The European Organization for Nuclear Research: Exploration, Encounter, and Exchange Through Particle Physics

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Introduction

By the close of World War II, many European physicists had moved to the United States to support the creation of the atomic bomb. Europe's infrastructure was in ruins, and "eminent physicists… had recognized that Europe would be competitive in nuclear physics only if the countries joined forces" (Schopper 87). The European Organization for Nuclear Research, or CERN, as it is more commonly known, became the solution to this European "brain drain". CERN was established in 1954 as a supranational laboratory dedicated to the peaceful exploration and application of atomic and subatomic physics. CERN's creation helped revive the European physics community; aided reconstruction of European economy; eased international tensions brought on by World War II; led to the invention of the World Wide Web, with its aim of exchanging information on a global scale; and encountered subatomic particles that may have played a role in the creation of our universe.

Historical Context

Prior to the 1800s, worldwide atomic theory in physics had been shunned in favor of the traditional theory of the four basic elements (water, air, fire, and earth), proposed by the Greek Empedocles in the fourth century B.C.E. ("Empedocles"). A fifth element, ether, was later added by Aristotle ("Ether"). This universal acceptance of traditional theory was challenged by Englishman John Dalton's studies of chemical elements around the turn of the nineteenth century. Dalton theorized that each element was made of its own atom, creating the basis of modern particle physics ("Subatomic particle"). J. J. Thomson's discovery of the electron in 1898 illustrated that the atom is composed of even smaller particles (Aczel 73). Modern particle physics theories stem from the work of Ernest Rutherford who, in 1911, discovered that the atom consisted mostly of an atomic nucleus. Following this discovery, Englishman Paul Dirac proposed the first quantum field theory in 1927 that described the electromagnetic field as a cloud of photons and explained the activity of electrons in an atom. James Chadwick supported Dirac's theory with the discovery of the neutron in 1932, the event normally associated with the birth of particle physics ("Subatomic particle").

In the years surrounding World War II, particle physics centered primarily on military purposes - the creation of the atomic bomb. The exchange of information between countries was discouraged due to wartime security (Krige 44). Through the Manhattan Project, the United States produced and used the first atomic bombs in 1945, gaining a near monopoly on atomic warfare. Following World War II, however, European countries split alliances between the Soviet Union and the US, a period known as the Cold War ("The Cold War"). The Cold War rose in severity from 1948 to 1953 as the Soviets developed and detonated their own atomic bomb (Britannica's "Cold War"). During this period of instability, the countries of Europe, decimated by war, struggled to recover (Lincoln 42). The European physics community experienced a "brain drain", in which "young and gifted nuclear scientists, in particular, would be attracted across the Atlantic to work on facilities available there" (Krige 1).

Background Information

In counterpoint to this global paranoia and divisiveness, the idea of an international European physics laboratory was proposed by Louis de Broglie in 1949. About a year later, Isidor Rabi supported this idea at the Fifth General Conference of the United Nations

Educational, Scientific, and Cultural Organization (UNESCO) in Florence, Italy, asserting that an international organization would “make more fruitful the international collaboration of scientists” (UNESCO 38). Rabi based the CERN proposal on the principles of the Marshall Plan and the Schuman Plan. The Marshall Plan, put into effect in June of 1947 by American General George Marshall, advocated for “the revival of a working economy in the world, so as to permit the emergence of political and social conditions in which free institutions can exist” (“Marshall Plan Announced” 0:43-0:52). One month before Rabi’s proposal in Florence, France’s Robert Schuman proposed a “Schuman Plan” that would link France’s and Germany’s coal and steel industries and place the union under international control. The Marshall and Schuman Plans hoped to facilitate the reconstruction of Western Europe’s economy and were key in the opposition of Communism during the Cold War (Krige 153, 159, 161). Rabi gained the support of America and France by incorporating these objectives into his proposal for CERN.

In addition to combatting Communism and restoring European economy, CERN’s founders envisioned a physics laboratory that would bring European scientists back to the continent and reunite the war-divided countries of the region. The laboratory’s primary focus would be to explore high-energy physics using particle accelerators - machines that generate continuous beams of subatomic particles (“Particle accelerator”) - while pursuing other fields such as computing and biology (Krige 44). In this way, CERN sought to quickly re-strengthen European physics so the continent could continue particle physics exploration soon after the end of World War II (Lincoln 42).

CERN’s creation would serve an additional, critical function: to allow the United States to “be kept currently aware of the latest advances of modern technology, in whatever nation these may occur" ("Science and Foreign Relations" 3). Transparency was a crucial asset for the US in the context of the Cold War (Krige 44-46).

<u>Opposition</u>

The proposal to establish a European nuclear physics laboratory was accompanied by some doubts and dissent. Given the destructive use of atomic power during World War II, European nations stressed that if a nuclear research facility was to be established, it would be for non-military purposes only (Aczel 71). As stated within the CERN establishment convention, "The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and… shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available" (5). Due to these non-military parameters, CERN encountered restraints on the use of its equipment - the technology and research could not be used to strengthen the military or economic might of any one member nation (Krige 45).

In addition to military and commercial restrictions, the CERN initiative encountered opposition from some European governments who felt that the project would put their countries at further economic risk following the hardships of World War II. Germany's Werner Heisenberg voiced disapproval at a UNESCO meeting in Paris in 1951: "Our country is in an extremely difficult economic position and I am not entitled at the present time to commit our government to any expense in this connection" (de Rose 174-175). The inclusion of West Germany as a founding member proved to be another obstacle in CERN's creation. While Rabi and company believed this incorporation was crucial in order to counteract Communism during the Cold War, fear of a Nazi resurgence caused disagreements over how many scientific and industrial opportunities West Germany was granted (Krige 47).

Another form of opposition came with doubts regarding the practicality of a new physics organization. Some countries, such as the United Kingdom, suggested using existing facilities rather than constructing a new international laboratory. Britain's George Paget Thomson advocated for this action at the Paris 1951 meeting, and felt that by using existing facilities, "physicists could begin work immediately and not have to wait many years for a new facility to be completed. As a sign of the seriousness of his proposal, Thomson offered the use of a 400-MeV [mega-electron volt] cyclotron at Liverpool University, which was nearing completion." Frenchman Francis Perrin countered that "the lack of more powerful equipment in the physics of fundamental particles would have the effect of 'prejudicing European states and the aspects of civilization that they represent'. Perrin reminded the meeting that Europe's scientists would move to America if they couldn't find good facilities at home; and he said that building a machine comparable to those being constructed in the United States would be 'far beyond the means of any single European state.'" This logic displays that France supported the idea of an organization with powerful equipment that would attract European scientists back to their home continent, but asserted that a project of that scale could only be accomplished through widespread international cooperation, and by the end of the conference most countries became supportive of this thinking (de Rose 175).

Impacts

The Paris 1951 conference eventually prompted the first resolution regarding the creation of an international physics laboratory. In the following two months, 11 countries established a provisional "Conseil Européen pour la Recherche Nucléaire", or CERN. In mid-1953, CERN's establishment convention was signed and ratified over the next 14 months by 12 member states (France, the United Kingdom, Denmark, West Germany, Switzerland, Belgium, Sweden, Norway, the Netherlands, Italy, Greece, and Yugoslavia). Finally, on 29 September 1954, CERN was officially established and the original acronym retained (CERN's "The History of CERN").

Upon its establishment, CERN sought to answer questions about the universe's earliest moments following the Big Bang by constructing particle accelerators, colliding subatomic particles together, and interpreting the findings produced by these collisions (Perritano). In 1957 and 1959, respectively, a 600-MeV accelerator and the 28 GeV (giga-electron volt) Proton Synchrotron (PS) became operational and were the highest-quality and best performing machinery of their kind (de Rose 175), thus kickstarting CERN's prominence in particle physics. According to "The History of CERN", the PS in particular was an early success in nuclear physics exploration. Through the PS, CERN was able to break world records in physics, which led to a surge of global recognition (Lincoln 42-43).

Additionally, both accelerators provided European physicists with powerful research machinery that equaled that of the United States, which brought back a sizeable amount of scientists from America to work at CERN. As physicist Valentine Telegdi commented in a personal interview, "There was very little of this begging for money. They supplied you with instruments and money. CERN was well funded… From that point of view, it was an enormous advantage" (Lippincott 449). This technological impact on the global physics community allowed for more extensive, higher-quality research, and allowed scientists to explore new subatomic phenomena (de Rose 175). Therefore, CERN's creation fulfilled its founders' vision of a Europe with strengthened ties through high-energy physics (Kowarski 381).

CERN also fulfilled its mission of strengthening the Western European economy after the war. The organization allowed multiple countries access to its advanced technology because the nations cooperated to purchase the equipment needed. No country was burdened economically because costs were shared, and each country was able to use the equipment for a manageable price. These savings were crucial to a war-ravaged Europe ("The Significance of CERN" 49:59-50:15).

However, not all of CERN's impacts were positive: "American support for CERN may have come at a price for American physicists. In later years, US policy-makers… used the existence of CERN as a reason to refuse requests from the US scientific community for expensive high-energy machines in their own country" (de Rose 175). American physicists were further impacted when scientists were directed to use the accelerators at CERN facilities for their research, which led to a decrease of employment at American physics laboratories (de Rose 175).

Legacy

Over 60 years after its creation, CERN remains a source of international collaboration and a focal point for groundbreaking research. CERN has added member states, including some from Eastern Europe following the Cold War (Krige 44). CERN has been a gathering place for scientists and physicists, and its diversity has led to new methods of cooperation between professionals in different fields (Aczel 60-61). CERN scientists have also "worked together for decades… to ensure that the spirit of competitive collaboration, unique to science, continues to thrive in particle physics" with its American counterpart Fermilab (Heuer and Oddone).

One of CERN's legacies, the World Wide Web, grew out of this spirit of cooperation. In 1989, Tim Berners-Lee invented the Web at CERN to fulfill the need for a method of exchanging information between universities (CERN "The Birth of the Web"). Public access to the Web was granted in 1993, and 22 years later, use of the Web has permeated our culture. To oversee the use of the Web, Berners-Lee organized the World Wide Web Consortium in 1994 (Britannica's "Sir Tim Berners-Lee"). Although the World Wide Web was initially focused on easing the exchange of information and ideas between researchers, society as a whole can thank CERN for what has been deemed one of history's greatest inventions (Aczel 15-16).

The creation of CERN also produced what some consider the pinnacle of scientific collaboration - the Large Hadron Collider, or LHC. Completed in 2008, the LHC's aims are simple: to utilize past knowledge to make advances in particle physics and to further understand the universe's creation (Aczel 8). On 4 July 2012, the LHC revealed the discovery of a particle consistent with the theorized Higgs boson (CERN "The Higgs Boson"). Britannica's "Higgs boson" states that the particle is thought to bestow mass on other subatomic particles and may have played a role in the universe's creation. As John Butterworth communicated in his book *Most Wanted Particle,* the Higgs discovery "is surely a sense of progress: there are things to find out that are important… and that once you have found them out are added to the body of human knowledge to the eventual benefit of us all." Butterworth speculated that the Higgs "can look forward to a period of intense scrutiny, where particle physicists… measure its properties as precisely as we can to see… whether it will yield any clues that might help us solve some of the remaining puzzles in physics" (245-248). In short, the global physics community is optimistic that encounters made at the LHC may be used to advance scientific knowledge and answer questions that have been debated for centuries (Giudice 241).

Conclusion

CERN began in 1954 as a method of reuniting and restrengthening the countries of Europe after World War II, uncovering the early universe's secrets, and bringing European particle physics back to its previous glory. Since its creation, the organization has explored new forms of international cooperation and new theories in particle physics. Its scientists have encountered subatomic particles including the Higgs boson, and exchanged a vast array of information globally through the World Wide Web, resulting in worldwide recognition. The organization accomplished this despite opposition to its initiative from countries such as the United Kingdom and Germany. CERN has impacted science, politics, and technology, and if history is any indicator, will continue to succeed, perhaps putting to rest the great questions of how the universe came to be.