Something unusual happened in 1945, when the Nobel Prizes were announced that winter. No one seemed to know the whereabouts of the physics prize winner, the German radiochemist Otto Hahn. He was to be given the prize for 1944 because the ceremony could not be held that year due to the World War. He was not found in Kaiser Wilhelm Institute (KWI) in Berlin Dahlem, where he worked last. In fact, the Institute itself was in a shambles, structurally and administratively, due to the War.

The 65-year-old scientist was under house arrest somewhere in England. He had for company two more Nobel laureates from his country, the famous crystallographer Max von Laue and quantum physicist Werner Heisenberg. Seven more scientists who were associated with the German nuclear programme were also there.

The War Scenario

During the 1930s, events on the political front and in nuclear science were playing out parallely. Neutron was discovered in Britain in 1932 and Hitler rose to power in Germany in 1933. In January 1939 nuclear fission was established in Germany and by September the war broke out in the European part of the world. Like the two camps in the battle field, science also got divided into two.

While some wanted to exploit uranium fission and the possibility of chain reaction for building a Super Bomb, others like Frederic Joliot Curie and his team thought of peaceful use like a controlled chain reaction in a nuclear reactor. If Britain, France and America could think of an explosive, so could German scientists under Hitler’s rule. With this assumption, labs in the Allied countries put a moratorium on the publication of scientific results on uranium and fission.

But the censorship was causing more worry. The results from the Italian and German labs were also not coming out. The free world countries, who were surely working on development of the nuclear weapon were under constant pressure; their obvious fear was, whether Germany was ahead of them in pursuit of the nuclear weapon? After all, fission was discovered in Germany, the only uranium mines in Europe, in Czechoslovakia, were captured by Hitler in 1939 and the only source of heavy water, Norsk Hydro, was also with him since Norway was taken over. And of course, he had bright scientists.

Mission Alsos

Out of this fear psychosis was born a systematic reconnaissance programme in 1943, titled ‘Mission Alsos’. This was a natural outcome for a project controlled by an army; the ‘Manhattan project’ to build a super bomb was under the control of the US army. Apart from intelligence experts from the military, six scientists also were attached to Alsos. The scientific component of the mission was overseen by Samuel Goudsmit, the Dutch physicist who discovered electron spin, and had since migrated to America. The headquarter of the mission was in England.

Alsos had three target areas – Italy, France and Germany. Italy was cleared at the early stage itself of any suspicion. France was on the list in spite of being an Allied country because it was occupied by Germany early in the war and its labs were populated by German scientists, may be by force. As the German labs were damaged by the allied bombing, they had found France a safe place to work.

In November 1944 Alsos could enter France when the advancing allied army forced the Germans to retreat. They interviewed Frederic Joliot, son-in law of Marie Curie, who was the head at College de France in Paris. He admitted that some German scientists indeed visited or worked in his laboratory. Two of his visiting Germans, Diebner and Bagge were later arrested when Alsos could enter Germany. Incidentally, these two were also the members of the National Socialist (Nazi) party. Prof. Friedrich von Weizsacker, a disciple of Heisenberg, was also in France during the occupation years. Alsos men found his technical papers sealed in a metal drum and dumped in a cesspool behind his house in Germany.
Between 24th April to 3rd May 1945, Alsos located ten scientists one by one from different places in Germany. The last to be had was Heisenberg from his home in Urfeld. He had reached there only two days back from Haigerloch, the new location of his Institute, the KWI. His wife Elisabeth recounts in her book (Inner Exile, 1980) that she was frightened seeing five soldiers, thinking they were Hitler’s army men, but was relieved to know that they were Americans! To get Heisenberg (and also Hahn), the Chief of Alsos, Colonel Pash and Goudsmit themselves had gone to their residences. Heisenberg told them, “I have been waiting for you”. He should have been, because three days back, on 30th April, Hitler had killed himself and the great Third Reich was on way to surrender soon.

The convoy of scientists was taken first to Versailles, Le Vesinet (both in France) and Huy in Belgium. The final destination was Godmanchester near Cambridge in UK. The two storied villa was called the Farm Hall. While they were in custody of the British army, the aim was to find out what they did in the past two years in their laboratories. Was there still a danger from Germany? Their rooms were fitted with hidden microphones. This part of the mission to record and transcribe what they talked and then put the threads together was nicknamed ‘Operation Epsilon’. It would also record the status of knowledge in nuclear field in Germany.

One may wonder, what was the use of flogging a dead horse? Germany was nearly defeated when these scientists were quarantined. The real reason was alarming. America did not want these scientists to land in the hands of Russian troops, when Germany fell. Even before the war was over, or the nuclear weapon was proved to exist, USA was thinking of competition the USSR could provide them in the nuclear field! This was the seed for the cold war.

Transcripts
The Farm Hall where they were kept in house arrest had two army officers (Captain Brodie and Major Rittner) to look after their needs, both very polite. As they all spoke German, the tape recording was transcribed in German language and then translated into English for the seniors to review. These transcripts can be considered reasonably reliable material to ascertain the status of their knowledge and if Germany indeed had plans to make a bomb.

A doubt has been expressed whether the scientists were aware of the recording and so talked only in a sanitized manner. However, this appeared unlikely from the nature of their discussions. It is not likely that ten persons could fake emotions 24x 7 for six months. Consider this dialogue that happened:

Diebner: “I wonder whether there are microphones installed here?”

Heisenberg: “Microphones installed? (Laughter) Oh, no, they’re not as cute as all that. I don’t think they know the real Gestapo methods; they’re a bit old-fashioned in that respect.”

That they were not pretending innocence came out clearly when the news of the Hiroshima bomb reached them on the 6th of August 1945. Like many people in the world outside, they too did not believe it at first. However, the disbelief was slowly worn out in two days, when another atom bomb exploded over Nagasaki.

The most affected by the news was Otto Hahn, who blamed himself for this devastating loss of innocent lives because he had discovered nuclear fission. He was so delirious that he needed a constant companion to watch over him, lest he harm himself. Walther Gerlach, the administrative head at the Reich Research Council, overseeing the war work in Germany, was also heard sobbing in his room. His grief was about his failure as a General. It was Hahn’s turn to console him. He said, “Are you upset that we did not make the uranium bomb? I thank God on my bended knees that we did not make it. Or are you upset that Americans could do it better than we could?”
With the help of newspapers they knew that the Hiroshima bomb was made of enriched uranium. They also knew the general principles of such a weapon. However the issue to be debated was, how much of uranium can make a bomb? What is the critical mass of enriched uranium? Critical mass is that mass in which self-sustaining chain reaction can be established. It is different for the bare fission core and when it is shrouded in a shield or a reflector. Then lesser material will do the same job.

During casual talk, without the aid of any papers and books, their estimate varied from 35 kg to about a ton! In addition, they never thought that the enrichment levels could be taken to levels as high as 90% and beyond. This defrayed the level of work done in Germany.

Some people consider that the higher estimate by Heisenberg for the required quantity of enriched uranium dissuaded him from going forward on the bomb idea. He thought that this quantity could not be had before the war was over.

Their discussion gives a clear picture about a couple of facts: They were working on three routes of uranium enrichment viz. gaseous diffusion, centrifuge and mass spectrometer based; a mention of photo-chemical method is also made, but it is not clear if they used it. They had a good base in Heavy water technology. They were attempting to get criticality in a pile but had not operated a self-sustaining chain reaction till then, at least as on record.

It appears surprising that there was no discussion or mention of the letter Paul Harteck wrote to the German War Ministry, indicating a possibility of a nuclear explosive ‘many orders of magnitude more than the present one’. Harteck was in-charge of the centrifuge work and his letter should have been as important as that of Einstein to President Roosevelt, both written around the same time, in 1939. Perhaps the army personnel monitoring the conversation did not know of Einstein’s letter back then and lost this important reference in editing.

**Unknown Plutonium**

Higher confusion prevailed about the Nagasaki bomb which was made of plutonium. Firstly the naming of the element number 94 was not known to them yet. Hence the newspapers’ garbled report mentioning the word ‘Pluto’ confused them. They were not aware of the scale at which America had worked, thus could not imagine that the element 94 could be a workshop reality.

It is interesting to read in the transcripts about scientific brainstorming in which wild suggestions are thrown, like freezing the Neptunium to stop beta activity or using Proto-actinium to get a chain reaction. You come across a sincere student in Hahn who learns from Heisenberg, how does a bomb explode. This series of discussions demonstrates the strong influence of isolation from the outside world!

The fact that Pu bomb uses implosion technique and the material is compressed to a great degree and the assembly goes to super critical mode, makes the discussion on critical mass relatively less important. Although they had experts on explosives, a couple of them were interned here in Farm Hall, it is clear that they were not working on the implosion route.

While they were in the Farm Hall, the British physicist PMS Blackett paid them a visit. He and Heisenberg knew each other well. They discussed about the direction science would take in Germany after the war.

The scientists were finally released on 3rd January 1946.

**Arguments and Counter Arguments**

Some utterances of Heisenberg in the Farm Hall indicated that they intentionally went slow so that the Nazis did not get the bomb to play havoc. This is plausible because many scientists like him and Hahn were known to be indifferent to the National Socialists to the extent that they disliked them. For being an admirer of Einstein, Nazis called Heisenberg a ‘white Jew’.

Hahn had resigned from the lecturer’s post of the Berlin University in 1933 only to avoid attending the party meetings. However, leader of the Alsos Mission, Samuel Goudsmit was not amused by this moral high ground taken by Heisenberg. He wrote his own book about Alsos Mission after the war and

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**Serber’s Gun Barrel**

An explosion occurs when a copious energy is released in short time and in contained space. It is as true for a Diwali cracker as for an atom bomb.

Just as the Farm Hall transcripts were declassified in 1993 some lecture material was declassified a year earlier. It came as a book titled *Los Alamos Primer* and was based on the lectures given by Robert Serber to the scientists working for the Manhattan Project, about the physics and techniques of making a nuclear weapon. He described two types of atom bombs – one called the Gun Barrel design and the other an ‘implosion device’.

In the gun barrel type of bomb two lumps of slightly lesser than critical mass are kept separately and brought together at high speed. This results in formation of a supercritical assembly and it explodes because of sudden release of enormous energy.

In the figure here drawn by Serber himself, a popular design of gun barrel assembly is given. A uranium sphere with a cylindrical cavity is the target and the cylindrical piece of uranium is called the bullet. The white portion is the reflector over the sphere. The bullet is rapidly shot into the cylinder to trigger the explosion. The discussion at the Farm Hall was about how big this sphere needs to be?

In the implosion method a sub-critical mass is compressed isostatically to enhance its density, thus making it supercritical. It is a suitable method for plutonium.

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attempted to make a case that “Germans could not make the bomb due to the failure of the German scientific organization and certain stupidities on the part of German Scientists” (Alsos, 1947, page 232).

Goudsmit was not at all charitable to Germans because his father and mother were taken to a concentration camp at Auschwitz in Poland and killed. But his criticism irrigated the German scientists who were already stressed being viewed under the magnifying lens. Max von Laue said that Goudsmit could not be impartial because he had suffered at the hands of the Nazis and argued that the service to Nazism was different from service to the German people. Philips Morrison, while reviewing the book Alsos writes that the argument like Laue’s, is given now in retrospect, after Germany was defeated.

The facts that came out after the war made it clear that the Army Weapons Bureau, which was controlling the Kaiser Wilhelm Institute of Physics, gave up the chase of the Super Bomb as early as 1942. This may be because they were convinced that the so called ‘new weapon’ would not be ready before the war and hence would not influence the outcome. This logic could have been articulated and conveyed by the veteran scientists who did not wish to augment the destructive power of the Nazis.

Heisenberg while in Farm Hall said, “The whole structure of the relationship between the scientist and the State in Germany was such that although we were not 100% anxious to do it, on the other hand we were so little trusted by the state that even if we had wanted to do it, it would not have been easy to get it through.” Anyway, there was no case to de-rate the capability of the German scientists.

However, the bitterness and the mind games about the German bomb continued for some more time. Robert Jungk wrote a book, Brighter than Thousand Suns (1956) to narrate the German side of the bomb story as if to counter Goudsmit’s allegations. The sub-title of his book was ‘the moral and political history of the atomic scientists’. However, in the second edition (1970) it was changed to ‘the personal history of the atomic scientists’. He described trials and tribulations of the scientists under Nazi rule; he even uses the Gandhian phrase ‘passive resistance’ to describe their attitude.

There are numerous other accounts of their struggle with conscience. Even inside Farm Hall prison, three scientists who were members of Nazi party were at pains to explain their stand to the other upright scientists. Diebner says that he joined the SS, thinking that after the war positions would be given only to members of the Party!

Meanwhile Heisenberg and Goudsmit kept writing to each other till 1967, when they called truce. Goudsmit emphasized one point which is valid any time: science cannot grow under a Fascist environment; liberal values only can foster its growth.

The transcripts of Farm Hall dialogues were de-classified only in 1993. Two books giving the transcripts were published along with the comments of the compilers. They are Operation Epsilon: The Farm Hall Transcripts introduced by Sir Charles Frank (Institute of Physics publishing, 1993) and Hitler’s Uranium Club: The secret recordings at Farm Hall by Jeremy Bernstein (Aspen Colorado publishing, 1996). As the transcripts do not give out a great picture of German readiness, one more spell of books and articles came out during 1990s, fifty years after the bomb. The most important of them was the fat biography of Heisenberg titled Heisenberg’s War by Thomas Powers, again giving Heisenberg’s side of the story.

All these view points and interpretations do not change one ground truth that there was no bomb on German soil till they surrendered. But the debate will never cease. It is because the science historians are dealing with abstract things like ‘intentions’ and ‘capabilities’ and not physical evidence.

As recent as in 2011 a large quantity (more than 1 lakh drums!) of nuclear waste was found in a rock salt mine near Hanover in Germany. The debate has been resurrected but there is no use of conjecture in the absence of any knowledge about the radioactivity level and the dominant nuclei in the waste. It could be a mining waste, laboratory waste or a later vintage waste from an unlikely accident in a silo of the theatre force. The details are not made public.

Let us go back to Hahn’s Nobel Prize. The Allied military first procrastinated on the delivery of the letter of official announcement from the Nobel committee of Hahn receiving the Prize. And when the time came for attending the prestigious ceremony, the permission to travel to Sweden was refused. They wanted Hahn to send a regret citing ‘personal reason’. When Hahn resisted and wanted to mention the detention, he was told the letter would not be dispatched.

For a scientist there is no greater honour and pleasure than receiving the Nobel Prize. Hahn was greatly disappointed. But this is how military minds work – everywhere, at all times.