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ARTICLE

The Origins of Euratom's Research on Controlled Thermonuclear Fusion: Cold War Politics and European Integration, 1958–1968

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The article traces the origins and early developments of European fusion research in the framework of Euratom and of postwar nuclear international institutionalism, and as an episode of both the technoscientific Cold War and the interaction between big science and politics in the history of European integration. Based on original Italian, French and European Union archival sources, the article deals with four main passages of Euratom's fusion history: the Euratom treaty and Euratom's first five-year programme (1958–62); the early attempts to establish a Euratom – CERN Joint Study Group for Fusion Research (1958–9); the launching of Euratom's first fusion programme; and the contribution of Euratom's 'fusion association contracts' with the member states to the creation and training of a European transnational epistemic community of fusion scientists and technocrats. The Merger Treaty of 1965, the 'crisis' of Euratom and the prospect of British entry in the Community, as well as the 'tokamak revolution' of the late 1960s, would contribute to substantially redefine the European fusion programme.

Introduction: Fusion, European Integration and the Cold War

Controlled thermonuclear fusion (CTF) plays a special role both in the history of the technoscientific Cold War and in the history of European integration. Research on fusion – the principle on which the H bomb is based – had military origins and sprang from early ideas developed in American, British and Soviet laboratories during and immediately after the Second World War. In the West research was boosted in the early 1950s as a consequence of the announcement of the explosion of the first Soviet atomic bomb in 1949. These developments set up a competition between the United States, the United Kingdom and the Soviet Union as to who would be the first to achieve controlled thermonuclear fusion for peaceful uses. However, it soon became clear that research was not likely to produce short-term scientific or economic returns; rather it was oriented towards very long-term results. Thus, fusion turned out to be a useful détente tool across the Iron Curtain, given also the undisputed Soviet leadership in the field.

In continental Europe, national research programmes were initiated in the mid-1950s. From the beginning, however, some sort of collaboration was deemed essential in order to carry out the financial and scientific effort required to compete with the major fusion powers. The creation of Euratom provided the means to pursue this collaboration. Research on fusion was listed among the priorities of the Euratom treaty of 1957 and was inserted in Euratom's first five-year programme. From then on, most research on nuclear fusion carried out by member states developed in the framework of Euratom. European collaboration has eventually led to two major achievements: EUROfusion, the European Consortium for the Development of Fusion Energy, established in 2014, which operates JET, the

Joint European Torus, based in Culham, UK, which began operating in 1983;[1] and Fusion4Energy, under which the EU and seven other partners have underwritten the ITER project, under construction at Cadarache, in the south of France. ITER, 'one of the largest and most expensive science projects ever', and also the most controversial, has led to significant political and scientific debate and scepticism on the feasibility and opportunity of a mega-experiment whose prospects are, to say the least, not clear.[2]

As a potential energy source lying 'always fifty years away', as the sceptics say, fusion may easily fall into the category of those sociotechnical rhetorical fantasies, 'dreamscapes of modernity' and energy myths, that over time have attracted enormous public resources, both at the national and at international levels.[3] One estimate says that of the $417 billion spent on R&D by International Energy Agency (IEA) member countries cumulatively in the period 1974–2008, less than $40 billion were allocated to energy efficiency, compared to some $56 billion allocated to the 'commercially unproven technology concept' of nuclear fusion.[4] This enduring financial effort can only be explained by a peculiar combination of sociotechnical and political motives, whose historical dimension, however, has so far been relatively neglected. Apart from popular science books,[5] most accounts are written by scientists involved in the research effort,[6] while more recently the 'fusion imaginary' has attracted new scholarly interest.[7]

This article explores the origins and political motives of European research in nuclear fusion as a case-study in the interaction between big science and politics in the history of European integration and in the Europeanisation of technoscientific research, in the larger framework of postwar nuclear institutional internationalism. It also shows the frictions and tensions between national scientific programmes and a common political interest in European collaboration. Thus this article is also meant as a contribution to Euratom's history and internal dynamics, a still relatively underexplored subject,[8] in

[1] Edwin N. Shaw, 'Joint European Torus', in John Krige and Luca Guzzetti, eds., *History of European Scientific and Technological Cooperation* (Luxembourg: Office for Official Publications of the European Communities, 1997); Edwin N. Shaw, *Europe's Experiment in Fusion: The JET Joint Undertaking* (Amsterdam: North Holland, 1990); Paul-Henri Rebut, 'The History of the JET Fusion Programmeme', *Plasma Physics and Controlled Fusion*, 29, 10B (1987).

[2] W. Patrick McCray, '"Globalization with Hardware": ITER's Fusion of Technology, Policy, and Politics', *History and Technology*, 26, 4 (2010), 283; Michel Claessens, *ITER: The Giant Fusion Reactor: Bringing a Sun to Earth* (Cham: Springer, 2019); Robert Arnoux and Jacques Jaquinot, *ITER. Le chemin des étoiles?* (Aix-en-Provence: Edisud, 2006); Mark Robinson, 'Big Science Collaborations: Lessons for Global Governance and Leadership', *Global Policy*, 12, 1 (2021). On the history of negotiations leading to the creation of ITER, Anna Åberg, 'The Ways and Means of ITER: Reciprocity and Compromise in Fusion Science Diplomacy', *History and Technology*, 37, 1 (2021).

[3] Sheila Jasanoff, 'Future Imperfect: Science, Technology, and the Imaginations of Modernity', in Sheila Jasanoff and Sang-Hyun Kim, eds., *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: Chicago University Press, 2015); Sheila Jasanoff and Sang-Hyun Kimm, 'Sociotechnical Imaginaries and National Energy Policies', *Science as Culture,* 22, 2 (2013); Benjamin K. Sovacool and Brent Brossmann, 'The Rhetorical Fantasy of Energy Transitions: Implications for Energy Policy and Analysis', *Technology Analysis & Strategic Management*, 26, 7 (2014); Vaclav Smil, *Energy Myths and Realities: Bringing Science to the Energy Policy Debate* (Washington, DC: AEI Press, 2010).

[4] Charlie Wilson and Arnulf Grubler, 'Lessons from the History of Technological Change for Clean Energy Scenarios and Policies', *Natural Resources Forum*, 35 (2011).

[5] Garry McCracken and Peter Stott, *Fusion: The Energy of the Universe* (Oxford: Elsevier, 2005, 2nd ed. 2013); Charles Seife, *Sun in a Bottle: The Strange History of Fusion and the Science of Wishful Thinking* (New York: Viking, 2008); Robin Herman, *Fusion: The Search for Endless Energy* (Cambridge: Cambridge University Press, 1990); Andrew Kirk, 'Nuclear Fusion: Bringing a Star down to Earth', *Contemporary Physics*, 57, 1 (2016).

[6] T. Kenneth Fowler, *The Fusion Quest* (Baltimore: Johns Hopkins University Press, 1997); Thomas A. Heppenheimer, *The Man-Made Sun: The Quest for Fusion Power* (Boston: Little Brown, 1984); Paul-Henri Rebut, *L'énergie des étoiles. La fusion nucléaire contrôlée* (Paris: Odile Jacob, 1999); Paul Reuss, *L'épopée de l'énergie nucléaire. Une histoire scientifique et industrielle* (Paris: EDP Sciences, 2007); Guy Laval, *L'énergie bleue. Histoire de la fusion nucléair*e (Paris: Odile Jacob, 2007).

[7] Simon Märkl, *Big Science Fiction: Kernfusion und Popkultur in den USA* (Bielefeld: Transcript Publishing, 2019); Melvin L. Eulau, *The Fusion Enterprise Paradox: The Enduring Vision and Elusive Goal of Unlimited Clean Energy*', PhD dissertation (Virginia Polytechnic Institute, 2019).

[8] Jaroslav G. Polach, *Euratom: Its Background, Issues and Economic Implication* (Dobbs Ferry, NJ: Oceana Publications, 1964); Michel Dumoulin, Pierre Guillen and Maurice Vaïsse, eds., *L'énergie nucléaire en Europe. Des origines à*

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particular with regard to developments in the 1960s.[9] John Krige has listed nuclear fusion among the seven main fields of technoscientific cooperation 'to be situated at the heart of the process of European economic and political integration'.[10]

Most documentation on nuclear fusion is still classified. Here we try to overcome this limitation by relying on a variety of archival sources: the French CEA (*Commissariat à l'Energie Atomique*) Archives in Fontenay-aux-Roses and the Italian Fusion Unity Archives in the *Laboratori Nazionali* in Frascati; the Euratom Commission and Jules Guéron files held in the EU Archives in Florence;[11] the Italian CNEN (*Comitato Nazionale Energia Nucleare*) Archives in La Casaccia and the private papers of Edoardo Amaldi[12] and Enrico Persico,[13] scientists involved in early European fusion research.

The Politics of Early Research on CTF and the Declassification Turn

Research on plasma physics and controlled fusion in the 1950s was partly an outcome of prewar and wartime scientific advances and fundamental change occurring in the relationship between science, the state and the military, and partly the consequence of deliberate politically-fostered national programmes embedded in the logic of Cold War competition.[14] In the United Kingdom a fusion programme was launched in 1951 by the UKAEA (United Kingdom Atomic Energy Authority) in the laboratories at Culham and Harwell under Robert Pease.[15] The US programme – the so-called Sherwood Project – was also officially launched in 1951, financed and supervised by the USAEC (United States Atomic Energy Commission) and carried out in four laboratories (Princeton, Los

Euratom (Bern: Peter Lang, 1994); Darryl A. Howlett, *Euratom and Nuclear Safeguards* (New York: Palgrave Macmillan, 1990); Peter Weilemann, *Die Anfänge der Europäischen Atomgemeinschaft: zur Grundungsgeschichte von Euratom 1955–1957* (Baden-Baden: Nomos Verlagsgesellschaft, 1983); Olivier Pirotte, *Trente ans d'expérience Euratom. La naissance d'une Europe nucléaire* (Bruxelles: Bruylant, 1988); Gunnar Skogmar, *The United States and the Nuclear Dimension of European Integration* (Basingstoke: Palgrave Macmillan, 2004).

[9] John Krige, *Sharing Knowledge, Shaping Europe: US Technological Collaboration and Non-Proliferation* (Boston, MA: MIT Press, 2016); John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe* (Boston, MA: MIT Press, 2016).

[10] John Krige, 'The Politics of European Scientific Cooperation', in John Krige and Dominique Pestre, eds, *Companion to Science in the Twentieth Century* (London: Routledge, 1997, 2nd ed. 2003), 900.

[11] One of the '*Canadiens*' of the French nuclear establishment who during the Second World War left France for Canada, where he continued to carry out research for the Allied effort, Guéron joined the CEA after the war and was director of the research center of Saclay. He served as the first director for research and education of Euratom. On Guéron, *Hommage à Jules Guéron* (Paris: CEA, 1992).

[12] Edoardo Amaldi came from the group known as the Rome school of physics – the so-called '*ragazzi di via Panisperna*' – led by Enrico Fermi. He was the director of the department of physics at Rome University and president of Istituto Nazionale di Fisica Nucleare. One of the founders of CERN, where he served as secretary general from 1952 to 1955, he was the first chairman of Euratom's Scientific and Technical Committee. Carlo Rubbia, *Edoardo Amaldi. Scientific Stateman* (Geneva: CERN 91/09, 1991); Fernando Ferroni, ed., *The Legacy of Edoardo Amaldi in Science and Society* (Bologna: Società italiana di fisica, 2010); Lodovica Clavarino, *Scienza e politica nell'era nucleare. La scelta pacifista di Edoardo Amaldi* (Roma: Carocci, 2014).

[13] Enrico Persico, like Amaldi, came from the Rome school of physics. A professor at the University of Turin, he also taught at Cambridge and in Canada. He was the Italian representative in the CERN Study Group on Fusion. Giovanni Battimelli, 'Enrico Persico', in *Dizionario biografico degli italiani*, 82 (2015), https://www.treccani.it/enciclopedia/enrico-persico_(Dizionario-Biografico)/ (last visited: 15 Feb. 2022).

[14] Michael Eckert, 'Plasmas and Solid-State Science', in Mary Jo Nye, ed., *The Cambridge History of Science, Vol. 5*: *The Modern Physical and Mathematical Sciences* (Cambridge: Cambridge University Press, 2003), 413–28; Richard Post, 'Plasma Physics in the Twentieth century', in Laurie M. Brown, Abraham Pais and Brian Pippard, eds., *Twentieth Century Physics, Vol. 3* (Philadelphia: Institute of Physics, 1995); John Hendry, 'The Scientific Origins of Controlled Fusion Technology', *Annals of Science*, 44, 2 (1987); Cornelis M. Braams and Peter E. Stott, *Nuclear Fusion: Half a Century of Magnetic Confinement Fusion Research* (Bristol: Institute of Physics Publishing, 2002); Jacques Jacquinot, 'Fifty Years in Fusion and the Way Forward', *Nuclear Fusion*, 50 (2010); Laila A. El-Guebaly, 'Fifty Years of Magnetic Fusion Research (1958–2008): Brief Historical Overview and Discussion of Future Trends', *Energies*, 3 (2010).

[15] Robert S. Pease, 'The UK Fusion Programme', *Plasma Physics and Controlled Fusion*, 29 (1987); J.D. Lawson and John Hendry, *Fusion Research in the UK 1945–1960* (Culham: AEA Technology, 1993).

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Alamos, Livermore, Oak Ridge) and in several US universities.[16] Generous funding by the AEC, which in the mid-1960s provided more than half the total national fusion budget (Defence and NASA providing the rest),[17] was intended to support research, because of its close association with the hydrogen bomb project, and in order to maintain American leadership in nuclear technologies.[18] From the very beginning research on nuclear fusion was thus characterised by the 'intermingling of science and politics'.[19]

In the Soviet Union a controlled fusion research programme was officially launched in May 1951. A council on toroidal magnetic thermonuclear reactors was headed by Igor Kurchatov, director of the Institute of Atomic Energy in Moscow (later named after him), where Andrei Sacharov and Igor Tamm would develop an experimental 'magnetic thermonuclear reactor' (tokamak). By the mid-1960s, fusion research was carried out in seven Soviet laboratories. After Kurchatov's death in 1960, Lev Artsimovich became the undisputed leader of fusion research in the Soviet Union and the world's leading authority in the field.[20]

A report released in 1966 by the United States Atomic Energy Commission on the status of fusion research in the world acknowledged Soviet leadership in the field: 'their effort is twice the US effort. In plasma theory the Soviets are preeminent and at this time their effort in theory is about four times the US effort. In number and variety of major experimental devices the Soviets also lead the world'.[21]

The prospect of producing energy for pacific uses from CTF was mentioned at the first United Nations Conference on the Peaceful Uses of Atomic Energy held in Geneva in August 1955. In his opening address, the president of the conference, Homi Bhabha, predicted that 'a method will be found for liberating fusion energy in a controlled manner within the next two decades. When that happens the energy problem of the world will truly have been solved forever'.[22]

Framed in the politics and discursive rhetoric of the Atoms for Peace programme,[23] and in the context of the emerging international institutionalism represented by the IAEA,[24] the path towards declassification took shape between 1955 and 1956. The political-diplomatic framework was provided by the official visit of Nikita Khrushchev and Nikolaj Bulganin to the United Kingdom, from 18 to 27 April 1956. This was the first visit of Soviet leaders to the West since the war. It was also meant as part of the 'charm offensive' of the Soviet premier, and as an international media event and step towards relaunching socialism after Stalinism, 'on the wings of Soviet science' and in the framework of the diplomacy of 'peaceful coexistence'.[25] On 21 April Khrushchev and Bulganin visited Harwell,

[16] Joan Lisa Bromberg, *Fusion: Science, Politics, and the Invention of a New Energy Source* (Cambridge, MA: MIT Press, 1982); Amasa S. Bishop, *Project Sherwood: The U.S. Program in Controlled Fusion* (Reading, MA: Addison-Wesley, 1958); Steven Goldberg, 'Controlling Basic Science: The Case of Nuclear Fusion', *Georgetown Law Journal*, 68 (1979–80); Stephen O. Dean, *Search for the Ultimate Energy Source: A History of the U.S. Fusion Energy Program* (New York: Springer, 2013).

[17] USAEC, Division of Technical Information, *AEC and Action Paper on Controlled Thermonuclear Research*. Washington, DC: USAEC, June 1966, iii–28.

[18] John Krige, *The First Twenty Years of Nuclear Fusion Research*, unpublished manuscript. On the role of thermonuclear technology advancement in shaping US global strategy, Jacob Darwin Hamblin, *The Wretched Atom: America's Global Gamble with Peaceful Nuclear Technology* (Oxford Scholarship online, 2021).

[19] Bromberg, *Science and politics*, 2.

[20] V.D. Shafranov, B.D. Bondarenko and G.A. Goncharov, 'On the History of the Research into Controlled Thermonuclear Fusion', *Physics – Uspekhi* 44 (8), Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences (2001); Paul R. Josephson, *Red Atom: Russia's Nuclear Power Program from Stalin to Today* (Pittsburgh: University of Pittsburgh Press, 2000), 167 ss.

[21] USAEC, *AEC and Action Paper*, iii–32.

[22] United Nations, *Peaceful Uses of Atomic Energy: Fifty Years of Magnetic Confinement Fusion Research, 1958–2008* (Geneva: IAEA, 2008).

[23] In the vast literature on Atoms for Peace, the combination of the political and discursive aspects are particularly dealt with in John Krige, 'Atoms for Peace, Scientific Internationalism, and Scientific Intelligence', *Osiris*, 2 (2006).

[24] David Fisher, *History of the International Atomic Energy Agency: The First Forty Years* (Vienna: IAEA, 1997).

[25] The Foreign Office records of Khrushchev's visit are now made available online by the Wilson Center Cold War International History Project, see Sergey Radchenko, *Love Us as We Are: Khrushchev's 1956 Charm Offensive in the UK*, CWIHP Dossier No. 71, April 2016. https://www.wilsoncenter.org/publication/love-us-we-are-khrushchevs-1956-charm-offensive-the-uk (last visited 15 Feb. 2022). See also Campbell Craig and Sergey Radchenko, 'MAD, not

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accompanied by Kurchatov, who gave a very open and in-depth speech on Soviet progress in the field: physicists 'the world over' were attracted by the 'extraordinarily interesting and very difficult task of controlling thermonuclear reaction'.[26] At the final press conference, held in London on 27 April, Bulganin stressed the importance of nuclear research as an instrument of peaceful collaboration between the two blocks.[27]

In that same April 1956, a delegation from the Swedish Academy of Sciences led by Hannes Alfven visited the Kurchatov Institute in Moscow – the first Western delegation to visit a nuclear research facility in the Soviet Union. In return Artsimovich and Igor Golovin participated in the astrophysics conference held in Stockholm in August 1956, where they met Lyman Spitzer (head of the Princeton programme, where he was developing the stellarator concept) and Robert Pease. Further contacts occurred at the conference on 'Ionization Phenomena in Gases' held in Venice in June 1957.[28] In 1958 *Nature* published a series of papers which represented the outcome of British–American exchanges of information, and articles from the Kurchatov Institute were published in English in four volumes.[29] In the same period the British announced a major breakthrough in plasma control in Harwell's Zeta 'pinch' machine, that immediately met with scientific scepticism and actually turned out to be a wrong interpretation of some experimental results. In fact it helped to accelerate the path towards declassification.[30]

By the mid-1950s fusion was at the forefront of international nuclear conversations and attracted more and more scientists' interest: in August 1957 *Nucleonics* noted that international conferences were 'overrun by the new breed of researchers working on the control of thermonuclear reactions'.[31] Issues of political prestige were also involved, reflecting the optimistic ideology of those *années folles* of pro-nuclear passion.[32] Acceleration of discussion on fusion was also related to the general sensation caused in the West by the Sputnik launch of October 1957. The announcement of declassification made by the three fusion powers at the second international Geneva Conference on the Peaceful Uses of Atomic Energy in September 1958 was thus the final episode of a series of steps clearly aiming at promoting scientific détente across the iron curtain.[33] A period of fusionist 'gold fever' had begun.[34]

The Treaty of Rome and the Origin of Euratom's Involvement in CTF

The fusion fervour of the mid-1950s fostered both the launching of national research programmes and the emergence of a common European interest in collaboration, in a field where European countries lay far behind the three major fusion powers.

Marx: Khrushchev and the Nuclear Revolution', *Journal of Strategic Studies*, 41, 1–2 (2018); Campbell Craig and Sergey Radchenko, *The Atomic Bomb and the Origins of the Cold War* (New Haven: Yale University Press, 2008); David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy 1939–1956* (New Haven: Yale University Press, 1994); David Holloway, 'The Soviet Union and the Creation of the International Atomic Energy Agency', *Cold War History*, 16, 2 (2016); Mark B. Smith, 'Peaceful Coexistence at all Costs: Cold War Exchanges Between Britain and the Soviet Union', *Cold War History*, 12, 3 (2012).

[26] Igor V. Kurchatov, *The possibility of producing thermonuclear reactions in a gazeous discharge*. Lecture given on 26 Apr. 1956 at the British Atomic Energy Research Establishment at Harwell, published in *Nucleonics*, June 1956.

[27] 'Visit to the United Kingdom of Bulganin and Khrushchev, 19–27 April 1956', History and Public Policy Programme Digital Archive, FO 371/122836. Document obtained by James Vaughan. http://digitalarchive.wilsoncenter.org/document/123798 (last visited 15 Feb. 2022).

[28] Braams and Stott, *Nuclear Fusion*.

[29] The collection was edited by Mikhail Leontovich under the title *Plasma Physics and the Problems of Controlled Thermonuclear Reactions*. On the importance of this publication for American fusion research see *Physics Today* 13, 7 (1960), 48.

[30] Herman, *Fusion*, 49 ss; Kriege, *The First Twenty Years*.

[31] Gary J. Weisel, 'The Plasma Archipelago: Plasma Physics in the 1960s', *Physics in Perspective*, 19 (2017), 191.

[32] Bertrand Goldschmidt, *L'aventure atomique. Ses aspects politiques et techniques* (Paris: Fayard, 1962).

[33] On declassification and for an account of the second Geneva Conference, see United Nations, *Peaceful Uses*; Fischer, *History of the IAEA*.

[34] Eckert, 'Plasmas and Solid-State Science', 425.

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In 1955 a fusion programme was initiated in France in Fontenay-aux-Roses by the CEA (*Commissariat à l'énergie atomique*).[35] In Italy a programme was officially launched in 1957 with the creation of *Laboratorio gas ionizzati* in the new research centre of Frascati, near Rome, under the supervision of CNRN (*Comitato nazionale ricerche nucleari*, from 1960 CNEN, *Comitato nazionale energia nucleare*), the Italian national nuclear agency founded in 1952.[36] In West Germany in 1957 plans were made to centralise research on fusion in the new centre of Garching, near Munich, associated with the Max Planck Institut für Plasma Physik and inaugurated in 1960.[37] The launching of fusion programmes was part of the more general process of reconstitution of postwar national nuclear research in Western Europe, while Euratom and CERN, the two major frameworks for collaboration at the European level in nuclear research in the mid-1950s, provided the opportunity to explore paths of cooperation in the field.

Among the priorities set by the treaty establishing the European Atomic Energy Community (Euratom), signed in Rome on 25 March 1957, was 'the study of fusion, with particular reference to the behavior of an ionized plasma under the action of electromagnetic forces and to the thermodynamics of extremely high temperatures' (Annexe I to art. 4 of the treaty). During the negotiations leading to the treaty, fusion was already defined 'a very urgent task' for the new Community.[38]

The reasons for such urgency were also political, and are to be framed in the context of international competition with the United States, the United Kingdom and the Soviet Union, in view of the Geneva conference. Euratom's institutions were to come into operation from 1 January 1958. On 11 September 1957 Euratom's *Comité intérimaire* entrusted the task of establishing a first research programme to a group of experts (*Groupe de la Recherche nucléaire*), who met in Paris on 3 December 1957, with the aim of making recommendations to the new Commission on strategic priorities. On that occasion a note presented by the French delegation was adopted as a basis for discussion. The note, prepared by the CEA, listed fusion among the top priorities to be pursued by the new Community: 'we should speed up on fusion research as the Americans, the British and the Russians have announced that it is going to be one of the main subjects of the Geneva Conference'.[39] In addition to scientific considerations, from the beginning the aim was to use Euratom in order to create a kind of European fusion 'fourth force'.

The Group of Experts' Report was developed along the lines of the CEA's note: nuclear fusion was 'the typical long-term research field where a common effort is particularly desirable. Experts have unanimously agreed on the urgency of a common action in this field where Anglo-Saxons and Russians have directed considerable investment and expect positive results'. The new Community's fusion endeavour would not be carried, however, in the Joint Research Center (JRC), provided for

[35] On fusion research carried out by the CEA in those early years, see Michel Trocheris, 'Controlled Thermonuclear Fusion Research Conducted by the French Commissariat à l'energie atomique', in *Peaceful Uses of Atomic Energy*. Proceedings of the Fourth International Conference, jointly sponsored by the UN and the IAEA and held in Geneva, 6–16 Sept. 1971, vol. 7.

[36] On the Italian fusion project, Barbara Curli, 'Italy, Euratom and Early Research on Controlled Thermonuclear Fusion, 1957–1962'; and Mauro Elli, 'Italy in the European Fusion Programme during the 1980s: A Preliminary Overview', in Elisabetta Bini and Igor Londero, eds., *Nuclear Italy: An International History of Italian Nuclear Policies during the Cold War* (Trieste: EUT, 2017). See also Bruno Brunelli, 'The History and Future of the Italian Fusion Programme', *Plasma Physics and Controlled Fusion*, 29 (1987).

[37] On the German fusion programme, Michael Eckert, '"Vom Matterhorn zum Wendelstein". Internationale Anstösse für Fusionsforschung in der BRD', in Michael Eckert and Maria Osietzki, *Wissenschaft für Macht und Markt. Kernforschung und Mikroelektronik in der BRD* (Munich: Beck, 1989); Susan Boenke, *Entstehung und Entwicklung des Max-Planck-Instituts für Plasmaphysik 1955–1971* (Frankfurt: Campus Verlag, 1991).

[38] Groupe de l'Euratom. Rapport du Groupe ad hoc, *Programme et Budget de Recherche*, 3 Jan. 1957, Archivi Storici del Dipartimento di Fisica (ASDF), Università di Roma 'La Sapienza', Archivio Edoardo Amaldi (EA), 175, 2, 1 (translations from French and Italian are the author's).

[39] *Note de la Délégation française sur les activités de recherche d'Euratom*, 28 Nov. 1957, Archives Historiques du Commissariat à l'Energie Atomique (AHCEA), Fontenay-aux-Roses, Archives du Haut-Commissaire à l'Energie Atomique (HC), F5.17.11.

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by the treaty and still in the course of (lengthy) discussion. Instead, a decision was made to entrust contracts to European laboratories, public or private, already active in some fundamental research related to fusion. The French also proposed to involve CERN.[40]

According to Euratom's Technical and Scientific Committee (TSC), chaired by Edoardo Amaldi, fusion was a sector on which Euratom could build its own identity as a new international scientific institution. In a July 1958 meeting of the TSC, the French member Francis Perrin, who was AG of the French CEA, underlined the importance of fusion and 'the hopes it raises', while warning against the 'technical and economic difficulties' it still faced. Fusion was 'an interesting, though distant, objective, for which Euratom could be *chef de file*'.[41]

A common programme would relieve the costs of research in a field where very long-term experimental results were expected and national programmes were at a very preliminary stage, nor were questions of industrial applications likely to arise (as with fission). Fusion would also strengthen Europe's modern 'identity', rooted in the 1950s faith in the capability of science and technology to deliver unlimited progress and social change. It was thus consistent with Euratom's mission to become one of the instruments of Europe's modernisation in the Cold War techno-scientific race.[42]

Research on fusion was thus included in Euratom's first research programme, set out during summer 1958. The political use of fusion made at the Geneva Conference, which opened on 1 September, was highlighted by several observers, including Felice Ippolito, the secretary-general of the Italian CNRN and active figure in this Euratom's start-up phase. In his preliminary report from Geneva he underlined that it was evident that possible 'industrial applications' of fusion were still 'very far ahead'. Although the great powers devoted 'enormous means' to fusion, the most eminent scientists attending the conference agreed that these studies were still at a 'university stage'. This was probably the reason why the Soviet delegates had been so 'open' on fusion, but very 'tight' on all other nuclear matters.[43]

However, from the declassification episode in Geneva onwards, fusion would continue to bear a symbolic value of collaboration which at times helped cross the rigid logic of the Cold War divide, thereby inaugurating a long tradition of European-Soviet-American cooperation lasting to some extent until nowadays.[44] This evident political dimension of fusion affected in different ways decision making on national and international funding over time, going beyond an economic-scientific rationale, in the name of political cooperation. This would apply also to European fusion research: although declassification opened up a new phase in fusion history and favoured European collaboration in the Euratom framework, such collaboration would since then be defined by a peculiar combination of political and scientific considerations.

The Euratom–CERN Joint Work Study Group, 1958–9

Early discussions on Euratom's fusion programme included the attempt to start a collaboration with CERN.[45] As anticipated during the first meeting of the group of experts of the *Comité intérimaire pour le Marché commun et l'Euratom*, the initiative came from France. The president of the CERN Council,

[40] Comité intérimaire pour le Marché commun et l'Euratom, *Compte-Rendu de la Réunion du Groupe de la Recherche tenue le 3 Décembre à Paris*; Comité intérimaire pour le Marché commun et l'Euratom, *Rapport du Groupe de la Recherche nucléaire*, 4 Dec. 1957, AHCEA, HC, F5.17.11.

[41] Euratom, la Commission, Comité scientifique et technique, *Projet de compte-rendu de la réunion du 7 juillet 1958*, Bruxelles, 18 July 1958, AEA, ADF, 190, 1, 1.

[42] On these cultural, discursive features of Euratom's early history, Barbara Curli, 'Nuclear Europe: Technoscientific Modernity and European Integration in the Discourse on Euratom's Early History', in Manuela Ceretta and Barbara Curli, eds., *Discourses and Counter-discourses on Europe: From the Enlightenment to the European Union* (London: Routledge, 2017).

[43] Relazione preliminare sulla II Conferenza di Ginevra sugli usi pacifici dell'energia nucleare, Sept. 1958, ADF, EA, 160, 2.

[44] On this issue see in general Fabian Lüscher, 'The Nuclear Spirit of Geneva: Boundary-Crossing Relationships of Soviet Atomic Scientists after 1955', *Jahrbücher für Geschichte Osteuropas*, 66, 1 (2018).

[45] *Le problème de la fusion: coopération d'Euratom avec les Etats-Unis, l'Agence Internationale de l'Energie Atomique (AIEA), l' Organisation Européenne pour la Recherche Nucléaire (CERN) et programme de recherches sur la physique des plasmas*

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François De Rose, formerly responsible for atomic questions at the Quai d'Orsay, approached the president of the Euratom Commission, Louis Armand, and Euratom's director of Research and Education, Jules Guéron, on the question of a possible common European endeavour on fusion research.[46] Between April and May 1958 the director-general of CERN, Cornelis J. Bakker, made plans to invite European experts ('and if possible American experts') with the idea of creating a study group on plasma physics in collaboration with Euratom.[47] Guéron and Euratom's TSC favoured the initiative, in particular its chairman Amaldi, who had long-lasting ties with CERN.[48] In CERN, moreover, there was concern that the very high-level engineering teams that had contributed to the construction of the proto-synchrotron might be dispersed: instead, they could have been taken up by fusion work.[49]

On 31 May 1958 a first meeting between Guéron, Bakker and John B. Adams, director of the proto-synchrotron division of CERN, laid the terms of reference for a joint study group that would evaluate and coordinate plasma physics research programmes being conducted or planned in Europe, and the training of suitable staff in universities. Members of the group would be 'European scientists engaged in fusion research work who could be considered as experts in this field'. Euratom would contribute two-thirds of the estimated costs, and CERN one-third.[50]

The group was to meet every month until the Geneva conference scheduled for September. Although approved by the CERN Council on 19 June, the joint project would soon meet the opposition of those members of CERN that were not members of Euratom.[51] Great Britain adopted a 'minimalist line':[52] as the most advanced in fusion research in Europe (and in the course of developing TN weapons, their first test having been carried out in May 1957), the British did not want to see themselves, through CERN, being drawn into a European fusion programme. Nor did they wish to share their privileged arrangements with the United States, or collaborate with partners much behind them. Instead, Switzerland and Sweden, two neutral countries, feared that public opinion might relate nuclear fusion to the H bomb, thereby damaging the image of CERN.[53]

The CERN Council finally decided to set up its own study group on plasma physics, in which Euratom's observers could participate.[54] The group held three meetings (on 25–6 September 1958; 11–12 December 1958; 5–6 March 1959) and produced a final report. This recognised the

dans le cadre du Groupe 'Fusion thermonucléaire contrôlée', Historical Archives of the European Union, Florence (HAEU), Archives of the Commission (AC), BAC-118/1986_2253.

[46] Dominique Pestre, 'Another Aspect of CERN's European Dimension: The "European Study Group on Fusion", 1958–64', in Armin Hermann, John Krige, Ulrike Mersits and Dominique Pestre, *History of CERN, Vol. II* (Amsterdam: North Holland, 1990). Here Pestre underlines the relationship between Sputnik and the fusion initiative. See also Luca Guzzetti, *A Brief History of European Union Research Policy* (Luxembourg: European Commission, DG XII, 1995); Krige, *The First Twenty Years*.

[47] Letter from Bakker to De Rose, 17 Apr. 1958, HAEU, Jules Guéron (JG) 93. Tentative names included Thonemann and Pease (UK), Winter, Vendryes and Huber (France); Brunelli and Persico (Italy); Biermann and Schlüter (Germany), Siegbahn (Sweden), Braams (Netherland).

[48] Guéron to Medi and De Groote, 20 Apr. 1958; Guéron to Bakker, 21 May 1958, HAUE, JG 93.

[49] Pestre, 'Another Aspect of CERN's European Dimension', 419–20. One of the reasons put forward was also to try to avoid the departure to the United States of Arnulf Schlüter, who during a meeting in Geneva in March 1957 had expressed vehement criticism of the 'Zeta' experience. Letter from Bakker to De Rose, 17 Apr. 1958, HAEU, JG 93.

[50] Euratom-CERN Joint study for Fusion Research. Minutes of Meeting held at CERN to discuss the possibility of setting up a joint study group to consider European fusion research programmes, 2 June 1958; ASDF, EA, Sezione Archivio del Dipartimento di Fisica (ADF), 190, 1, 1, and Note for the Commission by Guéron, 5 June 1958, HAEU, JG 93.

[51] Bakker to Guéron, 24 June 1958, HAEU, JG 93.

[52] Pestre, 'Another Aspect of CERN's European Dimension', 421.

[53] Krige, 'The First Twenty Years', 30.

[54] Bakker to Guéron, 3 July 1958, ASDF, EA, ADF 175, 2, 2. The CERN Study Group was chaired by Adams, and its members were the French P. Hubert and G. Vendryes from Fontenay-aux-Roses and P. Prévot, S.D. Winter and M. Trocheris from Saclay; the Italian B. Brunelli and E. Persico from Frascati; the German L. Biermann, G. von Gierke and A. Schlüter from the Max Planck Institut in Münich and Fuchs and Jordan from Achen; the British L.J. Bickerton from Harwell and Latham from the Imperial College in London; the Dutch C.M. Braams, H. Brinkman and ter Horst; K. Johnsen from Norway; the Danish O. Kofoed-Hansenthe, the Belgian Lafleur, the Swedish A. Dattner and K. Siegbahn; the Swiss

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'intractability' of fusion and its long-term perspectives, but also the desirability of pursuing research in the field in the hope of fostering a European identity in fusion research.[55]

From then on, however, interest in fusion seems to have slowed down at CERN, as its activities were concentrated on the start of the proto-synchrotron and early worries about dispersion of the CERN technical teams were quickly overcome by new work on the accelerator,[56] but also because Euratom launched its own fusion programme, involving the same members of the CERN Study Group who came from Euratom's member countries. CERN sponsored the formation of a European society for controlled thermonuclear research, an initiative taken by John Cockroft in order to relaunch British fusion leadership, but this apparently met with little enthusiasm.[57] Under the impulse of John Adams, the CERN Study Group continued to hold scientific meetings until 1964.

The Launching of Euratom's Fusion Programme: The French and the Italian Association Contracts

In September 1958, while the Geneva Conference was being convened and the CERN Study Group launched, the Euratom Commission decided to put Donato Palumbo in charge of the management of a common fusion programme. Palumbo, 'a fusion visionary', from then on until his retirement in 1986 would become the key figure of the European fusion programme, a role he fulfilled with a competence and dedication which was unanimously recognised, coordinating and stimulating the effort tirelessly.[58] He later spoke of his 'total dedication to the European Fusion programme throughout my 28 years in Brussels'.[59]

The first decision the Commission had to face was whether to opt for a common European fusion laboratory or to strengthen and coordinate national efforts. The issue of a common fusion facility had already been raised at the CERN level and had provoked several objections, especially from Britain.[60] Palumbo and the Commission were well aware of the (mainly political) difficulties that a common fusion laboratory would raise also, and even more so, among Euratom's member countries, as had already emerged during the December 1957 meeting of the group of experts of the *Comité intérimaire*. As a result, it was decided to set up a network of contracts of association between Euratom and the national nuclear authorities of the member countries: the community would coordinate and supervise the financial and scientific effort across the field.[61] This structure was partly modelled on the Sherwood Project in the United States, where the Sherwood Committee financed and coordinated research in American fusion laboratories, under the supervision of the USAEC.[62]

Between March and May 1959 Guéron started negotiations with the member states. On 23 December 1959 the Commission, Palumbo and Guéron met the representatives of the national nuclear authorities, in order to set the priorities of the new Community and outline the first five-year plan.

H.E. Knoepfel. Observers from outside organisations were Guéron and Palumbo for Euratom; L. Kowarski and P.J. Frank for the OEEC; and Bishop of the USAEC.

[55] *European Fusion Research: Report of the CERN Study Group on Fusion Problems*, 2nd draft, 24 Mar. 1959. ASDF, Archivio Enrico Persico (EP), 16/73. Enrico Persico was the Italian member (with Bruno Brunelli) of the Study Group.

[56] Pestre, 'Another Aspect of CERN's European Dimension', 425–6.

[57] On the reception of the British proposal see the correspondence between Adams and Persico in ASDF, EP, 16/73. Persico was invited to join as the Italian representative of the society.

[58] Jean Jacquinot, *Donato Palumbo (1921–2011), a fusion visionary*, http://www.iter.org/newsline/201/977 (last visited 15 Feb. 2022). Umberto Finzi, *Donato Palumbo*, in Dizionario biografico degli italiani, online, 80 (2014), http://www.treccani.it/enciclopedia/donato-palumbo_(Dizionario-Biografico)/ (last visited 15 Feb. 2022).

[59] Donato Palumbo, 'The Work of the European Commission in Promoting Fusion Research in Europe', *Plasma Physics and Controlled Fusion*, 29, 10B (1987).

[60] Pestre, 'Another Aspect of CERN's European Dimension'.

[61] *Fusion nucléaire: projet de la Commission de l'Euratom de développer un programme de recherche en matière de fusion contrôlée*, HAEU, AC, BAC-118/1986_497, 1959–60.

[62] Bromberg, *Fusion*.

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During the meeting the importance of fusion was restated (5 per cent of Euratom's budget would be devoted to it), and it was announced that the first association contract on nuclear fusion had been signed with the French CEA.[63]

Between 1959 and 1962, Euratom signed five association contracts: with the French CEA, located in Fontenay-aux-Roses; with the Italian CNEN-*Laboratorio gas ionizzati*, located in Frascati; with the German Institut für Plasmaphysik in Garching and with the KFA (*Kernforschungsanlage*) in Jülich; with the Dutch Institute for Plasma Physics (FOM) located in Rijnhuizen near Utrecht.

The French and the Italian association contracts had a similar organisational structure, retraceable through the minutes of meetings of the managing boards of the two associations. The Euratom-CEA association contract was managed by a *Comité de gestion* (CdG) that met every three months.[64] The CdG was constituted on a parity basis, with two representatives of Euratom (Palumbo and Ellerkman, with Guéron at times present at the meetings); two representatives of the CEA (Jacques Yvon, who was director of the *Physique et Piles atomiques* section of the CEA, and Jean-Pierre Goure), and Georges Vendryes, chief of the *Département de Recherche Physique* of the CEA, who was also the chief of the *Groupe de recherché* (and member of the CERN Study Group).[65]

The contract was initially financed for three years. The contribution was 75 per cent Euratom and 25 per cent CEA. According to Michel Trocheris, later to become chief of the *Groupe de Recherche*, when the contract was signed in 1959 work on fusion had hardly started within the CEA; thus the first French fusion research programme was actually defined in the framework of the association contract.[66] In 1959 the personnel involved in the contract amounted to sixty-one (two women). In 1961 it had already increased to 150, one-third of whom were Euratom's employees. Early activities were mainly devoted to outline a research plan which included collaboration with the *Service de physique* of the CEA Centre of Saclay, and to exchange researchers with other laboratories, in particular in the United States and the United Kingdom.[67] Cooperation on nuclear fusion was included in the United Kingdom-Euratom agreement signed in 1959.[68]

Fusion quickly became an important part of the CEA activities, to the extent that a complete reorganisation was needed as soon as 1962. The contract was renewed, involving a change in the terms of participation (Euratom 54 per cent, CEA 46 per cent). After the start-up phase, the role of Euratom funding was thus relatively diminished, although it retained the majority and the effort had overall increased. In four years, personnel had doubled: in 1963, after the reorganisation, total personnel amounted to 127 (six women), of whom eighty-four were from the CEA and forty-three from Euratom.[69]

In October 1959 a sub-contract was negotiated with the Italian *Laboratorio gas ionizzati* (LGI), founded in October 1957 and directed by Bruno Brunelli, and located in the newly-created

[63] Commission Euratom, Compte rendu sommaire de la réunion du 15 décembre 1959 à Val Duchesse. AHCEA, HC, F5.17.11.

[64] This paragraph is based on the Minutes of Meetings of the Euratom-CEA Association contract: Association Euratom-CEA pour la fusion contrôlée – Comité de gestion, *Procès-verbaux et documents annexes*, 3 volumes, B 2504-2505-2506, Archives historiques du Commissariat à l'Energie Atomique (AHCEA), Fontenay-aux-Roses, Haut Commissaire (HC).

[65] On this early French fusion community, Anatole Abragam, *De la physique avant toute chose* (Paris: Odile Jacob, 1987).

[66] Michel Trocheris, 'The History and Future of the French Fusion Programme', *Plasma Physics and Controlled Fusion*, 29 (1987).

[67] See for example Letter from Guéron to Arthur Ruark, Controlled Thermonuclear Fusion Division of Research, Atomic Energy Commission, USA, 12 Sept. 1960, *Notes sur le contrat d'association entre EURATOM et CEA*, HAEU, JG, 93.

[68] On the United Kingdom-Euratom Agreement, Mauro Elli, *Politica estera ed ingegneria nucleare. I rapporti del Regno Unito con l'Euratom (1957–1963)* (Milano: Unicopli, 2007); Stuart A. Butler, 'The Struggle for Power: Britain and Euratom 1955–63', *International History Review*, 36, 2 (2014), where, however, fusion is not mentioned.

[69] As a result of this reorganisation, the CdG was enlarged to four members from Euratom and four members from the CEA.

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Laboratori Nazionali in Frascati, near Rome.[70] The Association contract was signed in January 1960.[71] In 1962 the CEA withdrew and the Italian contract became independent.

The first meeting was held in July 1960 in Rome at the physics department.[72] Members of the *Comitato di gestione* (CdG) of the Italian contract were Edoardo Amaldi, Palumbo as representative of Euratom, and Bruno Brunelli as chief of the research group. Until 1962 a representative of CEA would take part in the meetings, while Brunelli continued to attend meetings at Fontenay-aux-Roses.

The financial effort of the Italian contract was split between Euratom at 60 per cent and CNEN at 40 per cent. The group was made up of fifty-seven people and included Enrico Persico (also a member of the CERN Study Group), Franca Magistrelli (the only woman of the group) and Alberto De Angelis, subsequently joined by John Allen from Harwell and George Linhart, Georges Maisonnier and Heinz Koepfeln from CERN.

As in the French case, great importance was attributed to training and education, with strong ties with Italian universities, the creation of courses and graduate fellowships, and a continuous exchange of researchers with laboratories abroad, in Europe, the United Kingdom, the United States and the Soviet Union. New figures were created, such as that of the Euratom *stagiaire qualifié,* who moved around between European laboratories.

The German Association Contract

The international nuclear fervour of the mid-1950s played a catalysing and accelerating role also in the development of German fusion research, in the framework of a more general reconstruction and re-legitimation of nuclear research in West Germany. Most plans revolved around the figure of Werner Heisenberg, Nobel Prize winner in 1932, one of the founders of CERN and the most prominent figure of the German nuclear establishment.[73] In the wake of the first Geneva conference, research teams on plasma and fusion were given new impetus in several nuclear establishments and in particular in the Max-Planck-Institut in Göttingen, where Heisenberg was based. This team included Carl Friedrich von Weizsäcker, Gerhart von Gierke and astrophysicists Ludwig Biermann and Arnulf Schlüter. The second Geneva conference (where Biermann gave a speech on the situation of German research on fusion) and the CERN Study Group (of which Biermann, von Gierke and Schlüter were the German members) provided further opportunities to accelerate national fusion research planning and attract public interest and political support, especially from the minister of atomic affairs Siegfried Balke.[74]

[70] On the origin of Italian fusion research, and related bibliography, see more extensively Curli, *Italy, Euratom, and Early Research on Controlled Nuclear Fusion*. In general, on Italian nuclear research in the 1950s and 1960s, Barbara Curli, *Il progetto nucleare italiano, 1952–1964. Conversazioni con Felice Ippolito* (Soveria Mannelli: Rubbettino, 2000); Bini and Londero, *Nuclear Italy;* Leopoldo Nuti, *La sfida nucleare. La politica estera italiana e le armi atomiche 1945–1991* (Bologna: il Mulino, 2007); Giovanni Paoloni, ed., *Energia, ambiente, innovazione, dal Cnrn al Cnen* (Roma-Bari: Laterza, 1992).

[71] Commission Euratom, *Note d'Information sur l'exécution du programme de recherches*, 3 May 1960, in Archivi ENEA, Frascati (AENEA), Contratto di Ricerca (CR) Euratom-CNRN (Laboratorio Gas Ionizzati), then Contratto di ricerca Euratom-CNEN (Laboratorio Gas Ionizzati).

[72] The Minutes of Meetings of the Italian Association contract are in AENEA, CR Euratom-CNRN, Comitato di gestione, Verbali, 1960–68.

[73] David C. Cassidy, *Uncertainty: The Life and Science of Werner Heisenberg* (New York: W. H. Freeman, 1992). On his public role in the reconstruction of post-war nuclear research in West Germany, Cathryn Carson, *Heisenberg in the Atomic Age: Science and the Public Sphere* (Cambridge: Cambridge University Press, 2010); Cathryn Carson, 'New Models for Science in Politics: Werner Heisenberg in West Germany', *Historical Studies in the Physical and Biological Sciences*, 30, 1 (1999); Michael Eckert, 'Primacy Doomed to Failure: Heisenberg's Role as Scientific Adviser for Nuclear Policy in the FRG', *Historical Studies in the Physical and Biological Sciences*, 21, 1 (1990).

[74] The role of the first Geneva Conference in catalysing the resumption of fusion research in West Germany will subsequently be acknowledged by Ludwig Biermann in his speech at the Second Geneva Conference; see Ludwig Biermann, 'Recent Work on Controlled Thermonuclear Fusion in Germany/(Federal Republic)', *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Vol. 31. Theoretical and Experimental Aspects of Controlled Nuclear Fusion* (Geneva, 1958).

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Here too Heisenberg's role as advisor and chief negotiator between science, industry and the state, both at the federal and the state level, was fundamental, in particular when the *Max-Planck-Institut für Physik und Astrophysik* (MPI, or *Max-Planck-Gesellschaft*, MPG, as in most archival documents here) moved to Munich in 1959, directed by Heisenberg and Biermann, and when in March 1960 the decision was officially made to build a centre devoted to fusion research in the nearby site of Garching. The centre would host, among others, the team of around twelve physicists led by Erwin Fünfer. Research on the stellarator was carried out in particular by R. Lüst, at that moment in Princeton, and C.P. Martens. Research in Garching would in fact mainly develop along the lines of the stellarator concept being pursued in Princeton, that would eventually evolve into the German Wendelstein concept.[75]

On 5 March 1959 during a meeting held in Geneva between Biermann and von Gierke on the German side, and Guéron and Palumbo for Euratom, a preliminary base for a fusion association contract was laid out.[76] Negotiations, however, soon turned out to be much more difficult than in the French and Italian cases, as reservations emerged on the German side on prospects of collaboration with the French.[77] The Kuratorium (the administrative board) of the MPI put forward military research being carried out in Saclay as a reason for approaching Euratom with great 'caution' and 'perplexity' – as Heisenberg wanted to put on record – over 'French predominance' in it. The French CEA was a more important partner for Euratom than the MPI, and worries were expressed over 'equality'. Heisenberg underlined that the MPI 'was not so much interested in Euratom's financing as in the exchange of experience with outstanding foreign scientists'. Balke, however, stressed the desirability of an association with Euratom 'for political reasons', as Germany had signed the treaty and was expected to respect it.[78]

Discussions dragged on for months. Palumbo insisted that an agreement with the Germans needed 'to be made and to be made quickly': firstly, given Europe's shortage of qualified scientists, it was Euratom's task to help train young researchers, that could only 'benefit from specialization' in an institution as prestigious as the MPI. Secondly, the association contract with the Germans would open for Euratom 'a window toward the United States' (*'une fenêtre sur le monde américain'*), given the tradition of exchange of qualified researchers between the MPI and research centres in the United States. Moreover, the contract needed to be signed quickly, because the Garching Center still had to start operations, and Euratom should be present to help orient its start-up phase.[79]

As a matter of fact, negotiations with Euratom accelerated the construction and the definition of the role and administrative structure of the new centre, to be named *Institut für Plasmaforschnung GmbH in der Max-Planck-Gesellschaft* (then IPP, *Institut für Plasmaphysik*).[80] The German position

[75] On Heisenberg's and Biermann's role in the establishment of Garching and in general in this early phase of German fusion research, see Eckert, 'Vom "Matternhorn" zum "Weldenstein"', and Boenke, *Entstehung und Entwicklung*.

[76] Letter from Biermann to Guéron, 18 Mar. 1959, and Notes on Discussion of 5 Mar. 1959, HAEU, JG 93; Donato Palumbo, *Prise de contact avec l'Institut Max Planck de Munich du 21 May 1959*, HAEU, AC, BAC-118/1986_2545, Energie nucléaire en République fédérale d'Allemagne: contrat fusion 'Munich'; contrat avec le Max Planck Gesellschaft pour la recherche concernant la fusion nucléaire. Vol. 6, 1959–60. In this document Palumbo reconstructs earlier discussions.

[77] Donato Palumbo, *Note pour M. Guéron. Contrat Munich – Conversations du 21 mai 1959*, Bruxelles, 29 May 1959. HAEU, AC, BAC-118/1986_2545.

[78] On the German position, based on the MPI Commission Meeting Minutes, see Eckert, 'Vom "Matternhorn"', 123–4. On Franco-German difficult postwar scientific collaboration, Corine Defrance, 'France-Allemagne: une coopération scientifique "privilégiée" en Europe, de l'immédiat après-guerre au milieu des années 1980?', in Corine Defrance and Anne Kwaschik, eds., *La guerre froide et l'internationalisation des sciences. Acteurs, réseaux et institutions* (Paris: Editions CNRS, 2016); Manfred Heinemann, 'La France et le CNRS dans la politique scientifique de la Max-Planck-Gesellschaft (1948–1981)', in Corine Defrance and Ulrich Pfeil, eds., *La construction d'un espace scientifique commun? La France, la RFA et l'Europe après le 'choc du Spoutnik'* (Bruxelles: Peter Lang, 2012).

[79] Donato Palumbo, *Note pour M.Guéron. Contrat Munich – conversations du 21 mai 1959*, Bruxelles, 29 May 1959. HAEU, AC, BAC-118/1986_2545.

[80] Letter from Biermann to Mathjsen, 15 Dec. 1959, transmitting a *Projet de contrat entre l'Euratom et le Max-Planck-Gesellschaft*, HAEU, AC, BAC-118/1986_2545.

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continued to be aimed at retaining a substantial degree of autonomy on national fusion research. The two parties eventually agreed on a three-year research programme, directed by a scientific committee where Euratom was represented only by scientists working full time in Garching. Euratom would finance one-third of total expenses and Euratom personnel would not exceed one-third of the total (scientists and technicians). Euratom would be informed of the results of research. However, publications would have to be authorised by the scientific director of the centre (where Euratom was not represented). Inventions and patents would be the property of the MPI according to German patent law.

The IPP started operations with an experimental team of thirty physicists, five engineers and twenty-five others, and a theoretical team of twelve researchers. Euratom's institutional role – Palumbo informed Guéron – would be limited to 'a minority participation . . . without any real power' in the administrative commission of the centre, which included members of the Bund, the Länder and the MPI. The German association contract was thus 'far from the conditions of the CEA contract' and even from what agreed upon during the 5 March meeting in Geneva. Moreover, other German fusion programmes were financed by the Bund (for example the group directed by von Weizsäcker in Hamburg), with little coordination with Munich: this last represented between half and two-thirds of the German effort in nuclear fusion.[81] Palumbo insisted that coordination with the other association contracts was necessary. But in spite of Euratom's 'evident lack of enthusiasm', Heisenberg held on to the independence of research carried out at Garching. As a result, unlike the French and Italian cases, only a part of German fusion research would fall under Euratom.[82]

In February 1960 discussions reached a stalemate[83] and were further delayed by an agreement reached in the meantime between the French CEA and the Soviet Glavatom. The issue was raised at the level of the permanent representatives in Brussels and in the Euratom Commission. While the CEA was willing to share information on the part of the agreement related to fusion research (but not on the rest), the agreement was vehemently criticised by the German delegate. As the Italian permanent representative pointed out, this was one of the first times when the Community had to face problems related to the scientific integration of Europe: 'as Community action in scientific research advances, it will be more and more difficult to distinguish between knowledge peculiar to a member state and that acquired in the framework of the Community effort'.[84]

Euratom insisted, however, on trying to move forward with the German fusion association contract and, as recommended by Guéron, 'accepted all the requests made by the MPG'. As a result, Euratom's negotiators were taken aback when they heard that the MPG was discussing an agreement with the Academy in Moscow, in the framework of a more general accord signed by chancellor Adenauer during a recent visit to the Soviet Union. This was all the more surprising given the strong reactions the Germans had expressed over the CEA–Glavatom agreement, and their reservations over the presence of a group of Russian and Bulgarian researchers in Fontenay-aux-Roses.[85]

In July 1960 the Germans rejected Euratom's text. A series of exchanges between the president of the Commission, Etienne Hirsch, and the newly appointed president of the MPG, Adolf Butenandt, attempted to solve the impasse.[86] Exchanges between the German Commissioner Heinz L. Krekeler

[81] Donato Palumbo, *Note pour M. Guéron. Contrat Munich – Conversations du 21 mai 1959*, Bruxelles, 29 May 1959. HAEU, AC, BAC-118/1986_2545.

[82] Compte rendu des négociations avec le MPG à Göttingen, 19 Aug. 1959. HAEU, AC, BAC-118/1986_2545.

[83] *Note sur le contrat 'fusion' Munich*, Bruxelles, 22 Feb. 1960, HAEU, AC, BAC-118/1986_2545.

[84] Accord entre le Commissariat français à l'énergie atomique et l'organisation soviétique Glavatom sur les échanges de connaissances et de stagiaires notamment dans le domaine de la fusion contrôlée, Extrait du Procès-verbal de la réunion restrainte du Comité des représentants permanents, tenue à Bruxelles le 7 avril 1960. HAEU, Archives du Conseil des Ministres, CM2/1960-550.

[85] Compte-rendu de la mission des 14 et 15 octobre 1960, Contrat fusion Munich (Max Planck Gesellschaft), HAEU, AC, BAC-118/1986_2545.

[86] Energie nucléaire en République fédérale d'Allemagne: contrat fusion 'Munich'; contrat avec le Max Planck Gesellschaft pour la recherche concernant la fusion nucléaire. Vol. 6, 1959–60, HAEU, AC, BAC-118/1986_2545.

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and Butendandt helped to overcome some last worries, specifically Heisenberg's, that the higher salaries of Euratom personnel might provoke protests from German researchers in Garching.[87] In the end, the perception that Euratom was not going to 'internationalise' Garching but instead would strengthen German national efforts in fusion, as was happening with the other association contracts, helped to overcome the remaining reservations.

The agreement was finally signed in January 1961, after the Germans accepted the establishment of a mixed *Comité de gestion* (on the model of the French and Italian contracts) composed by Palumbo, Linhart and Glaesner for Euratom; Biermann, Fünfer, von Gierke, Schnitter and Telschow for the IPP. When compared to Fontenay-aux-Roses and Frascati, the growth of the Garching Center was equally – and actually even more – impressive, especially considering that when negotiations had started with Euratom a couple of years earlier there were just 'a few sheds'. During 1961, the first actual year of operation, the number of personnel involved had increased from eighty-six to 218.[88]

Euratom's Association Contracts and the Emergence of a Transnational European 'Fusion Community'

Although prior to the Second World War plasma physics research had been carried on for years, its practitioners worked in diverse environments and generally did not share a common self-understanding as plasma physicists.[89] Postwar politically-motivated funding and the institutionalisation of research played a fundamental role in affecting the scientific status and visibility of the discipline, and in shaping the professional identity of its scientists. The declassification turn further favoured the institutionalisation, at both national and international levels, of fusion research, and facilitated the establishment of university courses and the proliferation of scientific meetings. In the United States, plasma physics became an official subdiscipline in April 1959 with the foundation of the Division of Plasma Physics of the American Physical Society. Project Sherwood helped to assemble a fusion community based on different specialties (from gaseous electronics to geophysics, to astrophysics and spectroscopy), though not exempt from internal division, scientific disagreement and personal rivalries.[90]

Euratom's fusion experience has thus to be contextualised in this more general global framework. It embraced the scientific enthusiasm surrounding declassification, the technoscientific rivalry and cooperation in that specific phase of the Cold War, and the ways the new institutional setting provided by the treaty fostered European scientific collaboration. All of this helped produce a new transnational European fusion community.

The CERN initiative and Euratom's programme were the two main fusion efforts at the regional European level. The CERN Study Group played an important role at the beginning but was progressively pushed into the background as CERN moved towards other research priorities, while Euratom emerged as the main reference point for European fusion research. In reality, although the two organisations showed different institutional identities and political drives, they both contributed to the emergence and visibility of a European fusion community.

Palumbo played a fundamental liaison role in launching and developing the Euratom association contracts. Continuously informed on fusion developments in other European and non-European laboratories, he was also aware of those research paths that seemed more promising than others, and his opinion was usually respected. Fusion gradually became an important aspect of European scientific collaboration: it was a new field of research, very internationally oriented, with Euratom playing a new and significant role in the framework of international nuclear institutionalism.

[87] Eckert, 'Vom "Matternhorn"', 124 and n.46 and 47.

[88] Rapport 63/31, Contrôle comptable au contrat d'association Euratom/Institut Plasmaphysik, no 003-61-1 FUAD, HAEU, AC, BAC-118/1986_2545.

[89] Eckert, 'Solid-state', 417.

[90] Gary J. Weisel, 'Properties and Phenomena: Basic Plasma Physics and Fusion Research in Postwar America', *Physics in Perspective*, 10 (2008); Weisel, 'The Plasma Archipelago'. On internal division and political-personal rivalries often exacerbated by the institutionalisation of the Sherwood project, see Bromberg, *Fusion*.

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The coordinating role that Palumbo played in the early years of the association contracts was first formalised by the establishment of a *Groupe de liaison 'Fusion thermonucléaire'*. Its task was to assess periodically the scientific content of research carried out in the national centres. Subsequently, and more effectively, a committee of directors of the associated laboratories was also established, bearing the authority and the possibility to model research programmes according to information exchanged among directors. These forms of liaison had the merit of enhancing 'the coherence of research carried out' at the community level.[91]

Questions related to the 'hidden integration' of Europe through science and technology at the intersection of national and transnational processes, as well as the tensions arising from them, have been developed by recent historiography that has stressed the role played by networks of scientific and technical expertise.[92] Naturally, and as in other realms of European technoscientific collaboration, the transnational community of scientists, technicians, technocrats, community officers and science managers devoted to the fusion project developed over time a bureaucratic interest in the continuation and financing of fusion programmes. From this point of view, the case of fusion provides another case-study in transnational élite formation, both as the outcome of practices of circulation of knowledge and as an aspect of the relationship between European regionalism and globalisation.[93] European regionalism, in particular, raises a series of issues relating to the historical roots and culture of a 'European public hand' in technoscientific sectors, and to the ways it has affected both national objectives and European research policies over time. We know, however, that experts, whose influence and legitimacy is knowledge-based, may pursue innovative policies as much as they may slow down change.[94]

In general, the importance of training a new generation of European scientists was very much present in the Euratom project, in order to bridge the scientific manpower gap with the United States; as an aspect of the technoscientific Cold War; and with the aim of strengthening European integration politically. It is not surprising that from a discursive point of view Euratom adopted so much of the traditional rhetoric of scientific internationalism, with its emphasis on the politically unifying features of science and its capacity to generate material and social exchange, and ultimately peace, though applied on a regional scale (science as overcoming intra-European boundaries and fostering integration and understanding). The ambition to mobilise 'the best European technical teams' and increase them in number and qualification would help Europe regain its scientific and industrial pre-eminence while fostering European political unity.[95]

In the case of fusion, the best European technical teams were indeed mobilised for a research effort involving continuous exchange among European laboratories, as well as between Europe, the United States, the United Kingdom and the Soviet Union. In this global framework, European fusion developed its own regional identity which was to be perceived, both internally and internationally, as one of the not many real achievements of Euratom.

[91] Rebut, *L'énergie des étoiles*, 220.

[92] 'Tensions of Europe: Technology and the Making of Europe', special issue of *History and Technology*, 21 (2005), eds. Johan Schot, Thomas J. Misa and Ruth Oldenziel.

[93] Wolfram Kaiser and Johan Schot, eds., *Writing the Rules from Europe: Experts, Cartels, and International Organisations* (Basingstoke: Palgrave Macmillan, 2014); Martin Kohlrausch and Helmuth Trischler, eds., *Building Europe on Expertise: Innovators, Organizers, Networkers* (Basingstoke: Palgrave Macmillan, 2014); Edgar Grande and Anke Peschke, 'Transnational Cooperation and Policy Networks in European Science Policy-Making', *Research Policy*, 28 (1999); Erik van der Vleuten and Arne Kaijser, eds., *Networking Europe: Transnational Infrastructures and the shaping of Europe, 1850–2000* (Sagamore Beach: Science History Publications, 2006).

[94] Luca Guzzetti, ed., *Science and Power: The Historical Foundations of Research Policies in Europe* (Luxembourg: Office for Official Publications of the European Communities, 2000); Olof Hallonsten, 'Continuity and Change in the Politics of European Scientific Collaboration', *Journal of Contemporary European Research*, 8, 3 (2012).

[95] Barbara Curli, 'Une rhétorique de transition: la naissance d'Euratom et le discours sur la modernité technoscientifique européenne', in Michel Dumoulin, Jürgen Elvert and Sylvain Schirmann, eds., *Stratégies et acteurs/Strategies and actors. Construire l'Europe au XXème siècle/Building Europe in the XXth century. Liber amicorum Eric Bussière* (Stuttgart: Franz Steiner Verlag, 2022).

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In the report of the CERN Study Group of March 1959, a comparison was made between the European and the US effort in terms of scientific staff (210 versus 288) and operating costs ($6.7 million versus $28.7 million). Although the number of staff was comparable, costs in Europe were 'but a small fraction of those of the USA'. The problem was not related just to fusion but characterised European science in general: 'There is undoubtedly a serious shortage of physicists in Europe, and plasma physics and fusion research can only take a fraction of these people'. Education and training should be supported in European universities, and the exchange of staff working on fusion between the various laboratories 'encouraged'. 'Now that there are no longer questions of security or classification in fusion work, the only problem is to arrange that European staff can move freely between the laboratories'.[96]

In the case of Euratom, the association contracts, while supporting the members states' national efforts in fusion research, contributed to the formation of a European fusion community and to the continuous exchange of information, scientists and training experience. However, different national approaches soon emerged, in particular concerning the circulation of information and the independence of research; and in relation to *juste retour* funding, that is, the request that the backflow into member states (e.g. in the form of contracts for national laboratories and industries) would be in proportion to the participation to the Community budget. This was generally felt and resented by Euratom's smaller member states, in light of the more advanced French and German national nuclear programmes and their capacity to attract more funding, and it represented one of the several weaknesses of the Community.[97] The case of fusion can be partly understood within these same internal dynamics.

Unlike the Italian and French contracts, the two German fusion centres (Garching and Jülich) opted from the beginning for a minority association with Euratom, in order to safeguard their autonomy and to avoid having to divulge their research results to other partners. In 1963 Euratom's participation in the association contracts was as follows: 54 per cent in the association with CEA; 60 per cent with CNEN; 33 per cent with Garching; 40 per cent with Jülich; 40 per cent with the Dutch FOM.

As far as funding was concerned, a report sent to the Commission in June 1964 by the Italian CNEN started to question the fairness of distribution. In 1963–4, out of a total fusion budget of $13 million, France had obtained $6.6 million (51 per cent), Germany $3.8 million (29 per cent), Italy $1.1 million (14 per cent) and the Netherlands $0.6 million (5 per cent). Italy was particularly penalised, as its contribution to Euratom's total budget amounted to 23 per cent.[98]

These discussions emerged alongside wider preoccupations about Euratom's future, related in particular to the launch of the second five-year programme and the prospective merger of the executives. However, unlike concerns over the Joint Research Centre or other Community programmes whose prospects were questioned at the time, fusion continued to be seen as a sector of cooperation to be safeguarded and enhanced. European fusion had to survive if Euratom – a European nuclear identity – were to survive.

Somehow paradoxically, it was Heisenberg himself who raised the issue of the financial crisis of Euratom and of the painful effects that it would have on German and European fusion research. In September 1963, in a long letter to the president of the Euratom Commission, Pierre Chatenet, Heisenberg took the opportunity to comment upon 'past cooperation and future projects' in fusion research and to assess the experience of the German association contract by that time. Collaboration with Euratom had turned out to be 'very fruitful for both contractors', and a reduction in Euratom's financial support would severely harm Germany's future progress in fusion research.[99] A

[96] European Fusion Research. Report of the CERN Study Group on Fusion Problems, 2nd draft, 24 Mar. 1959, ASDF, EP, 16/73.

[97] Kohlrausch and Trischler, *Building Europe on Expertise,* 224.

[98] Euratom: contratto sulla fusione termonucleare e fisica del plasma (Laboratorio gas ionizzanti a Frascati), June 1964, Archivio storico CNEN, Centro ENEA, Casaccia, b. 1039.

[99] Letter by Werner Heisenberg to Pierre Chatenet, President of the Euratom Commission, 26 Sept. 1963, HAEU, AC, BAC-118/1986_2545.

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few weeks later, in a letter to the German Commissioner Krekeler, who had just visited the Garching facility, Heisenberg underlined the close ties with the United States and the aim of the MPG 'to enlarge and intensify our activities in order to raise our Institute to the same rank as that of the three main American centers or of the British center of Culham. I am convinced that reaching this goal is also in the interest of Europe'.[100] Though this limited documentation does not allow more general conclusions, it is plausible that the experience of practical cooperation in the Euratom framework, and the extent to which the German national fusion programme benefitted from it, may have in part contributed to what is usually referred to as Heisenberg's late 'conversion' to the cause of European integration.[101]

Conclusion: The 'Fusion Rescue' of Euratom

The early history of European fusion politics confirms the centrality of the nuclear in the development of postwar international organisations and in the relationships between states during the Cold War,[102] as well as the role of the nuclear in European integration. Fusion's early history may provide yet another example of a Community policy which during the 1960s helped to develop *both* the national *and* the supranational dimensions of a new sector of scientific research, through *sui generis* bilateral arrangements (the association contracts between Euratom and the research centres of member states), formal and informal networks and liaison structures, personal exchanges and connections, and institutional funding. It confirms how big science collaborations on a European level have been characterised by flexible though complex organisational tools, modelled according to different sectors, historical circumstances and the political priorities of member states, whose political will has often coincided with the need to share costs and encourage knowledge transfer.[103] At the same time, scientific and technical collaboration among member states has served 'as a catalyst' for political integration.[104]

The fusion story may thus offer another thread in the ever more complex narratives of European integration, currently undergoing yet another process of revision.[105] If assessed in the global framework of nuclear institutionalism, Euratom's fusion effort in the 1960s contributed to the construction of a European nuclear identity and to reducing the technoscientific gap with the main nuclear powers on a regional level, while it supported and accommodated national programmes and strategies.

In 1968, the council of ministers of the 'new' European Community after the merger of the executives charged a *Groupe ad hoc 'Fusion Thermonucléaire contrôlée'* to present a report on the status of fusion research in the Community in order to help decide on future programmes. The ad hoc group's membership was a peculiar yet significant blend of science and politics at the Community level. It was constituted by the directors of the laboratories which had signed association contracts with Euratom

[100] Letter by Werner Heisenberg to H.L. Krekeler, 14 Oct. 1963. HAEU, AC, BAC-118/1986_2545.

[101] For a discussion on this aspect of Heisenberg's biography, see Carson, *New Models for Science in Politics*.

[102] John Krige and Kai-Henrik Barth, 'Science, Technology and International Affairs', in John Krige and Kai-Henrik Barth, eds., *Global Power Knowledge: Science and Technology in International Affairs*, special issue, *Osiris*, 21 (2006).

[103] Hallonsten, 'Continuity and Change'; Pierre Papon, 'European Scientific Cooperation and Research Infrastructures: Past Tendencies and Future Prospects', *Minerva*, 42 (2004).

[104] Helmuth Trischler and Hans Weinberger, 'Engineering Europe: Big Technologies and Military Systems in the Making of 20th Century Europe', *History and Technology*, 21, 1 (2005), 64.

[105] For recent discussions on the complexity of writing on European cooperation overcoming stereotyped narratives, see Wolfram Kaiser and Richard McMahon, eds., *Transnational Actors and Stories of European Integration: Clash of Narratives* (London: Routledge, 2019); 'Re-engaging Grand Theory: European Integration in the Twenty-first Century', special issue, *The Journal of European Public Policy*, 26, 8 (2019); Kiran Klaus Patel and Wolfram Kaiser, 'Continuity and Change in European Cooperation during the Twentieth Century', *Contemporary European History*, 27 (2018); N. Piers Ludlow, 'Widening, Deepening and Opening Out: Towards a Fourth Decade of European Integration History', in Wilfried Loth, ed., *Experiencing Europe: 50 Years of European Construction 1957–2007* (Baden-Baden: Nomos Verlag, 2009); Wolfram Kaiser and Antonio Varsori, eds., *European Union History: Themes and Debates* (Basingstoke: Palgrave Macmillan, 2010).

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(a sixth contract had just been signed with the Belgian Ecole militaire in Brussels), and by the permanent representatives, in addition to a number of Community officials: all in all a clear indication of the political importance the Community and its member states attached to the fusion issue.

The report was presented in May 1968, in the context of a more general rethinking of the Community's research activities and industrial policy after the merger of the executives. This would include a reorganisation of the directorate-generals that had inherited Euratom's prerogatives, while the United Kingdom was again approaching Palumbo – head of the new fusion division of the Community – in view of likely British entry to the EEC.[106] The report proudly underlined how in less than ten years the Community had 'considerably increased its relative influence in the world and its scientific reputation in fusion research'. In 1968, the Community represented around 20 per cent of the world's fusion effort, as compared to 7.5 per cent in 1959. Researchers in fusion laboratories in the Community amounted to 465, as compared to around 500 in the United States (of whom 315 were employed by the AEC), 600 in the Soviet Union and 100 in the United Kingdom.[107] As for research prospects, however, the report was cautious and proposed to wait for the conclusions of the upcoming international conference on plasma physics and CNF at Novosibirsk. In Novosibirsk, Artsimovich announced the 'tokamak revolution'. This opened up a new era both in the history of fusion and in the scientific and political nature of the effort, leading to a series of discussions, related also to British EEC entry, whose outcome would eventually be the decision to build the first big European fusion machine, known as JET.

Research on this phase is still at a preliminary stage and is not dealt with here. What can be said is that archival evidence highlights the fundamental political consensus and interest among all member states (including West Germany and, above all, France, which in the mid-1960s was also in the course of developing thermonuclear weapons) in favour of the continuation of the fusion programme. Fusion would turn out to be one the very few original policies that would survive the crisis of Euratom and the merger of the executives. Indeed, fusion will be perceived as one of the most suitable candidates to relaunch a European nuclear identity in the 1970s, when the prospects for possible common energy policies would be dramatically shattered by the oil crisis. Seen from this angle, the tokamak revolution also changed the politics of fusion research and its Cold War dimension.[108]

The origins of a European 'big fusion machine' thus lay as much in the political necessity of rescuing European integration as on scientific and technological considerations. As this article has tried to show, this is partly explained by the Cold War origins and peculiar political features of fusion research. Although the technoscientific and commercial rationale of big fusion endeavours (from JET to ITER) has been questioned at various times, they continued to attract political consensus and funding. Possible shortcomings of this approach – the excessive centralisation of research efforts, the absorption of the majority of Community funding and diversion from other possible research prospects – have periodically been raised but have been met either with substantial political opposition or bureaucratic inertia. However, some of these features and limits were already foreseeable in the 1960s. In a long report addressed to Edoardo Amaldi in July 1967, Bruno Brunelli assessed the Italian fusion programme and the Frascati association contract, and outlined the many merits of the programme, especially for countries like Italy which in the mid-1950s suffered a substantial technological gap with the fusion powers. Without Euratom, that gap would have increased within the bounds of the Community, and the exchange of researchers and information would have been more difficult. However, caution was needed when contemplating any future European fusion programme. With this in mind, Brunelli expressed some scepticism about the construction of a big machine, 'not to

[106] Pease, *The UK Fusion Programme*.

[107] Rapport du Groupe ad hoc 'Fusion Thermonucléaire contrôlée' au Comité consultatif de la recherche nucléaire, 30 mai 1968; Description des travaux exécutés dans le cadre des contrats d'association, Annexe au Rapport. HAEU, AC, BAC-118/1986_2251, 1962–1968.

[108] This change affected also the US fusion programme, which, as Weisel writes, was pursued with renewed vigor, 'no longer by Cold War technocrats, but by managers hoping to demonstrate that science could contribute to the public good'. Weisel 'The Fusion Archipelago', 218.

mention a big fusion reactor!', that would have altered the structure and objectives of national as well as European research[109] – as some critics of ITER still claim today.

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[109] Archivio storico CNEN, Centro ENEA, Casaccia, b. 1039.

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