgruppe Schild". It was an independent athletic association.

One of the scholars that were expelled from Hamburg University like your father was the physicist and later Nobel Prize winner Otto Stern.[9] Did your father or you know him?

Yes, but my father knew him a lot better than I did. I mean this is a funny thing. They were colleagues. I learned about his experiments much later, not here in Hamburg. He was just a personal friend. But then he retired – he was expelled – and he lived in Berkeley while I was working there – after the war I was working in Berkeley. We visited him several times but he somehow lost interest. He very rarely came to the seminars in Berkeley.

You mean he lost interest in science?

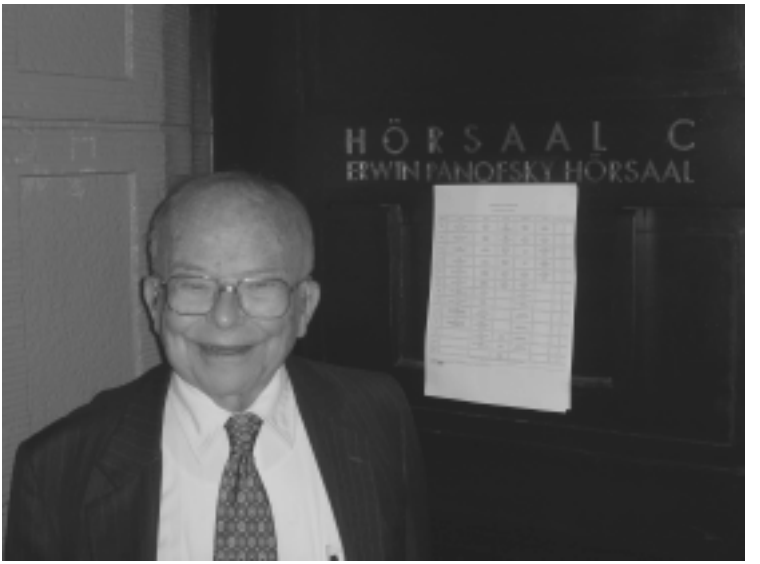
Yes, or at least he lost interest in any social interaction. He lived in a comfortable place and enjoyed food and drinks etc. but he never did anything in physics again. And I really never understood why. I visited him a few times and talked to him about my work after the war.

Do you think the language barrier could have been the reason for his lost interest in science?

No, I don't think so. Maybe, but he lived in Berkeley and he had a housekeeper.

That already answers my next question. Your father – although he came from the humanities – had contacts to natural scientists as well?

Oh yes, he did. Once, later in Princeton, he knew Einstein quite well and they talked a lot about mysticism and historical things. I was the chauffeur because neither Einstein nor my father drove and I did. So, I would drive the car around when my



"I am a 'Klempner.'"
Wolfgang K. H. Panofsky at the door of the Erwin Panofsky lecture hall, University of Hamburg, 6 July 2006

father was talking with Einstein about the philosophy of science and about ancient mysticism and whether there was any correspondence between ancient mysticism and modern science.

Where did you take them?

We just drove around Princeton. I can tell you this one story: We drove on one of the big highways and a policeman stopped us. And I thought I had done something wrong, but the policeman said: "Oh, I just wanted to look at the great man!" He just stopped us because he wanted to take a look at Ein-

stein! Intellectually I had nothing to do with Einstein and I had nothing to do with Stern.

How did you experience Einstein as a person? You were quite young at that time?

I was very young. He was a phenomenon and very famous. Much later, in Berkeley, I once gave a seminar on proton scattering and he listened but he didn't say anything. I'm an experimentalist – I mean I'm a "Klempner."

In February 1939 the news spread – also in the United States – that Otto Hahn and Fritz Strassmann had discovered nuclear fission. At that time you were a student at Caltech.[10] Who told you about this discovery and what was the reaction amongst the students and lecturers?

There was not very much reaction. I went to a lecture once, and I'm now rather vague what the occasion was. I went to a lecture by Fermi[11] – whether he was a visitor at Caltech or whether it was a seminar somewhere else I'm somewhat confused – but he actually made an estimate of the critical mass of an uranium explosive on the blackboard. That was before I had anything to do with it. So, I knew that such a thing was possible and I knew that there were several neutrons per fission and I knew therefore that a basic mechanism for a chain reaction existed. But I didn't pay very much attention. When

the war started, military work was organized at Caltech – but Caltech mainly worked on the development of rockets under Charles Lauritsen. I worked on improving the accuracy of antiaircraft fire by measuring shockwaves from supersonic projectiles. I didn't know that there was such a thing as Los Alamos and all that.

Well, that only started in 1943 anyway.

That's right. Before that was going on I was also teaching in addition to finishing my Ph. D. thesis on precision X-ray measurements. I wrote a textbook on electricity and magnetism together with Carl Anderson.[12]

The discoverer of the positron.

Yes. At that time there was a whole textbook written by Duane Roller and Robert Millikan which we thought was terrible. Anderson and I decided to rewrite it and so we wrote a complete textbook on electricity and magnetism for students. Then I met Jesse DuMond, that's my wife's father.

From the famous laboratory?

Yes. He was a famous x-ray physicist and I got my thesis working with him and I married his daughter. Then I got involved in the nuclear situation by complete accident.

Is it right that Luis Alvarez actually called you in 1943?

That's correct. What happened there was that in 1943 Oppenheimer[13] asked Luis Alvarez[14] to devise means by which the explosive power of the nuclear bomb could be measured. Luis Alvarez who, as you know, was a very ingenious man, didn't like to do things if somebody else had already done it. So, he started reading some of the reports which had been written by DuMond and myself and some other associates measuring the shockwaves of supersonic bullets and he said: "Hey, those guys have already done what Oppenheimer had asked me to do!" He made arrangements to have me come to Los Alamos. I already had some security clearance for much less sensitive military work.

But you worked from Caltech for Los Alamos?

I worked from Caltech. I would go back and forth. I would in fact take the instruments which we had developed at Caltech for measuring the shockwaves and then I was the only one of the Caltech group in addition to DuMond who was given clearance to know about this. I went back and forth from Caltech to Los Alamos carrying instruments back and forth. At Los Alamos I simply adapted the instruments which were used to measure the shockwave from supersonic projectiles and adapted them for the nuclear purpose. At the same time Oppenheimer had a big fight about this. He did not permit

any compartmentalization of information. Anybody who had clearances could go to all the discussions. So, I was invited – while I was in Los Alamos – to listen to all the discussions about nuclear weapons design. I understood very little because I was very busy making these other things work.

That's where all the famous physicists participated.

All the physicists where there and I was sitting there. I mean, everybody who had a color-coded white badge would go to these meetings, so I learned quite a lot. The only thing I did technically was make these devices for measuring the explosive power. We developed a theory for the actual shape of the shockwave. That's a published paper. The shockwave had a vertical front, then a rarefaction and then again a very steep negative edge to it. It had a shape of the letter N. Then we devised a way that these detectors would calibrate themselves because they had a frequency response that goes from zero to about 25 kHz. So, by simply changing the static pressure you can automatically calibrate them. Then I participated in the Trinity test in July of 1945.

You were in a plane if I'm informed correctly?

Yes. We hoped to drop the devices but the weather was very bad. In the last moment Oppenheimer got worried that the yield was not predictable.

So, it might be too strong?

It might be too strong, so he ordered the airplane to be at a distance larger than 25 km from the explosion. At that distance it made no sense for us to drop the device.

What was your impression of the explosion?

Well, we had worked very hard in getting ready for this. We were very tired. Everything was ready to actually drop the device. Frankly, the thing was: We took sketches of the mushroom cloud and so forth and immediately after that I fell asleep. People now ask these questions: What was your impression? And people assume that everybody would think that this was a critical moment in history – which it was – but everybody had been working like a dog, everybody was tired. 45 million people died in World War II and somehow this discontinuity in history didn't impress itself on you till somewhat later.

How much later?

That depends on the people.

And in your case?

Right after the war I went to Berkeley with Luis Alvarez and I immediately got very worried about the atomic bomb.

But before, when you got involved in the project, were you concerned the Germans might work on the same thing?

"Right after the war I immediately got very worried about the atomic bomb."
Michael Schaaf, Wolfgang K. H. Panofsky and Hartwig Spitzer

I know this sounds terrible. To me it was just another wartime assignment. I was working for one military project and by a technical combination this turned out to be useful for the other project and before all this happened I did not worry about the Germans or the Japanese or anything.

So you didn't feel the difference in quality?

No, because I knew little about the atom bomb beforehand. I knew there was such a thing, but I didn't know what Los Alamos was doing. I was working on these peripheral things

and I simply beforehand was not worried about it very much. It is very hard to translate oneself into the wartime atmosphere. At that time basic physics in the United States had stopped essentially. Except for some teaching essentially all the active research people in physics were doing military work. There was this very big organization OSRD (Office of Scientific Research and Development), and people worked on radar and on rockets and on submarine detection and on anti-aircraft guidance – many of the senior people who were leading these various activities were also working on the nuclear weapons. I am an honest man. It did not impress me as being a discontinuity in military power until after it happened.

I did not get the answer on when you later started to get active.

I started to become very agitated about it after Hiroshima and Nagasaki when the total number of casualties became clear. Then I moved to Berkeley and in Berkeley I started to become very active, giving talks to labour unions and service clubs.

So that was your political awakening?

That was essentially a political awakening but it wasn't really political. At least I didn't look at it being political. I was looking at it as a need to explain to a lay audience about the fact that a factor of a million in explosion power means something! I was trying to explain the tremendous discontinuity between

a conventional explosive and nuclear weapons. I started running around and giving talks about explaining that. And I joined an organization called the Northern California Association of Scientists which was a branch of what later became the FAS.[15] It was a somewhat disappointing experience. I remember giving a talk to a labour union meeting and some big steel worker came up and asked me: "Who are you? Some kind of a commie?"[16] My attempt to explain the technical discontinuity of the advent of nuclear weapons didn't work very well. I did a lot of it, but it was a disappointing experience.

Did you discuss it with your father?

No, because we were 3,000 miles apart. My father took a very critical attitude. I don't know whether you know the famous story. My father lived next door to John Wheeler, who was one of the main people who worked on the nuclear reactor in the early days, and an FBI man came to us – my father – to renew John Wheeler's security clearance. He asked: "What do you think of your neighbour?" My father said: "He is a mass murderer." So, the FBI man wrote down "mass murderer." The FBI man continued: "Do you have any reason to doubt his loyalty to the United States?" My father said "no," and the FBI man went away. The FBI man was sufficiently stupid that he did not understand the point of the whole conversation.

No, to be serious, I talked to my father and he was very negative about it but he didn't understand much about it and I tried to explain it to him. My own awareness came immediately after the events but not before and not during them. Even afterwards I didn't think much about it. I was aware when at Los Alamos a petition from Chicago was circulated asking first for a demonstration explosion open to the world public, but I didn't think about it very hard. Then I really got involved and got perturbed about it by two events, one was the Oppenheimer hearing. The fact was that everybody in Washington – interestingly enough most of the programme officers who supported high energy physics were very liberal people and they were working for the Atomic Energy Commission – were terribly upset about the Oppenheimer treatment and the nature of the hearing and the unfairness of the hearing. I signed various letters about it.

When did you come back to Germany for the first time after the war?

Keine Ahnung.[17] I really do not remember that.

Do you have any recollection of post war Germany? Did you visit the destroyed city of Hamburg?

I was in Hamburg only after it was completely rebuilt. I have seen terrible pictures and found it very shocking.

In 1965 was a conference where you gave a talk. Wouldn't that have been the first time or did you see Jentschke[18] before in Hamburg?

The first time I went back to Europe was in 1956, but I went to Russia. That was my first trip to Russia. Then in 1959 I negotiated with the Russians on arms control. But when I first went to Germany …

So, not immediately after the war? It must have been much later?

Not immediately after the war. I never visited Hamburg until it was rebuilt.

Did you have the opportunity to talk to some of the protagonists of the German Uranium Club like Werner Heisenberg or Carl Friedrich von Weizsäcker?

I was with Heisenberg on a committee about the future of high energy physics. We never talked about nuclear weapons. I was annoyed with Heisenberg because Heisenberg at that time was sort of anti-experimental. He thought he had the theory of everything. He had the famous non-linear differential equation.

That must have been after 1958.

Yes. So, I only had a fleeting contact with him. He was basically trying to sell this one particular equation which I thought was mildly interesting but had absolutely no experimental consequences which made any sense to me. So, I was sort of turned off to be frank. But no, the answer is, I did not talk to him about his work in Germany during the war. I did a lot of reading afterwards of material from an author who worked on

it in detail. I wrote a book review about a book called *Heisenberg's War.*

By Thomas Powers.

Yes.

After the war you were in California and worked at the Radiation Laboratory in Berkeley on elementary particle physics and the design of particle accelerators. In the early 1950s you worked on the neutral π meson together with Jack Steinberger.

That's right, on quite a few things. Firstly I worked on building the proton linear accelerator under Luis Alvarez. Then I did experiments at the proton linear accelerator, then I worked on the early π experiments. I did the well known experiment on absorption of negative pions in hydrogen and deuterium which gave the parity of the pions and the mass difference between neutral and charged pions and all that stuff. And then I joined Steinberger[19] on the synchrotron.

Who, by the way is of German origin, too.

Oh, yes. He was also an émigré, but he was a very different person. He vacillated between being a theorist and an experimentalist while I did hardly any publishable theoretical work. He wrote an autobiography recently. He didn't like Berkeley and Berkeley didn't like him. I remember once when we were both sitting there on a measurement of the π^0. Lawrence[20] ap-

peared bringing a congressman to look at the machinery. Lawrence said: "Could we shut down the synchrotron, so I can show this machine to the congressman?" Steinberger said: "I'm doing something important!" This was not a good way to have Lawrence love Steinberger and Steinberger love Lawrence. I knew Lawrence very well, he was very authoritarian.

Although you had very good working conditions you left Berkeley for Stanford in 1951. Why?

The reason was the loyalty oath. I was very productive in Berkeley. I was also doing some military work in Berkeley. Do you know what the MTA is?

No.

That is historically quite important to see what happened at that time. That was at the time of the Korean War. Lawrence got worried that the uranium supply into the United States would dry up because it all came at that time from Africa. He made several proposals to generate plutonium, firstly in a breeder reactor and then by using an accelerator to breed plutonium. He decided to build a pilot model of a machine to breed plutonium by having a very high average current linear accelerator producing a large number of neutrons. He wanted to build a machine to make about a gram of neutrons per year. The pilot program for that was secret and was at that time

called the Materials Testing Accelerator (MTA). That couldn't be fitted in Berkeley. There was an abandoned Naval station at Livermore. He proposed to first build a pilot section. Edward Lofgren built the ion source. I designed the linear accelerator and Harold Brown, who later became Secretary of Defense, built the target area. We actually got an average current of a quarter ampere of seven MeV protons. It was very difficult to build a target because the protons have a very short range and it is very hard to stop the beam. I did that as an avocation and to do a favor to Alvarez. Then started the loyalty oath campaign.[21] I was very unhappy about it. But interestingly enough the people who were most unhappy were people who had a strong European background because most Americans were unaccustomed to this sort of purgatory political climate, while people from Europe knew for instance that Mussolini had used the loyalty oath as a means of purging the academic world. I had all sorts of security clearances. I signed it but I went to many meetings opposing it. Serber[22] signed it. I did the same thing. Steinberger did not sign. He never had a job offer, so he left Berkeley anyway. There was no issue in his case. Gian Carlo Wick and Jeff Chew[23] did not sign it and got fired. I got mad and I told Lawrence I'm quitting. Lawrence was not happy. He took me to the head of the Board of Re-

gents and we had a discussion, which did not convince him and he did not convince me. I made it known that I was quitting and I had several offers and went to Stanford.

In May 1956 you joined the first American delegation of scientists that went to the USSR after the war.

That's right.

Some of its participants included Victor Weisskopf,[24] Luis Alvarez, Freeman Dyson,[25] Abraham Pais,[26] Murray Gell-Mann.[27] Whose initiative was it and what was the aim of the talks?

The Soviets decided – the initiative was entirely from the senior theoreticans like Landau[28] and others in the Soviet Union. They had secretly started Dubna. They had both started the accelerators in Moscow (ITEP)[29] and in Dubna, which is essentially the eastern socialist countries' equivalent of CERN.[30] They decided to break the iron curtain by inviting us and we went. Actually I travelled with Alvarez. Alvarez to me is an amazing person. He was in some respect very right wing. We talked a lot about things. He said: "After the nuclear bomb no war is possible anymore." He was always an absolutist in many ways. Then it turned out on the way that we had to make an emergency landing in Estonia. The Russians didn't know what to do with us there. Then we went on. We had a very good

"I was annoyed with Heisenberg."
Wolfgang K. H. Panofsky after the interview with Michael Schaaf and Hartwig Spitzer, Hamburg, 6 July 2006

time in Moscow and then went to Dubna. I've written many reports about it and so did other people.

Did you meet Igor Kurchatov[31] or Igor Tamm[32]?

I went to the Kurchatov Institute. I remember there having a discussion about the future of high energy physics. At that time I remember once I was visiting their research reactor. There was an interesting discussion as sort of a joke. Fermi had proposed to build an accelerator in orbit around the whole earth. One of the Kurchatov people asked me whether I had estimated how much that would cost. I gave him the answer: The sum of the Russian and American budget would pay for it in two years! They then changed the subject. We had many discussions about the future of high energy physics and co-operations. I was very much impressed by the work of Budker.[33]

The best accelerator physicist of the Soviet Union.

He was at that time still in Moscow. Later he started the institute in Novosibirsk. We became very close friends. At the meeting we talked very little politics. It was a real break in the iron curtain.

Did you speak to Landau as well?

No, but I shook hands with him.

Did the Russian physicists speak English or did you have to use a translator?

Sometimes. I became very well acquainted with Tamm, he spoke English. And Kapitza.[34]

Peter or Sergei?

Both. Well, that is complicated. Sergei Kapitza I met later because he translated my textbook. I had written the E&M[35] textbook with Melba Philips. She had been fired because she didn't want to testify before Congress and in consequence had no job, so I got hold of her and we wrote the textbook together. The Russians translated it without asking permission. When I went to Russia later they suddenly paid me 340 roubels. I couldn't take it out, so I bought an oboe for my daughter.

In these discussions with the Russian physicists did they speak openly – I mean also about political topics?

They were amazingly open. They tried to demonstrate their openness. We visited at their homes quite a bit.

Do you know that your talks took place only a few weeks after Khrushchev's famous secret speech at the 20th party congress which marked the beginning of the so-called thaw period? Could you feel that beginning of a political change?

There was no feeling of change politically. I mean there was a feeling of change of suddenly opening up by the Russians, see-

ing how much they accomplished. They accomplished a lot, but they didn't do much experimental physics. Their machines were designed terribly conservatively – over designed in some respect. Their actual instruments were largely copies from western experiments. It was sort of a mixture of technological accomplishment but not scientifically. They tried to demonstrate that they had no secrets. I remember one instance in Dubna. There was some magnet and I got interested in details how the windings were and how it was designed and I asked some questions. It turned out it was behind a fence and we couldn't get to it. Nobody had the key. Veksler[36] got mad and got a guy with an axe to break down the gate just to demonstrate to me that they didn't have any secrets. It was some dumb magnet. I mean it was not terribly profound – I was just asking some questions on some technical details of winding the coil and various completely unfundamental questions. But Veksler was absolutely insistent to demonstrate that there were no secrets anymore in high energy physics. Then we invited him back to the Rochester Conference. He gave a famous speech saying there are now three branches of physics: experimental physics, theoretical physics and diplomatic physics.

At about the same time – the mid 1950s – Oppenheimer asked the Atomic Energy Commission to do research on nuclear terrorism –

which, as we know, is still of some relevance now. He appointed you and Robert Hofstadter[37] with the task to write a report on that.

That's right.

What was the outcome of that report and is it still of relevance today?

This is a typical thing. Bob Hofstadter and I wrote the report. It was classified because it had all the details about the radiation from highly enriched uranium and plutonium. We just did all the combinations of particle x flowing in and particle y going out. The history was, that Oppenheimer was asked in congressional testimony: "How do you detect a nuclear bomb that comes into the United States in a crate?" He said: "With a screwdriver!"

That is why it is called the 'screwdriver report!'

Yes, Hofstadter and I got commissioned to answer the question if one cubic inch of highly enriched uranium or plutonium was hidden in a box, how would you detect it by nuclear means. We wrote this report and even today it is basically right. The physics haven't changed. You still can't detect a nuclear device unless you are close to it. We are wasting an enormous amount of money in the United States by building better and better detectors but the basics physics puts very severe limits as to what you can do. Of course the detectors

have improved some of the data. The accuracy of the results has improved enormously, but the basic physics is still the same. I don't know whether you know the American story how to catch a rabbit? In order to catch a rabbit you have to put salt on its tail, but while you are trying to do that you first have to catch the rabbit. It is the same with nuclear terrorism. The detectors are now improved but the radiation obeys the inverse square law; you can do all sorts of things to improve data analyses but you have to be there. The report got written and still I don't know whether it got declassified.

Later you were one of the scientific advisors to John F. Kennedy in the Scientific Advisory Committee.

First with Eisenhower.

Yes, but afterwards with Kennedy.

That's correct.

What was your main task and how much influence did you have? What was achieved?

The whole committee had enormous influence on many things! Firstly, the Scientific Advisory Committee helped Eisenhower to take nuclear test banning extremely seriously. Eisenhower had the idealistic concept that you could have scientists negotiate as official negotiators to lay the technical basis for arms control agreements which then politicians would negotiate

where the technical framework was immutable. That was a failure but in 1958/59 there were the conferences …

"Atoms for Peace"?

No, "Atoms for Peace" was separate. That was on nuclear reactors and so on. The 1958/59 talks were on the technical means of detecting nuclear explosions. I chaired one of the Technical Work Groups (TWG II) with the Russians on detecting nuclear explosions in space because Teller[38] had proposed that the Russians could cheat by carrying out nuclear tests by sending up one rocket to carry the nuclear weapon and then sending up another rocket with a detection gear. Both of them would be deployed at the correct distance of one another. I was asked by parts of the President's Scientific Advisory Committee to chair a committee of which both Bethe[39] and Teller were members to write a technical report in response to Teller's proposal of how to detect nuclear explosions in space. We wrote the report. It was in my biased opinion very important because for the first time we contradicted Teller by not saying: "If it can be done, never mind what it costs – the Russians would do it." But we used for the first time the question of value. If the Russians were going to do that … We wrote in the report basically that the scientific efforts to do that was so large that American security would

probably be improved if the Russians would use money for doing that rather than some other mischief. Teller signed that report! After we wrote that report we went to Geneva and discussed the same problem with the Russians. That was very influential.

Did you have direct access to Eisenhower or just by recommendations?

We met personally with Eisenhower several times. I met with Kennedy several times.

But with Kennedy you had the official job of a scientific advisor whereas with Eisenhower you were rather part of these committees.

No. Eisenhower appointed – after Sputnik – James Killian as the official science advisor and set up a President's Science Advisory Committee of which I was member. I met Eisenhower a few times. Later I was on the General Advisory Committee (GAC) to Carter on arms control. He had a separate arms control science advisory committee.

In 1974 you joined another American delegation of scientists to the Soviet Union to discuss questions of nuclear disarmament. On this occasion you visited Andrei Sakharov[40] in Moscow.

That's correct.

In his memoirs Sakharov writes about a walk with you through the nightly streets of Moscow discussing matters of arms control: "Die Ansichten des Delegationsleiters Panofsky kamen meinen eigenen

besonders nahe."[41] *Can you still remember what you were talking about?*

No. We both had the same idea that nuclear weapons are useless other than to deter the use of nuclear weapons by others. We met several times. At that time our National Academy founded a Committee on International Security and Arms Control (CISAC) and we would meet with the Soviets usually once or twice a year. Sometimes Sakharov was part of the Soviet group and sometimes he was not. I'm sorry, I just plainly do not remember that particular conversation. I didn't know he wrote that. That's very interesting.

He also mentions that in October 1987 you met again in Vilnius. Meanwhile Gorbachev was in power and Sakharov had been allowed to return to Moscow from his exile in Gorky. So that must have probably been a much more open atmosphere in general.

I know. I met Sakharov probably three or four times during these parts of these bilateral discussions sponsored under the auspices of the control group chartered by our National Academy of Sciences, of which I was a member (the chairman actually) – I'm interested in this reference. I mean, I'm not very learned in a historical sense.

"We agreed on many subjects."
Sidney D. Drell, Andrei Sakharov and Wolfgang K. H. Panofsky
at the SLAC Lepton-Photon Symposium in 1989

When you first met him in 1974 did he speak openly or was he cautious considering the fact that his flat could have been bugged?

No, he talked fairly freely. After talking to him in his flat I went back then and we met with some other Russians and he said: "The discussion you had last night may endanger our

mutual relations." Whether it was bugged or whether it was simply known that whoever went in and out – there were clearly informers there who would monitor who would cross the threshold of Mr Sakharov.

Did you both speak English or was an interpreter present?

It wasn't one to one. I think Paul Doty may have been there. I know I met Sakharov several times. I know we agreed on many subjects. We talked about lots of arms control. I think it was very rarely one to one except for that one walk in the woods.

Now, 60 years after Hiroshima, the nuclear threat still persists. Has the role of the physicist in other words his responsibility in order to overcome this threat changed over the years?

The answer is yes! One of the things which I find extremely depressing in the United States is that after the really very constructive interaction which we referred to with Eisenhower and then with Kennedy the role of science in general in interacting at the highest level has decreased. Of course the role of the physicist has been also somewhat diluted because the dangers are now also partially in biology and so forth. Therefore other scientists have more to say. I'm working with what is called the Jason group. Essentially all the advisory groups at the highest levels have been dismissed. I was a member of the advisory committee to the NNSA.[42] That got disbanded.

That's all on the higher level. What about the bottom level? Did you notice a change in attitudes of young physicists? Are they more interested now in getting involved?

I would say less. Okay, you are not talking about the interest of the government. The government has been deliberately essentially cancelling all the highest levels advisory committees under the argument – which is technically correct but wrong in its implication – namely that there is plenty of scientific talent in the in-house laboratories. But of course that is filtered through the policies of the different departments. The community of basic scientists is largely – I would say – less interested. We are trying very hard to change that. The Jason group has that as an objective. The Federation of American Scientists has that as an objective. Interesting enough at SLAC[43] some of our regular and Monday colloquia have an arms control focus simply because there are interested people around. Sid Drell[44] is around and I am around – people to shoot their mouth off. It is hard to maintain the interest. The result of course is that people who do go into military research are much more disconnected from the basic science. The military scientific establishment is more separate. Whenever I give talks about arms control subjects, people always agree. It is almost like – what I call – preaching to the choir. The academic scientists have lib-

eral attitudes but at the same time also an attitude of helplessness. They are simply not in the process.

Taking a more global look on disarmament there is only one country in the world that has so far disarmed all its nuclear weapons – South Africa in the early 1990s. Is there anything the world can learn from this?

South Africa actually had six devices, but there are many countries that had nuclear weapons programs!

Like Brasil.

Brasil is very interesting. Brasil had three parallel nuclear weapons programs by the three services which went probably less far than they advertised. They were mainly dragging their feet.

Problematic however are those countries that already have nuclear weapons and don't want to get rid of them. My question is: Can we learn anything from the South African example? I mean, although the country was in a singular transmission process it was willing to give away all its nuclear warheads!

I have a prejudice. None of the current nuclear weapons states have been willing to give nuclear weapons away. China at least has a no-first-use policy. The UK has decreased some numbers and narrowed down their nuclear weapons to a single service. None of the other ones have. My firm convic-

tion is that the United States must take the leadership in decreasing that because if the United States – which has by far the strongest capability in conventional non-nuclear weapons – says: "We need nuclear weapons," it is almost impossible to persuade anybody else that they don't need any. Nuclear weapons are – what I call – the great equalizers. There is a famous quotation by the deputy minister of defence in India: "Never negotiate with the United States unless you have a nuclear weapon!" I feel very hopeless that unless the United States changes its basic policy about nuclear weapons, and greatly drastically reduces both their salience and their number, the others won't do that – and have no reason to. It is very hard to defeat the logic that if the world's strongest power in terms of conventional weapons still says they need nuclear weapons …

… why should the others say …

… if they say that – and even improve them and find new missions for them and all that. That argument is very difficult to counter.

Tomorrow the opening of the Carl Friedrich von Weizsäcker Centre for Science and Peace Research will take place here in Hamburg. What personal relations do you have with Weizsäcker?

Essentially none. I met Weizsäcker personally once at DESY.[45] And then once I gave the Weizsäcker memorial lecture.

In the early 1990s or mid 1980s but not before. – What scientific, political or moral role model did you have that influenced you?

Hans Bethe is fairly close because he was doing his duty but he was using the fact that he was clearly extremely useful as a platform to say: We need a test ban. We need arms control. We don't need more and more nuclear weapons power etc. On the one hand he was able to maintain his service to the country while at the same time being highly judicious of what he did. At the same time using the fact that he was working on these things as a soapbox, as a basis for explaining what has to be done. Bethe is probably the best approximation. There are other people. I know Henry Kendall[46] quite well. We were good friends. I knew Pauling[47] quite well but he would oversimplify things very badly. I have continuous interest and involvement in military problems. I still have access to these things. I try to maintain communication. I think one of the most constructive things to do is to talk with people in India and China and hopefully Iran who are technicians, who at least speak a common language. I got into big arguments with Jack Steinberger, who I otherwise know very well, who does say: "We just should throw these things away." But he doesn't examine the political process which is involved to get rid of them.

"I try to maintain communication."
Hans Bethe and Wolfgang K. H. Panofsky (ca. 1988/1989)

What would you personally see as your most remarkable sustaining scientific achievement?

I think certainly from my own point of view the early experiments in Berkeley on measuring the properties of the π meson, that was the most productive thing I've ever done … on π^- absorption in hydrogen and deuterium determining the parity of the pion. The fact that the π^- was pseudo scalar in nature, measuring the $\pi^-\pi^0$ mass difference. That whole group of experiments.

What fundamental questions in physics would you like to see answered?

The simple fact that the standard model which has three generations of quarks and three generations of neutrinos and three generations of leptons fits everything but it obviously can't be the last word. Therefore what are the reasons for all these parameters and masses in the standard model? And then of course in astrophysics all the questions that the rapid expansion in early inflation can only be explained by large invisible masses and energy etc. But there is certainly an enormous number of things. And of course the whole question about how gravity fits into all the other forces and the standard model. String theory – at SLAC I listened to seminars which I don't understand – is internally consistent and incorporates gravity into the other things but I don't have the foggiest feeling whether it is right or not.

Professor Panofsky, thank you very much for the interesting interview.

Annotations

1 Erwin Panofsky (1892–1968), German art historian.
2 High school.
3 Grade 10.
4 Natural Science.
5 John Wheeler (1911–), theoretical physicist, participated in the development of the hydrogen bomb.
6 "The plumbers."

7 Old elite high school in Hamburg.
8 'Non-Aryan.'
9 Otto Stern (1888–1969), Nobel Prize for physics 1943, revealed the existence of electron spin.
10 California Institute of Technology.
11 Enrico Fermi (1901–1954), Nobel Prize for Physics 1938, built the first nuclear reactor.
12 Carl Anderson (1905–1991), Nobel Prize for Physics 1936, discovered the positron.
13 Robert Oppenheimer (1904–1967), 1942–1945 director of the Los Alamos Laboratory.
14 Luis Alvarez (1911–1988), Nobel Prize for Physics 1968, developed the hydrogen bubble chamber.
15 Federation of American Scientists.
16 Communist.
17 "No idea."
18 Willibald Jentschke (1912–2002), first director of the DESY Accelerator Laboratory in Hamburg.
19 Jack Steinberger (1921–), Nobel Prize for Physics 1988, revealed the existence of the muon neutrino.
20 Ernest Lawrence (1901–1958), Nobel Prize for Physics 1939, invented the cyclotron.
21 In 1950 the regents of the University of California asked all faculty members to sign a statement, that they never had been members of the communist party or similar organizations.
22 Robert Serber (1909–1997), theoretical physicist.
23 Gian Carlo Wick (1909–1992) and Geoffrey Chew (1924–), theoretical physicists.
24 Victor Weisskopf (1908–2002), co-founder of the Federation of Atomic Scientists.
25 Freeman Dyson (1923–), worked on the clarification of the theory of quantum electrodynamics.
26 Abraham Pais (1918–2000), quantum field theoretician, biographer of Niels Bohr and Albert Einstein.
27 Murray Gell-Mann (1929–), Nobel Prize for Physics 1969, classi-

fied elementary particles, “father of the quark”.

28 Lev Landau (1908–1968), Nobel Prize for Physics 1962, developed a theory of superfluidity.

29 Institute for Theoretical and Experimental Physics.

30 Centre Européen de Recherches Nucléaires.

31 Igor Kurchatov (1903–1960), scientific director of the Russian atomic bomb program.

32 Igor Tamm (1895–1971), Nobel Prize for Physics 1958, developed a theory of beta decay.

33 Gersh Budker (1918–1977), accelerator physicist.

34 Piotr Kapitza (1894–1984), Nobel Prize for Physics 1978, discovered superfluidity. His son Sergei became a physicist, too.

35 Electricity and Magnetism.

36 Vladimir Veksler (1907–1966), director of the laboratory for high energy physics in Dubna.

37 Robert Hofstadter (1915–1990), Nobel Prize for Physics 1961, investigated the way in which electrons are scattered by nuclei.

38 Edward Teller (1908–2003), “father of the US hydrogen bomb”.

39 Hans Bethe (1906–2005), Nobel Prize for Physics 1967, discovered the carbon cycle in stars.

40 Andrei Sakharov (1921–1989), Nobel Prize for Peace 1975, “father of the Soviet hydrogen bomb”.

41 Andrej Sacharow: Mein Leben, München: Piper 1991, p. 484. Translation: “Panofsky’s opinions as leader of the delegation came very close to mine.”

42 National Nuclear Security Administration. NNSA is a semi-independent unit of the Department of Energy, responsible for nuclear weapons, non-proliferation and associated matters.

43 Stanford Linear Accelerator Center.

44 Sidney D. Drell (1926–), former co-director of SLAC, disarmament specialist.

45 Deutsches Elektronen-Synchrotron, accelerator center in Hamburg, Germany.

46 Henry Kendall (1926–1999), Nobel Prize for Physics 1990, confirmed the existence of quarks. He founded the Union of Concerned Scientists.

47 Linus Pauling (1901–1994), Nobel Prize for Chemistry 1954, Nobel Prize for Peace 1962, revealed the nature of the chemical bond.