

Beyond Uncertainty: Heisenberg, Quantum Physics and the Bomb
by David C. Cassidy

Comments and Corrections

by Klaus Gottstein

Page	<i>Original Text (O) / Comment (C)</i>
24	<p><i>O: the center of town, Marienplatz, with its famous cathedral, the twin-towered Frauenkirche (Church of Our Lady)</i></p> <p>C: The twin-towered Frauenkirche, though in the center of town, is not at the Marienplatz. It is at Frauenplatz, in the vicinity of Marienplatz.</p>
31	<p><i>O: Bavaria's mad king Otto, had once ruled Greece</i></p> <p>C: "Mad King" Otto I of Bavaria (*1848, † 1916), brother of Ludwig II, is not identical with King Otto I of Greece (* 1815, † 1867) who was another son of Ludwig I and uncle of Ludwig II.</p>
49	<p><i>O: That night, when a ship was ordered to sail into a hopeless battle against the Entente fleet, the sailors mutinied</i></p> <p>C: In November 1918, it wasn't just "a ship" that was ordered to sail into a hopeless battle but the entire fleet stationed at Kiel.</p>
58	<p><i>O: To the end of his life he [Heisenberg] always vigorously opposed the federalist tendencies of Bavaria and other German states in favor of a centrally governed nation</i></p> <p>C: Heisenberg did not "always vigorously oppose federalist tendencies of Bavaria and other German states in favor of a centrally governed nation". It is true that he stressed the responsibility of the Federal Government for the support of advanced science and technology but he collaborated loyally with the Bavarian Government. The Bavarian Minister of Culture, together with the Federal Minister of Science and Technology, was on the Supervisory Board (Kuratorium) of Heisenberg's institute.</p>
58	<p><i>O: By 1919 he [Heisenberg] had also committed himself to the family goal of gaining and preserving social standing through academic achievement ...</i></p>

	<p>C: Heisenberg was not interested in “gaining and preserving social standing through academic achievement”. He was just interested in science. Of course, as a young man he was also interested in gaining financial independence from his father by finding a secure academic position.</p>
104	<p><i>O: ... Austrian immigrants who had recently helped drive Soviet Russians out of neutral Finland. ...</i></p> <p>C: Finland was not neutral. It had belonged to the Russian Empire under the Czars, although most of the time with a semi-autonomous administration. Thus, Finland was on the side of Russia in World War I although some volunteers fought on the side of Germany. Finland had unilaterally declared independence in 1917, after the October Revolution in Russia, concluding a peace treaty with Germany. Soviet Russians were driven out of Finland with the help of a German army division under Graf Goltz.</p>
177	<p><i>O: Some readers have not fully appreciated that Heisenberg’s philosophical pronouncements were always tailored for public consumption and most were informed and motivated by his specific aims in addressing each particular audience.</i></p> <p>C: Certainly this does not apply for Heisenberg’s posthumous work “Ordnung der Wirklichkeit” (Order of Reality) which he wrote during the war and never published.</p>
194	<p><i>O: Heisenberg had been invited to a musical soiree at the home of the German ambassador to Denmark, Ernst von Weizsäcker,</i></p> <p>C: Ernst von Weizsäcker was not “the German ambassador to Denmark”. He was Counselor (Gesandtschaftsrat) at the German Legation to Denmark under the envoy. (Germany did not have an embassy in Denmark then, just a legation, and Ernst v.W. was not its head.)</p>
215	<p><i>O: ... Heisenberg and his advisors went astray. Their new response to regime anti-Semitism — filling vacated positions — may appear reasonable when viewed in terms of preserving German physics. Yet there is no indication that they ever reflected on the broader implication of this tactic, that the preservation of decent science under the Nazi regime would support the arguments that National Socialism was not so bad after all ...</i></p>

	<p>C: Here it is stated that “Heisenberg and his advisors went astray” because, instead of taking a moral stand, they tried to find theoretical physicists who were as competent as possible to fill the chairs vacated by the dismissal of Jewish scientists. But apart from the fact that Heisenberg and his advisor Planck <i>had</i> protested against the dismissal of their Jewish colleagues, what else could they have done, in 1934, once they had decided to stay in Germany and to rescue as much as possible of German science? The alternative would have been that incompetent people would have been appointed by the Nazi authorities, as it indeed often happened, to the disadvantage of students. This would have been of no help to the dismissed chair-holders.</p>
241	<p><i>O: The Munich faculty settled on the conservative Nobel Prize-winning experimentalist Walther Gerlach, who had worked with Otto Stern on a famous 1922 atomic-beam experiment that lent overwhelming support to the existence of half-integer quanta in atoms.</i></p> <p>C: Walther Gerlach is described as “Nobel prize-winning experimentalist”. As a young man, Gerlach had carried out the famous Stern-Gerlach experiment together with Otto Stern but the Nobel Prize was only given to Stern, not to Gerlach.</p>
249	<p><i>O: He [Heisenberg] began to associate his own fortunes with the fortunes of his profession.</i></p> <p>C: This sounds as if Heisenberg had invented this association without justification. However, the freedom or even the life of anyone who was, like Heisenberg, personally attacked for his professional stance by a leading Nazi newspaper was in grave danger. His case might be used to provide an intimidating example for others. There were solid reasons for Heisenberg to see his fate connected to that of his profession.</p>
268	<p><i>O: under the direction of Reinhard Heydrich, later notorious as the “hangman of Lidice.”</i></p> <p>C: Heydrich was certainly a “hangman” but he died on June 4, 1942. The Lidice massacre was carried out on June 9, 1942 when Heydrich was already dead.</p>
285	<p><i>O: With war frustratingly averted and average citizens lusting for action, local party and political officials, spurred on by the network of</i></p>

	<p><i>state and party organizations, had little trouble inciting mobs in every city and town across the Reich into a bestial frenzy of violence against Jews and Jewish property during the night of November 9 – 10, 1938.</i></p> <p>C: “Average citizens” were not “lusting for action” in 1938, as I remember very well when my parents and my grandparents returned home and talked about their conversations with average citizens. (I was 14 years of age at the time.) Quite different from the eve of World War I, they noted, there was no enthusiasm for war. People in Germany were only too happy, as they were in Great Britain and France, when it seemed that war was avoided. The “Kristallnacht” mobs in German towns did not consist of average citizens but mostly of SA men in civilian clothes ordered to burn and destroy Jewish property, burn synagogues and harass Jews. “Average citizens” looked on in a mixture of fear, curiosity and disgust.</p>
296	<p><i>O: Two days after Hitler unleashed his army into neutral Poland, England and France declared war on Germany.</i></p> <p>C: Poland was not “neutral”. It was allied with France and Great Britain and had non-aggression treaties with the Soviet Union and Germany. The latter was terminated by Hitler a few months before the invasion. In 1938 Poland had taken part in the dismemberment, by Germany, of Czechoslovakia, occupying the region of Teschen.</p>
302/303	<p><i>O: Critics and supporters of Heisenberg have been sharply divided. Two former members of British wartime nuclear research, Rudolf Peierls and Nevill Mott, offer the following explanation: “It is reasonable to assume that [Heisenberg] wanted Germany to win the war. He disapproved of many facets of the Nazi regime, but he was a patriot. . . . Most citizens of most countries at war participate in the war effort when called upon, and the few who do not require exceptional courage and exceptional strength of conviction.”</i></p> <p><i>Others have offered the opposite assessment of Heisenberg. In their view Heisenberg did display exceptional courage by gaining a leading scientific position on the project, thereby taking a large share of responsibility for the direction of research. From this position he was able to suppress information that might have led to a bomb, and he further sabotaged the project by slowing it down and keeping other, less scrupulous scientists from constructing a weapon that would indeed have enabled Hitler to win the war.</i></p> <p>C: Both assumptions on Heisenberg’s attitude towards the war and his reactor project need some clarifications and corrections. It is true that</p>

	<p>Heisenberg was a non-Nazi patriot. Many non-Nazi conservatives did not want Hitler to win the war and at the same time they did not want Germany to lose the war, with all the bitter consequences that this would imply. Their quiet hope up to 1944 was that the Army would somehow get rid of Hitler short of losing the war, and that it would then be possible to achieve a tolerable peace settlement. This is what some circles of the Army had intended for several years and what the conspirators of July 20, 1944 finally tried, without success. My impression is that also Heisenberg did not want Nazi-Germany to win the war. At the beginning of the war he even thought that Germany had no chance to win, like a chess-player who has one rook less than his opponent.</p> <p>Why did Heisenberg want to remain in control of the reactor project? There are other reasons available than the considerations of rivalry quoted by Dr. Cassidy. First of all, it was a very challenging project of nuclear physics. Secondly, the “less scrupulous physicists”, if they took over, might have started an unrealistic crash program to build a bomb, with unforeseeable consequences for all who were involved, not when it succeeded – that was deemed impossible by Heisenberg under war conditions – but when it unavoidably failed after enormous expenses in manpower and finances. The harsh personal consequences for those in leading positions in the project would be unforeseeable, quite likely charges of sabotage, punishable by death.</p>
313	<p><i>O: Given the setting of the meeting (German-occupied Denmark), the occasion (Heisenberg’s lecture in a propaganda institute), and the topic (nuclear fission, controlled and otherwise), it may be little wonder that Heisenberg’s visit greatly disturbed his former mentor. Heisenberg felt he had failed to communicate with Bohr. Bohr and Heisenberg had been close friends and colleagues for nearly 20 years. If Bohr came away from their meeting in great distress, it may well have been because Heisenberg said something distressful. ... The boyish-looking Heisenberg recalled opening the discussion with the taller and more distinguished-looking Bohr by asking whether Bohr believed that “as a physicist one has the moral right to work on the practical exploitation of atomic energy.” An obviously startled Bohr responded by asking whether Heisenberg believed that atomic energy could be practically exploited in this war. “Yes, I know that,” Heisenberg answered. However, he claimed that he was referring only to a machine. Because of the technical difficulties involved, he told Bohr, a bomb could not be produced before the war was over.</i></p> <p>C: Dr. Cassidy followed here the faulty description of the Copenhagen meeting given by Robert Jungk in his book “Brighter Than a</p>

Thousand Suns” which was criticized by Heisenberg in a letter to Jungk. In fact, what Jungk describes is approximately what Heisenberg had intended to say but was unable to utter because Bohr broke up the conversation when Heisenberg started, very cautiously and in very involved language, to mention the feasibility of atomic bombs. In brief, Bohr had misunderstood that Heisenberg was working on such bombs and wanted Bohr’s assistance or cooperation on this project. For more details see the Comment below.

Moreover, it was the fear that Heisenberg and the Germans were building the atomic bomb that drove the intensity of the Manhattan Project, eventually bringing about the nuclear age. The old wounds opened by Jungk’s book in the new era of nuclear distress [during the Cold War] surely brought for Bohr a flood of painful memories and unresolved anger that flowed onto the pages of his unsent letters to the man who, as Bohr saw it, had dared to exploit the German occupation of Denmark in order to raise the prospect of an atomic bomb in Hitler’s military arsenal.

C: Because of the many misleading simplifications and erroneous statements that can be found in the literature about Heisenberg’s visit to Bohr in Copenhagen in 1941, about Jungk’s book, and Bohr’s unsent letters we reproduce here a detailed account which was published in the Internet¹ in 2002 :

Klaus Gottstein:

New insights?

Heisenberg’s visit to Niels Bohr in 1941 and the Bohr letters²

The documents recently released by the Niels Bohr Archive do not, in an unambiguous way, solve the enigma of what happened during the critical brief discussion between Bohr and Heisenberg in 1941 which so upset Bohr and made Heisenberg so desperate. But they are interesting, they show what Bohr remembered 15 years later. What Heisenberg remembered was already described by him in his memoirs “Der Teil und das Ganze”. The two descriptions are complementary, they are not incompatible. The two famous physicists, as Hans Bethe called it recently, just talked past each other, starting from different

¹ Published in:

The Week That Was (TWTW), www.sepp.org/NewSEPP/Heisenberg-Bohr.htm, March 2, 2002

² Klaus Gottstein was a member of the Max Planck Institute for Physics from 1950 to 1970 under the directorship of Werner Heisenberg. For several years he was head of the experimental division of the Institute. In 1969 he asked Heisenberg about his visit to Bohr in 1941, and Heisenberg told him. He also had many conversations with Carl Friedrich von Weizsäcker who had accompanied Heisenberg to Copenhagen in 1941 and talked to Heisenberg immediately after Heisenberg’s discussion with Bohr at which Weizsäcker had not been present..

assumptions. They did not finish their conversation. Bohr broke it off before Heisenberg had a chance to complete his intended mission.

Heisenberg and Bohr had not seen each other since the beginning of the war in 1939. In the meantime, Heisenberg and some other German physicists had been drafted by Army Ordnance to explore the feasibility of a nuclear bomb which, after the discovery of fission and of the chain reaction, could not be ruled out. How real was this theoretical possibility? By 1941 Heisenberg, after two years of intense theoretical and experimental investigations by the drafted group known as the "Uranium Club", had reached the conclusion that the construction of a nuclear bomb would be feasible in principle, but technically and economically very difficult. He knew in principle how it could be done, by Uranium isotope separation or by Plutonium production in reactors, but both ways would take many years and would be beyond the means of Germany in time of war, and probably also beyond the means of Germany's adversaries. (When Heisenberg heard about the Hiroshima bomb, almost four years later while interned in Farm Hall, at first he could not believe it.) Heisenberg and von Weizsäcker were very glad about this result. It meant that they were spared a difficult moral decision. They were able to concentrate on the construction of a reactor for power production, a goal easily compatible with their value system. If a bomb would have been within reach, how could they have avoided being forced to build it without sacrificing their lives as saboteurs? But what about the long-range future? Was the construction of nuclear weapons unavoidable? Was it conceivable that the then small community of nuclear physicists could come to an agreement not to work on bomb construction? Heisenberg and his friend and colleague von Weizsäcker decided that it would be helpful to have discussions with Bohr, their father figure. In a kind of naiveté they did not realize that their old cordial relationship with Bohr had been affected by the events of the war. For Bohr his old friend Heisenberg was now a representative of an enemy country, of the occupying power of his native Denmark, whose remarks would have to be looked upon with suspicion.

Heisenberg managed to make the trip to Copenhagen in September 1941, using the opportunity of a scientific conference arranged by the German Culture Institute in Copenhagen, boycotted by Bohr. Heisenberg spent several days in Copenhagen and probably saw Bohr several times, in Bohr's office, in Bohr's home and on a walk. On the latter occasion when there was no danger of being overheard by the Gestapo, Heisenberg undertook to broach the questions which were the real reasons for his trip.

What is written above is the gist of what Heisenberg wrote and what he explained to friends and colleagues when questioned. But his explanations were not accepted everywhere, particularly not by some of his British and U.S. colleagues and by some later writers who were convinced that Heisenberg did all he could to make the bomb for Hitler, but failed, and after the war tried to white-wash himself. The situation became even worse in 1956 when the American journalist Robert Jungk published a book "Heller als tausend Sonnen" (Brighter Than a Thousand Suns) in which he described, greatly exaggerating, Heisenberg's satisfaction with the technical difficulties of bomb construction and the lack of enthusiasm for overcoming these difficulties, as a secret plan to prevent, for moral reasons, the construction of an atomic bomb for Hitler which otherwise he could have built. Heisenberg, and particularly von Weizsäcker, wrote letters to Robert Jungk in which, while appreciating Jungk's extensive research and detailed accounts of the developments, criticized some of his generalisations and exaggerations. Cathryn

Carson, in her article “Reflexionen zu ‘Kopenhagen’”, appended to the German edition of Frayn’s play “Copenhagen”, quotes from these letters. In the Danish translation of his book, which appeared in 1957, Jungk published an extraction of Heisenberg’s letter, but only the laudatory part. It was known that Bohr took exception to Jungk’s book which he had read in the Danish edition. Jungk’s book, unfortunately, did much to harm Heisenberg’s credibility, particularly as the wrong impression had arisen in some quarters that Heisenberg had commissioned it. Heisenberg was unaware of this. He never “portrayed himself after World War II as a kind of scientific resistance hero who sabotaged Hitler’s efforts to build a nuclear weapon”, as was suggested by James Glanz in The New York Times recently. Heisenberg always stressed how content he had been that nuclear weapons did not seem to be feasible for several years to come so that Hitler and his government made no efforts to build them when this had become clear to them.

Meanwhile, all kinds of rumours circulated about the “real” motives behind Heisenberg’s 1941 visit to Bohr. It was suggested that he wanted to do some spying, to find out what Bohr knew about the nuclear efforts in the U.S. and Great Britain. It was suspected that Heisenberg wanted to enlist the support of Bohr for the German project. On the basis of some conversations which Heisenberg and von Weizsäcker had had with members of Bohr’s institute there was also the version that the real reason for Heisenberg’s visit was the intention to convince Bohr that Germany was going to win the war, that this outcome was desirable, and that Bohr had better end his unwillingness to cooperate with German authorities. It was generally held that the formerly cordial relationship between Bohr and Heisenberg was severely disturbed, if not severed, ever since. Few members of the international community knew that they continued to have friendly relations after the war, visiting each other, with their families, in their homes in Copenhagen and Göttingen, spending their vacations together in Greece [or South Italy], and that Bohr wrote an article for the Festschrift to Heisenberg’s sixtieth birthday in 1961.

When it became known that the Niels Bohr Archive in Copenhagen held a letter by Bohr to Heisenberg, written after the appearance of Jungk’s book but never sent, speculation concentrated on this document, to be published 50 years after Bohr’s death, i.e. in 2012, from which the solution of all the open questions was expected. However, to end speculation, the Niels Bohr Archive released 11 documents pertaining to Heisenberg’s visit, including the much-discussed unsent letter, preceded by an article by Aage Bohr, published in 1967, on “The War Years and the Prospects Raised by Atomic Weapons”. The documents, with the exception of one letter written by Heisenberg to Bohr, are unfinished drafts written by Bohr in the late 1950s and early 1960s, addressed to Heisenberg, but never sent. As the director of the Niels Bohr Archive, Finn Aaserud, points out, the documents have to be viewed with caution. They were written 16 years or more after the event and represent just drafts, not finished papers. Nevertheless, the contents of the documents are interesting and, depending on the pre-established views and opinions of the readers of today, surprising to a lesser or greater degree. Here are some of the general characteristics of the documents, with my comments in brackets:

- Bohr’s tone in addressing Heisenberg is extremely cordial and friendly.
- Bohr was still highly interested in clarifying Heisenberg’s intentions and motivations behind his 1941 visit. His sentences in Document 11 c “I have long been meaning to write to you ...” and “I have written in such length to make the case as clear as I can for you and hope we can talk in greater detail

about this when opportunity arises” are proof of this. (This is new information. Heisenberg was under the impression that Bohr and he, having differing recollections of their discussion, had come to the conclusion that it would be best to let rest the spirits of the past. It is a pity that the letter was not sent. Several opportunities for clarifying conversations were missed at later meetings of Bohr and Heisenberg. It seems that Bohr was afraid he might hurt Heisenberg’s feelings by insisting too much on his interpretation of the events.)

- Document 1 contains the confirmation that Bohr and Heisenberg met several times during Heisenberg’s visit to Copenhagen in 1941: Bohr refers to “our conversations” in the plural, and he mentions “our conversation in my room at the institute” as well as the strong impression Heisenberg’s remarks made “on Margrethe and me”. Since it is unlikely that Bohr’s wife Margrethe was present at the confidential conversation in Bohr’s room in the institute one may assume that Heisenberg’s recollection is correct that he was also invited to Bohr’s home. Moreover, there is Heisenberg’s and von Weizsäcker’s testimony that the critical discussion took place during a walk, to avoid unwanted earwitnesses.
- Bohr was, at the time of the visit in 1941, highly distressed by the circumstances of Heisenberg’s visit, his lecture at the German Culture Institute and his contacts with the German Embassy (more correct: Legation) in Copenhagen. (Heisenberg had assumed Bohr would understand that without such contacts he would not have obtained visa and permission to enter occupied Denmark.)
- Bohr understood and appreciated that one of Heisenberg’s reasons for the visit was genuine care: to see how Bohr and his institute fared under German occupation and to be of assistance, if at all possible (Document 11 c).
- For Bohr it was of central and sad significance that Heisenberg during his visit expressed his conviction of a German victory whereas Bohr, as a Danish patriot, had placed all his hopes in a German defeat. Since towards the end of the war Heisenberg’s conviction must have disappeared, Bohr wondered whether Heisenberg, in retrospect, had forgotten or repressed his earlier views. (Again, for Heisenberg, mentioning the prospects for a German victory, was not central to his mission. At the beginning of the war he had, in private, expressed the view that Hitler would lose the war like a chess-player would lose a game into which he entered with one castle less than his opponent. However, after the surprisingly fast defeats of Poland and France, the occupation of large parts of Europe and the initial great victories and advances in the Soviet Union, with the U.S. still neutral, Heisenberg like most non-nazi Germans had come to the conclusion that a German victory now seemed likely. They feared that a German defeat would mean Soviet occupation of Europe which, even for anti-nazis, was considered an even greater evil than German domination. Auschwitz and the full extent of nazi crimes was not yet known, but Stalin’s massacres were. The hope - completely unrealistic as we now know but considered realistic at the time - was that after a German victory the German army would get rid of Hitler and his henchmen. The anti-nazi stance of many German generals, who later took part in the assassination plot of July 20, 1944, was known to persons who, like Heisenberg through the “Wednesday Society”, were close to opposition circles. For Heisenberg, it was part of his care for Bohr to think in sober terms of the future and of Bohr’s and his institute’s survival. It would be advisable to end opposition to a victorious

Germany. It is obvious that Heisenberg's assessment of Germany's chance to win the war must have changed a few months later when the U.S. entered the war and the German army suffered severe setbacks in Russia.)

- Bohr mentions several times his reticence caused by his suspected surveillance by German police. (There is no indication of an awareness by Bohr that Heisenberg was under the same handicap. He had to be extremely cautious in choosing his language. Mentioning to Bohr the existence of a German nuclear programme and of his involvement in it, could be interpreted, and probably was, treason punishable by death. In public conversations, also in the cafeteria of Bohr's institute, he may have had to say things which did not represent his opinion. This situation is well-known to people having lived under cruel dictatorships.)
- Document 6 says that Heisenberg "did not wish to enter into technical details but that Bohr should understand that he knew what he was talking about as he had spent 2 years working exclusively on this question." Bohr had known about the possibility of nuclear weapons only in a very general way and at that time still had held the opinion that the technical difficulties were insurmountable. Therefore Heisenberg found it necessary to mention his two years of investigations in order to convince Bohr that he was not "talking moonshine". Bohr had been "doubtful looking" (Document 11 a).
- Bohr wondered (and this is new information) who had authorized Heisenberg to discuss with him military secrets. (Heisenberg had assumed Bohr would understand that he spoke in his private capacity as Bohr's old friend and colleague who, however, because of the delicacy of the subject discussed, had to use very involved language. Bohr, on the other hand, could not imagine that Heisenberg acted on his own initiative, without any special permission, let alone orders. But this was so. Heisenberg had thought, naively, that Bohr would be ready, as he always had been in earlier times, to discuss with him possible solutions for complicated problems. He had lacked the sensitivity for Bohr's patriotic feelings and misgivings under the changed circumstances of war and occupation. On the other hand, it is justified to say that it took great moral courage to talk to Bohr about implications of his secret work. Heisenberg risked his neck.)
- Constant German propaganda talks of the imminent use of "new weapons" fortified suspicions by Bohr and his Danish colleagues that there was a German nuclear bomb programme. Assertions by Jensen to the contrary were not trusted though he himself was considered honest. But Jensen was working on the reactor programme, and it had to be doubted that he was privy to all aspects of the programme.
- After Bohr's escape to Sweden and subsequent flight to Great Britain in the autumn of 1943 "it was quite clear already then, on the basis of intelligence reports, that there was no possibility of carrying out such a large undertaking in Germany before the end of the war". (Document 11 b). This is a remarkable confirmation of Heisenberg's own conclusion. It is also interesting that these intelligence reports had no influence on the progress of the Manhattan project.
- Aage Bohr writes "After the outbreak of war and especially after the occupation of Denmark we in Copenhagen were completely cut off from following the allied nations' efforts in the field of atomic energy." Niels Bohr confirms this in Document 11 c. (Also Heisenberg knew that. How could he expect to do some spying, as some writers have suggested?) In a footnote to his article Aage Bohr assures the reader that no secret plan was submitted to

	<p>his father by Heisenberg “aimed at preventing the development of atomic weapons through a mutual agreement with colleagues in the allied countries.” Again, in Document 11 c, this is what Bohr remembers. It is quite true, also according to Heisenberg. It had indeed been Heisenberg’s intention to get Bohr’s opinion on possibilities for such an agreement or on other ways out of the impasse presented by the basic feasibility of atomic weapons. But Heisenberg never had a chance to present his questions because of Bohr’s reticence and Bohr’s unwillingness to continue the conversation when Heisenberg, as an introduction, had told Bohr that atomic weapons were technically possible, and that he knew it. He was not even allowed to add, as he had intended, that the technology was very difficult and would take a long time, thereby giving the small international community of atomic scientists a chance to use their influence in the meantime. Bohr had stopped listening. This is admitted by Bohr in Document 11 c where he writes “During the conversation, which because of my cautious attitude was only brief ...”</p>
314	<p><i>O: ... Heisenberg had sought ethical advice on science in the political arena, not from Bohr, but from his German academic elders, Max Planck and (probably) Max von Laue, both of whom were in Berlin and more accessible than Bohr. Though in semiretirement, Laue was still vice director of the Kaiser Wilhelm Institute, as he had been since the days of Einstein. Yet among the scant surviving records there is no indication that Heisenberg or his colleagues approached Planck or Laue about the morals of nuclear research...</i></p> <p>C: Heisenberg’s earlier political problems, particularly during the SS affair, were due to the internal political situation in Germany by which Planck and von Laue were also affected. Bohr, in neutral Denmark, was not directly involved. Nevertheless, Heisenberg met him several times after 1933, and it is not unlikely that he also consulted Bohr. Planck and von Laue, on the other hand, did not work on applications of nuclear physics, and Heisenberg’s relation to them, though very friendly, was not as close and intimate as his relation to Bohr who was a father figure for him. It is very plausible, I think, that he would rather have turned to Bohr when it came to questions of very deep significance, not only for himself but for the future development of mankind.</p>
316	<p><i>O: the most likely answer seems to be that Heisenberg was indeed joining his friend and colleague Carl Friedrich in a conscious or unconscious propaganda effort instigated by the Foreign Office subdivision under Carl Friedrich’s father.</i></p> <p>C: I do not think that it is right to assume that Heisenberg joined Carl Friedrich von Weizsäcker “in a conscious or unconscious propaganda effort instigated by the Foreign Office” when he decided to visit Bohr</p>

	<p>in Copenhagen in 1941. Heisenberg used to visit Copenhagen frequently but after the beginning of the war this had become impossible. The conference at the German Culture Institute in Copenhagen provided an opportunity to make another visit to Bohr and to talk things over. "The dilemmas of nuclear research" had already become acute, at least in theory. Heisenberg's postwar affidavit is very plausible. The conference at the German Culture Institute, although a conference on astrophysics, was indeed a propaganda undertaking from the point of view of the Foreign Office and German occupation authorities in Denmark. For Heisenberg, participating in it was just a compromise necessary for obtaining the otherwise unattainable permission to go to Copenhagen.</p>
317	<p><i>O: Bohr's wife, Margrethe, never wavered in her opinion of the episode: "No matter what anyone says, that was a hostile visit!" Bohr and Heisenberg were never as close thereafter as they had been before the war.</i></p> <p>C: Heisenberg's letter to his wife which he wrote in Copenhagen in 1941, the recent discovery of which caused much excitement, has now been published³ This letter shows that Heisenberg, two days after his famous, misunderstood conversation with Bohr, spent a harmonious evening with Bohr at Bohr's home. They discussed physics, Heisenberg played the piano, and Bohr read a story to him. Thus, Bohr's "rage" after the ill-fated discussion cannot have been as deep as is often assumed. Their personal friendship continued, as is also shown by the fact that they visited each other after the war with their families in their homes and spent their vacations together in Greece or South Italy. It is true, however, that Heisenberg was always sad that Bohr had misunderstood the purpose of his 1941 visit, and the unsent Bohr letters also show that Bohr, unknown to Heisenberg, also continued to ponder about the "mystery" why he and Heisenberg had so different memories of that event. (The "mystery", of course, was to a large extent Robert Jungk's doing.) In any case, probably because both of them thought that the other one preferred not to discuss the matter any further, they never tried to clarify their mutual misunderstanding. That is unfortunate.</p>
320	<p><i>O: For his [Bohr's] part, that man [Heisenberg] had returned home pleased at least to receive the imprimatur of the German Foreign Office as a traveling spokesman for the Reich.</i></p>

³ Werner Heisenberg, Elisabeth Heisenberg, Meine liebe Li, Der Briefwechsel 1937 – 1946, Herausgeber Anna Maria Hirsch-Heisenberg, Residenz-Verlag 2011

	<p>C: It is not fair to say that “Heisenberg was pleased to receive the imprimatur of the Foreign Office as a traveling spokesman for the Reich”. He was certainly glad to be allowed to travel abroad and meet old friends and colleagues in Denmark, the Netherlands and Switzerland but he lectured on physics, not on politics. He was not a spokesman for Germany but for modern physics and he tried to contribute to the maintenance of relations between German physicists and their colleagues abroad.</p>
334	<p><i>O: In 1942, the society’s 28 members included such noted figures as the surgeon Ferdinand von Sauerbruch; General Ludwig Beck, chief of the army general staff ...</i></p> <p>C: In 1942 General Ludwig Beck, member of the Wednesday Society, was no longer chief of the army general staff. He had been in that position until 1938 when he resigned in protest against Hitler’s war preparations. Beck took part in the plot of July 20, 1944 and committed suicide when it failed.</p> <p>The name of the famous surgeon is Sauerbruch, not von Sauerbruch. He was not one of the conspirators.</p>
352	<p><i>O: Throughout his life, Heisenberg saw himself as primarily responsible only for his own circle of friends, colleagues, and students. Although he had taken on the task of preserving decent German physics, he did so primarily within his own professional circle and through his own personal survival and advance.</i></p> <p>C: What is probably meant here is Heisenberg’s opinion, expressed in his wartime manuscript “The Order of Reality”, published only posthumously, that under a cruel dictatorship where one is helpless with regard to the general political developments, one should <i>at least</i> try to preserve an island of decency within one’s own circle of influence. It is misleading, however, to generalize this restrained attitude of Heisenberg under conditions of dictatorship to his whole life. Under brutal Nazi dictatorship he saw indeed no alternative, apart from the willful acceptance of martyrdom, to preserve, as much as possible, decency and good science at least within his own circle. When it became possible after the war to extend his activities to the public in general, without those restrictions, he did not hesitate to accept this responsibility. Throughout his life, Heisenberg felt the responsibility stemming from his position as a leading scientist, and he acted accordingly, often at the expense of his personal convenience and inclinations. He accepted the positions of president of the</p>

	<p>Humboldt Foundation (caring for foreign students in Germany), president of the Deutscher Forschungsrat (giving advice on science policy to the Federal Government) and Vice President of the Max Planck Society, and he was very active in founding new institutes inside and outside the Max Planck Society and on the international level (Heisenberg was one of the founding fathers of the Max Planck Institutes for Astrophysics, for Extraterrestrial Physics, for Plasmaphysics, the German Electrosynchrotron DESY in Hamburg, and the European Center for Nuclear Research CERN in Geneva). He also spoke out publicly in the 1950s when the government of Lower Saxony appointed a minister of science from an extreme right wing nationalist party who had then to resign. Heisenberg also signed a petition against the Nazi film producer Veit Harlan (“Jud Süß”) when the latter tried to re-enter the movie scene after the war with new films. - Dr. Cassidy also seems to reproach Heisenberg for limiting “his efforts to extract from the authorities military exemptions for physicists” during the war but not for nonphysicists. The latter, of course, would have been quite impossible for Heisenberg who could only claim that physicists were needed for his special projects.</p>
<p>373</p>	<p><i>O: Did Heisenberg ever know before Farm Hall that only about 50 kilograms of fissionable yet extremely rare Uranium-235 were required to create a critical mass that would explode as an atomic bomb? If so, why didn't he pursue it? If not, why not? The answers are still ambiguous. Recently discovered Soviet documents suggest that such a calculation by Heisenberg exists among captured German documents,</i></p> <p>C: These calculations made by Heisenberg on orders by, and for, German Army Ordnance have been published after the war in his collected works (edited by W. Blum, H. P. Dürr and H. Rechenberg) and recently thoroughly analyzed by Carl H. Meyer and S. Günter Schwarz (Preprint 467, Max Planck Institute for the History of Science, Berlin 2015, available in the Internet under http://www.mpiwg-berlin.mpg.de/en/resources/preprints.html. - Unfortunately, the leading author Carl H. Meyer died just after the publication of this preprint of 34 pages so that his extensive book on Heisenberg remains unfinished). Meyer and Schwarz find, as explained in the preprint, that Heisenberg closed his calculations without giving a number for the critical mass. For whatever reason he did not take this last step which was within reach for him. However, several indications exist that Heisenberg must have known, at least around 1942, that the critical mass for U 235 was in the range of 10 to 100 kilograms. This estimate is given in an anonymous report to Army</p>

Ordnance of 1942 in which Heisenberg was very probably involved. This is in agreement with a remark by Otto Hahn at Farm Hall that Heisenberg had once told him that about 50 kilograms would be sufficient for getting an explosion. Moreover, the German physicist Manfred von Ardenne recalled in his memoirs that Heisenberg told him during the war that only a few kilograms of ^{235}U are needed to trigger a chain-reaction. And when asked at the Harnack Haus meeting in Berlin on June 4, 1942 how large a bomb would have to be to destroy a large city, such as London, Heisenberg gave as a rough estimate that it would be about the size of a pineapple, which was not very far from the truth.

Strangely enough, when Heisenberg heard the first news about the Hiroshima bomb he could not believe that it was a true nuclear bomb. In his first interrogation by his trusted old friend Sam Goudsmit he had asked him about nuclear work in the U. S. during the war and was told that the U. S. had other things to do and did not work on nuclear problems. Heisenberg had been glad to believe this. It confirmed his hope that he and his group were ahead of the Americans and might be able in future negotiations to use their advanced knowledge as a bargaining chip. So he assumed after hearing the first news of the Hiroshima bomb that it was just a new type of high-pressure chemical bomb. Meyer and Schwarz speculate that Heisenberg, in order to protect his bargaining chip from potential British listeners-in, gave as reason for his disbelief just the old value of several tons of $\text{U } 235$ which had been under international discussion before the war after the discovery that only the rare isotope $\text{U } 235$ was prone to fission when bombarded by neutrons. In any case, this period of disbelief, “chip protection” and ton-value for the critical mass lasted only for the three hours from 6 pm to 9 pm on August 6, 1945 when a second BBC broadcast made it clear that the Hiroshima bomb was a nuclear bomb indeed. Only one week later Heisenberg gave a lecture which showed that he would have been able to develop the correct theory of nuclear weapons, had he concentrated on that subject earlier.

The alternative explanation for Heisenberg’s ton estimate for the critical mass from 6 pm to 9 pm on August 6, 1945 is that Heisenberg had just forgotten what he had known in 1942 about the critical mass. After all, in the meantime he had worked on cosmic rays, matrix theory, philosophy and on test reactor construction under the chaotic conditions of the final stages of the Second World War and had not been interested in der critical mass which would have been important only for the canceled project of investigating bomb building. Nevertheless, Meyer and Schwarz, unlike myself, cannot believe that Heisenberg could have forgotten such a crucial value as the critical

	<p>mass of U 235. They adhere to their hypothesis of “bargaining chip protection” which, I must admit, is not entirely without backup evidence.</p>
<p>376</p>	<p><i>O: “it was the view of the researchers that the conditions for the production of a bomb were at that time not available within the framework of the technical possibilities then accessible in Germany.” Thus, they were not engaging in any race with the Allies to build a bomb, mainly because the available resources did not permit it. Instead, they continued, “The further work therefore concentrated on the problem of the machine for which, in addition to uranium, heavy water is required.” That work was slowed by the limited supply of heavy water, but they nearly achieved a chain reaction by the time the war ended.</i></p> <p><i>This harmless sounding statement contrasts with Bohr’s remembered impression of Heisenberg’s aims in 1941, while neglecting the many other substantive reasons for the project’s lack of progress.</i></p> <p>C: Heisenberg’s statement does not contrast with his own description of his meeting with Bohr. It only contrasts with Bohr’s misunderstanding of Heisenberg’s intention and with Jungk’s faulty description of the meeting in his book “Brighter Than a Thousand Suns”.</p>
<p>377</p>	<p><i>O: Weizsäcker declared at Farm Hall: “I don’t think we ought to make excuses now because we did not succeed, but we must admit that we didn’t want to succeed.” And just prior to this: “I believe the reason we didn’t do it was because all the physicists didn’t want to do it, on principles. If we had wanted Germany to win the war we could have succeeded.” To which Hahn replied, “I don’t believe that, but I am thankful we didn’t succeed.” But later that night, according to Rittner’s paraphrase, Heisenberg told Hahn, “he feels himself that had they been in the same moral position as the Americans and had said to themselves that nothing mattered except that Hitler should win the war, they might have succeeded, whereas in fact they did not want him to win.” The upshot seemed to be: in order to protect their competencies in the public arena they would emphasize the material conditions of war in their memorandum the next day, while they would invoke moral scruple as a primary reason for their poor showing, for now, only in the private sphere. Laue reported the emerging dual argument in his August 7 letter to his son, “All of our uranium research was directed toward the achievement of a uranium machine as an energy source, first because no one believed in the possibility of a bomb in the foreseeable future, and second because fundamentally</i></p>

no one of us wanted to put such a weapon in Hitler's hands."

C: Regarding Major Rittner's paraphrase of Heisenberg's remarks to Hahn in their private conversation on the reasons why he and his group had been unable to construct a bomb while the Americans succeeded: There is no doubt that Heisenberg and Weizsäcker were certain after the second half of 1941 that they knew, in theoretical principle, the road leading to an atomic bomb. At the same time they were convinced that this road was so long and difficult in practice that the construction would take many years and was not feasible while the war lasted. This opinion was accepted by the leading authorities of the Nazi Government. Heisenberg was very happy with this outcome which spared him the moral decision whether to participate in a large bomb project or risk his life by refusing to cooperate in it. Thus, his "poor showing" had nothing to do with "moral scruples". Heisenberg's thought that he could have been successful in bomb-construction like his American colleagues, had he been in their moral position (being on the side of a morally good cause) and having the same resources at his disposal, was just an expression of his sound self-confidence. Several of the allied bomb-builders had been his students at Leipzig university before 1933. Scientifically, he knew, he could also have done it. To protect his "competence in the public arena" was of no importance in this respect.

Weizsäcker, on the other hand, with his inclination towards philosophy and diplomacy, was just speculating about the reasons why the German scientists did not set up a huge project as the Americans did, which then might also have succeeded. Knowing the lack of enthusiasm for the Nazi goals, to say the least, of Hahn, Heisenberg, himself and some other prominent colleagues Weizsäcker mused that this was the reason for their reluctance to take up a really serious, large-scale approach to the problem. He did not derive this opinion from personal self-confidence but from the tentative feeling that under the leadership of his friend and mentor Heisenberg the existing group could have been successful. Hahn was skeptical with respect to this explanation but he, indeed for moral reasons, was glad that the German project had not resulted in a bomb.

378

O: ... at least one of the German scientists had the audacity to congratulate the German scientists for their moral superiority for having not built the bomb! According to the Farm Hall transcript, Weizsäcker stated on August 7, "History will record that the Americans and the English made a bomb, and that at the same time the Germans, under the Hitler regime, produced a workable engine. In

	<p><i>other words, the peaceful development of the uranium engine was made in Germany under the Hitler regime, whereas the Americans and the English developed this ghastly weapon of war.”</i></p> <p>C: Weizsäcker did neither congratulate his colleagues nor himself for moral superiority (which he never claimed), he just stated what he thought was a paradoxical or contradictory fact. At the time he made that remark he did not know that the Americans had not only made a Uranium bomb but were also far ahead of the Germans in the development of a “uranium engine”.</p>
380	<p><i>O: Since the project had never progressed much beyond its status in 1942, Heisenberg wrote in 1946, he and his colleagues were therefore conveniently spared “the difficult moral decision” of whether or not to build atom bombs for Hitler. Heisenberg and his colleagues had good reason after the war to portray their project as they did. In order to reestablish German science, to ensure that scientists could never again be disregarded and abused by their government, and to counter public criticism of their wartime behavior, it was essential that, once again, they acquire as much influence as possible, first in the British zone, then within the emerging West German state. As previously, emphasizing the prestige and utility of nuclear research and technology was the surest means of establishing themselves as vital to Germany’s science and to its economic revival.</i></p> <p>C: Here the impression is given that “Heisenberg and his colleagues”, in order to “counter public criticism of their wartime behavior”, sought to “acquire as much influence as possible ... “. Heisenberg’s prestige and fame as one of the principal founders of quantum mechanics and as Nobel Laureate were so great that he certainly did not need a new emphasis on nuclear research to establish himself as vital to Germany’s science after the war. Heisenberg, like almost everybody else after the war, considered nuclear energy as vital for the economy of the future and he wanted Germany to take part in this promising field. As for himself, he soon lost personal interest in the technicalities of reactor building which he left to Karl Wirtz and Wirtz’s students who moved to Karlsruhe and the new Centre for Nuclear Research established there while Heisenberg and the remainder of his institute moved from Goettingen to Munich, filling the gap left by Wirtz and his group by a new experimental group working on Plasma Physics under Dr. von Gierke.</p>

386	<p><i>O: The moral implication was clear. Jungk, acknowledging the help of C. F. von Weizsäcker, published a near-verbatim repetition of Weizsäcker's appalling private statement at Farm Hall: "It seems paradoxical that the German nuclear scientists, living under a saber-rattling dictatorship, obeyed the voice of conscience and attempted to prevent the construction of atom bombs, while their professional colleagues in the democracies, who had no coercion to fear, with very few exceptions concentrated their whole energies on production of the new weapon."</i></p> <p>C: This is not a near-verbatim repetition at all. In Weizsäcker's private statement there is no mention of "the voice of conscience", nor does the word "moral" appear. This is in agreement with a statement by Max von Laue who was present during the discussion at Farm Hall. He reported, as Dr. Cassidy quotes a few lines later: "I did not hear the mention of any ethical point of view. See also Comment for page 378.</p>
389	<p><i>O: Certainly it was unacceptable for Heisenberg and his close colleagues to claim that they had consciously delayed the project because of moral scruples.</i></p> <p>C: This was never claimed by Heisenberg.</p> <p><i>O: It was not much better for Heisenberg to say that he might have built the bomb had that been attainable during the war, but otherwise to absolve himself of any moral or ethical failing.</i></p> <p>C: This is an example of Heisenberg's honesty. He had always stated that he had come to the conclusion during the war that building the bomb under German war conditions would not be feasible, and that he was happy about this outcome because it relieved him from making a moral decision: whether build the bomb for Hitler or risk dying as a conscientious objector. When asked "Assuming that building the bomb would have been feasible, would you have built it?" he could have answered: "I do not reply to hypothetical questions!" But he was honest enough to reply (my paraphrase): "Considering my family and my physics, I am not sure that I would have chosen the realistic risk to die as a martyr. In other words: I might have built it, with the unrealistic hope that somehow its use might be avoided."</p> <p><i>O: After all, had he and his colleagues not worked on reactors to power the German war machine?</i></p>

C: Heisenberg and his colleagues worked on achieving a chain reaction in a “machine” now called a nuclear reactor. It was a test. Any practical use, such as powering submarines, was far away. There were no plans ready for any such application, apart from creating heat. Even that would have needed huge engineering efforts for which no preparations had been made.

O: Had he and they not allowed themselves to be exploited by a monstrous regime?

C: This is true. But everybody who did some work in Nazi Germany was exploited, willingly or unwillingly, by its monstrous regime. This was unavoidable once one had decided not to emigrate. It was also true for artists, musicians, actors, and teachers of any kind.

O: Had their very work on any aspect of nuclear fission not instilled the fears that drove the intensity of the Manhattan Project to complete its work, at least through the end of 1944?

C: This is true. Heisenberg had hopefully assumed that also the Americans would not be able to overcome the enormous technical difficulties connected with building an atomic bomb while the war lasted. But he was aware of its feasibility in the long run, and he was afraid, according to Mrs. Elisabeth Heisenberg, that the Americans, with their vast resources, would be first to overcome these difficulties and use the bomb on Germany, if the war lasted long enough. That was the reason for Heisenberg’s wish to discuss these matters with Niels Bohr in 1941 in the naïve hope that perhaps an international agreement could be reached among the relatively small “family” of nuclear physicists not to work on nuclear bombs.

Incidentally, the British Secret Service had been informed by Paul Rosbaud that the German uranium project was only concerned with reactor building, not with bomb making. (This is also mentioned by Dr. Cassidy.) But this information was withheld from the physicists of the Manhattan Project who were believing they were in a race with the Germans who was first in bomb-making. Probably the Secret Service did not want to run the risk of having been disinformed. But they also did not make further enquiries.

O: How did this all come about? How did these highly educated scientists, blessed with the best of moral culture and learning and the highest ideals of scientific inquiry, find themselves in this situation?

	<p>C: This is a very good question which also applies to the German elite as a whole and to the German people in general. Many historians, political scientists, philosophers, psychologists and novelists have written about it. To deal with this question one would have to delve deeply into German and European history, in particular that of the First World War, of the Weimar Republic, and into special fields of human psychology.</p>
394	<p><i>O: Over a decade later, amidst a reorganization of West German nuclear energy policy, Heisenberg finally moved, along with his institute, to his beloved Munich, where he remained for the rest of his life. Long before the move, his institute was renamed the Max Planck Institute for Physics and Astrophysics, an institute within the Max Planck Society, the network of federally funded research institutes that replaced the Kaiser Wilhelm Society in the early postwar years. He remained director of the non-academic state-supported institute until he was forced by illness to retire in 1970.</i></p> <p>C: Up to the move from Göttingen to Munich in 1958 Heisenberg's institute was named Max Planck Institute for Physics. It was renamed Max Planck Institute for Physics and Astrophysics with that move, not "long before" it.</p> <p>Heisenberg was not "forced by illness to retire in 1970" but he retired from the post of director because he had reached the mandatory age limit. After retirement he remained very active, kept an office in the institute where he worked with Hans Peter Dürr and others every day, travelled to the United States, lectured and took part in discussions. He fell seriously ill only a few months before his death in 1976.</p>
398	<p><i>O: The plan naturally met with little objection from the increasingly powerful conference of West German university rectors, of which Zierold happened to be president.</i></p> <p>C: Kurt Zierold, an administrator, was never president of the conference of West German university rectors. From 1949 to 1952 he was vice president of the Notgemeinschaft, and from 1952 to 1964 he was secretary general of the Deutsche Forschungsgemeinschaft.</p>