

abecedari quàntic

Xavier Roqué
iHC i Departament de Filosofia UAB

Xerrada inaugural de la mostra **100 anys de la mecànica quàntica**
CRAI Biblioteca de Física i Química
Any Internacional de la Ciència i la Tecnologia Quàntiques
UB, 12 de novembre 2025

ABECEDARI QUÀNTIC

A de _____
B de _____
C de _____
D de _____
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Y de _____
Z de _____



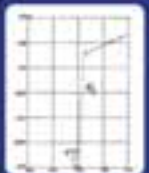
A History Wall of Quantum Physics

Scroll or Click to Start 

1908
"Specific Heat Decreases Steadily as Low Temperatures..."



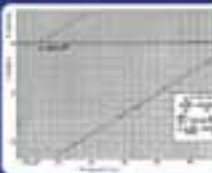
8 April 1911
Discovery of Superconductivity



July 1912
Undoing the Anomalous Zeeman Effect

Die beiden Haupt-Linien des Zeemans zerfallen in die sechs einfachen Linien durch Magnetonen, und in eine einfache Linie, verursacht durch Spin, und die Auswertung von der allgemeinen Erklärung der anomalen Zeeman-Effekte resultiert. Diese sind sind gegeben durch die Plücker-Koeffizienten.

December 1913
Arnold Bohr's Electron Orbits Revolt?

1911
A Kicks the Atom

Yukawa sprach sich über eingeborenen Quantenpunkt Inventionen, die in einem von drei Modellen... die Stabilität als eine Funktion von Folge der... eines atomaren Wirkungsquantums...

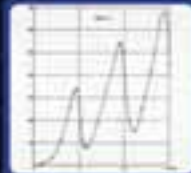
1911
The Nuclear Atom (Was No Quantum Physics)



January 1912
Atomic Theory With the Quantum: A First Overambitious Attempt



April 1914
An Experimental Proof of Bohr's Quantum Jumps?



First Hint of Wave-Particle Dualism

$$\vec{p} = \frac{1}{c} \left[h\nu \vec{x} + \frac{c^2}{8\pi r^2} \right] dV/d\tau$$


1911
Light Quanta Are Indistinguishable!



April/May 1913
The Bohr Atom: Progress and Paradoxes

$$W_{\tau_2} - W_{\tau_1} = h\nu,$$

1916
From Spontaneous To Stimulated Emission



30 Oct - 3 Nov 1911
"Die Cantor", or: The Invention of the Workshop



Hilbert und die Physik.
Von M. Born, Göttingen.
1907
A Mathematician Learning and Teaching Modern Physics

March 1918

Public Images and Models of the Atom

The Deutsches Museum in Munich asked Arnold Sommerfeld to provide drawings and models to present to the public the new image of the atom that the physicist had created. In this way, the Bohr model became such a powerful symbol of the atom that it could hardly be revised by quantum mechanics.

BS



Drawing / model by Arnold Sommerfeld for display at the Deutsches Museum Munich, 1918.
Deutsches Museum, Archives

Related Events

1927

[How Would a Quantum Mechanical Atom Look Like?](#)

c. 1922

[Can you see Solid Matter With Bohr's Atoms? And](#)

Quantum Foundations Collection

One hundred years ago, Wolfgang Pauli, Werner Heisenberg, Erwin Schrödinger, and others laid down cornerstones of quantum mechanics. UNESCO has designated 2025 the International Year of Quantum Science and Technology in recognition of these breakthroughs and of the revolutionary impact that quantum science and technology have had and promise to have. To celebrate this centennial, the Editors of the Physical Review journals have collected the papers below that established the foundations for the field.

The collection opens with an Editorial by Dagnur Brühl of Heinrich Heine University Düsseldorf, offering an introduction to the exciting history and to the blossoming applications that, as UNESCO puts it, "are doing some of the most exciting breakthroughs of the 21st century."

—The Physical Review Editors

[Browse by decade](#)

[1900](#) [1910](#) [1920](#) [1930](#) [1940](#) [1950](#) [1960](#) [1970](#) [1980](#) [1990](#) [2000](#) [2010](#)

Editorial

Celebrating the first century of quantum physics and preparing for the next one

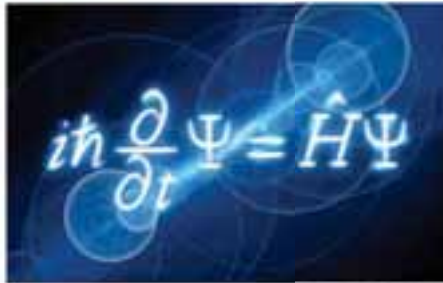
[View Article](#)

1900

[View Article](#)



1920

[Previous decade](#)[Next decade](#)

1922 Atoms have quantized spin

By observing the deflection of atoms in a spatially varying magnetic field, Walter Gerlach and Otto Stern showed experimentally that the spin of an atom is quantized and exists in two discrete states.

W. Gerlach and O. Stern, Der experimentelle Nachweis der Richtungsquantelung im Magnetfeld, *Z. Phys.* 9, 541 (1922)

[View Article](#)

1923 Light is not purely wavelike

Arthur Compton discovered the phenomenon now known as the Compton effect, by which a high-energy photon transfers some of its momentum to a charged particle. The result confirmed that light can act both as a wave and as a stream of particles.

A. Compton, A quantum theory of the scattering of x-rays by light elements, *Phys. Rev.* 21, 482 (1923)

[View Article](#)

1925 Pauli exclusion principle

Wolfgang Pauli pointed that two electrons in an atom cannot simultaneously inhabit the same quantum state. For the case of electrons in atoms, the principle implies that they can never have the same values of their four quantum numbers, including the spin quantum number. Pauli's principle explained how Bohr's model of the atom can be connected to the structure of the periodic table and was later extended to all fermions.

1925 Matrix formulation of quantum theory

After his famous trip to Heisenberg, Werner Heisenberg derived the quantized energy levels of a one-dimensional oscillator in terms of physical quantities, such as transition probabilities, that could in principle be measured. These fundamental papers by Heisenberg, Max Born and Pascual Jordan developed the full consistent formulation of quantum mechanics, based on matrices.

W. Heisenberg, Über quantentheoretische Umdeutung kinematischer



Women in the History of Quantum Physics

INTRODUCTION

WHQP PUBLICATIONS

WHQP TALKS

WHQP LOGO

Introduction

From its uncertain beginnings at the dawn of the twentieth century, quantum physics has had an enthralling history of scientific success and has grown into an extraordinarily rich and diverse techno-scientific field. Conventional narratives of its historical development, however, feature an almost exclusively male cast of characters, with only the exceptional presence of well-known heroines of physics such as Maria Skłodowska-Curie, Lise Meitner, and Maria Goppert Mayer. Yet, many more women have actively contributed to the progress of quantum physics than are typically acknowledged. *Women in the History of Quantum Physics (WHQP)* aims to recover and highlight the contributions of the numerous female physicists who, from diverse backgrounds and in different ways, have helped propel the field forward. By focusing on lesser-known figures and introducing a gender perspective to the historical study of physics, we aim to challenge the conventional male-dominated narratives that often reinforce the masculine image of the field.

The WHQP collaboration was founded in early 2021, in preparation for the [International Year of Quantum Science and Technology](#). The group, which encompasses an international and interdisciplinary team of historians, philosophers, physicists, and writers — ranging from early career scholars to renowned academics, has been remarkably productive with several conference panels completed and more scheduled, a book in press, and yet more projects in the works.

For more info, please contact [Margriet van der Horst](#) (chair), [Patrick Charbonneau](#) (associate chair), or [Daniella Mamelli](#) (past chair). You can also follow our activities by signing up for our [Facebook group](#).

WHQP gratefully acknowledges funding and support from [APS-PRIP](#). For other quantum century activities, consult the [Consortium for History of Science, Technology and Medicine](#).

WiHQ Publications

- Mirjam Blaauwboer, "Hendrika J. van Leeuwen: Portret van de eerste vrouwelijke lector bij Technische Natuurkunde in Delft," *Nederlands Tijdschrift voor Natuurkunde* **81**(1), 4-6 (January 2015). https://www.koninklijke-ninr-publications/ndisensations/biographies/HJvL_vanLeeuwen.pdf
- Elke Crull and Guido Bartsch, eds. *Grete Hermann - Between Physics and Philosophy* (Dordrecht: Springer, 2017). <https://doi.org/10.1007/978-94-024-0970-3>
- Mirjam Blaauwboer, "Leeuwen, Hendrika Johanna van, in: *Digitaal Vrouwenlectuur van Nederland* (2017) <https://resources.huygens.knaw.nl/womenlectuur/nederlandstalig/leeuwen>
- Gernot Münster, "Keine klassische Karriere?" *Physik Journal* **19**(6), 30-34 (June 2020). <https://pro-physik.de/zeitchrift/physik-journal/2020-6/>
- Margriet van der Heijden, "Tatiana Ehrenfest-Afanasjeva: No Talent for Subservience," in: Uffink, J., Valeris, G., Weirsd, C., Zuchowicki, L. (eds) *The Legacy of Tatjana Afanasjeva* (Cham: Springer, 2021). https://doi.org/10.1007/978-3-030-42971-6_1
- Michelle Frank, "A Hidden Variable behind Entanglement," *Scientific American Magazine* **326**(4), 42 (April 2023). <https://www.sciencemag.com/interactives/2023/04/04/hidden-variables-origins-story-behind-the-2023-nobel-prize-in-physics/>
- Mike Cuffaro and Michel Janssen, "Women in the history of Quantum Physics project under way," *AP History Newsletter* **56**(1), 23-23 (2024). <https://wp.brightspotcdn.com/52/12/67/14441494e6b0ca6f006c2c2515/history-newsletter-vol1-2024.pdf> https://www.aip.org/sites/default/files/2024-06/v56n1_2024-f_digital-pages.pdf
- Andrea Reichenberger, "Philosophie und Physik: Zu Grete Hermanns neukantianischen Interpretation der Quantenmechanik," in: Kay Herrmann und Boris Schweizer (eds.), *Der Geist der kritischen Schule*. Berlin, Heidelberg: J. B. Metzler, 2024, pp. 277-295. https://doi.org/10.1007/978-3-662-68345-3_18
- Margriet van der Heijden, "More is known about him than about her: Tatiana Ehrenfest-Afanasjeva," *Physics Today* **77**(1), 40-47 (2024). <https://doi.org/10.1063/PT.3.5381>
- Andrea Reichenberger, "Grete Hermann's ethical philosophy of physics," *Physics Today* **77**(9), 44-50 (2024). <https://doi.org/10.1063/pt.etra.ajce>
- Justine M. Singleton, "THPP Winning Essay: From Wright Field to MIT: The lessons and legacy of Carolyn Beatrice Parker," *APS News*, May 5 (2025). <https://www.aps.org/programs/2025/05/winning-essay-carolyn-beatrice-parker>
- Arne Schirmacher, "Die Quantenphysikerinnen," *Physik Journal* **24**(6), 26-30 (2025). <https://pro-physik.de/zeitchrift/physik-journal/2025-6/>
- Daniela Mondini, "Laura Chalk," *Physik Journal* **24**(4), 32-34 (2025). <https://pro-physik.de/zeitchrift/physik-journal/2025-4/>
- Johannes-Gerit Hagmann, "Maria Goeppert Mayer," *Physik Journal* **24**(5), 38-40 (2025). <https://pro-physik.de/zeitchrift/physik-journal/2025-5/>
- Andrea Reichenberger, "Grete Hermann: Eine Brückenbauerin zwischen Physik, Philosophie und Politik," *Physik Journal* **24**(6), 36-38 (2025). <https://pro-physik.de/zeitchrift/physik-journal/2025-6/>
- Margriet van der Heijden and Mirjam Blaauwboer, "Hendrika Johanna van Leeuwen: Die Wissenschaftlerin hinter dem Bohr-van-Leeuwen-Theorem," *Physik Journal* **24**(7), 42-44 (2025). <https://pro-physik.de/zeitchrift/physik-journal/2025-7/>
- Andrea Reichenberger, "Shaping the history of quantum physics to make women visible," *Nature Reviews Physics* (2025). <https://doi.org/10.1038/s42254-025-00850-4>

THE ATOMIC ALPHABET

A	for ATOMIC	原子
B	for BOMB	炸弹
C	for COMBAT	战斗
D	for DUMB	愚蠢
E	for ENERGY	原动力
F	for FALLOUT	原子灰
G	for GUERRILLA	奇袭队
H	for HOLOCAUST	大屠杀
I	for IGNITE	点火
J	for JUNGLE	丛林地带
K	for KILL	杀害
L	for LIFE	生命
M	for MUTANT	突然变异体
N	for NUCLEAR	原子核
O	for OBLITERATE	抹杀
P	for PANIC	恐慌
Q	for QUAKE	地震
R	for RUBBLE	粉碎
S	for STRIKE	奇袭
T	for TARGET	目标的
U	for URANIUM	重金属元素
V	for VICTORY	胜利
W	for WAR	战争
X	for RAY	射线
Y	for YELLER	杂技
Z	for ZERO	零



Chris Burden
The Atomic Alphabet, 1980

1900

1925

Condicions autoimposades

Enllaçar les lletres amb sentit històric...

~~...sèrie lineal d'idees brillants d'uns homes joves
successió de revolucions tecnològiques
explotació pràctica de descobriments desinteressats~~

Revelar dimensions ignorades, especialment el gènere i la política
Parar esment en la literatura històrica

2025

1900

1925

1961–1965

1990

2025

A de ARXIU

Archive for the History of Quantum Physics

American Philosophical Society, Philadelphia
American Institute of Physics, College Park
Harvard University, Cambridge

Cornell University, Ithaca
University of Pittsburgh
University of Minnesota, Minneapolis
University of California, Berkeley

Niels Bohr Archive, Copenhagen
Science Museum Library, London
Deutsches Museum Library, Munich
Accademia dei XL, Rome
Médiathèque, Cité des Sciences et de l'Industrie, Paris
Universidad Autónoma de Madrid
Universitat Autònoma de Barcelona
Universität Konstanz
Max Planck Institut für Wissenschaftsgeschichte, Berlin

Hebrew University of Jerusalem
University of Melbourne
National Diet Library, Tokyo

Archive for the History of Quantum Physics

ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS	ARCHIVES FOR THE HISTORY OF QUANTUM PHYSICS
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Heisenberg Correspondence, 2014-2015	Heisenberg Correspondence, 2015-2016	Heisenberg Correspondence, 2016-2017	Heisenberg Correspondence, 2017-2018	Heisenberg Correspondence, 2018-2019	Heisenberg Correspondence, 2019-2020	Heisenberg Correspondence, 2020-2021	Heisenberg Correspondence, 2021-2022

Delta

1900

1912–1913

1925

1927

1962

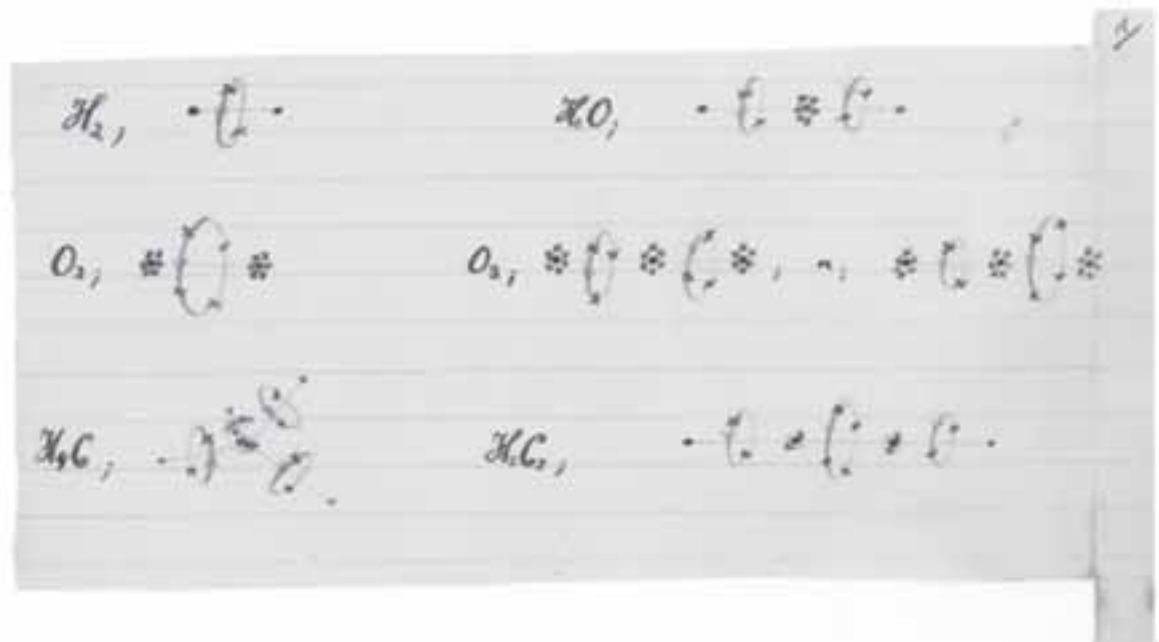
2025

B de BOHR

“Crec que he descobert alguna cosa sobre l’estructura dels àtoms. Podria estar equivocat... però no ho crec”.

Niels a Harald Bohr, 19/06/1912, citat a N. Bohr, *L’estructura i la filosofia dels àtoms*. Ed. a cura de J. Heilbron, trad. de X. Roqué (Barcelona: Institut d’Estudis Catalans; Vic: Eumo, 2010), p. 15.

Imatge: “Rutherford Memorandum” (juliol 1912), dins: F. Aaserud i J. L. Heilbron, *Love, Literature and the Quantum Atom* (Oxford: Oxford University Press, 2013), p. 168.



“La seves idees sobre l'espectre de l'hidrogen són molt enginyoses i sembla que funcionen; però la combinació de les idees de Planck amb la mecànica antiga fa que sigui molt difícil formar-se una idea física de tot plegat”.

E. Rutherford a N. Bohr, 13 de març de 1913
AHQP, bobina 6, secció 3

March 20th., 1913.

Dear Dr. *Bohr*,

I have received your paper safely and read it with great interest, but I want to look over it again ^{carefully} when I have more leisure. Your ideas as to the mode of origin of spectra and hydrogen are very ingenious and seem to work out well; but the mixture of Planck's ideas with the old mechanics make it very difficult to form a physical idea of what is the basis of it. There appears to me one grave difficulty in your hypothesis, which I have no doubt you fully realise, namely, how does an electron decide what frequency it is going to vibrate at when it

1900

1925

1927

C de COMPLEMENTARIETAT

2025

Contraria sunt complementa

L'ús d'un concepte clàssic per a elucidar un fenomen exclou l'ús simultani d'un altre concepte clàssic igualment necessari en d'altres circumstàncies.

Escut d'armes de Niels Bohr, capella del castell de Frederiksborg, Hillerød. Europeana CC BY-NC-ND



1900

1905

1922

1924–1927

D de DUALITAT

2025

“La difracció d’electrons en un cristall [...] és anàloga a la difracció de raigs X [...], i és evident que s’ha d’interpretar en termes de la mecànica ondulatoria”.

C. J. Davisson and L. H. Germer, “Reflection of electrons by a crystal of nickel”. *Proceedings of the National Academy of Sciences*, 14 (1928): 317–322



Lester Germer i Clinton Davisson (1927)
Bell Laboratories, Alcatel-Lucent USA, courtesy
AIP Emilio Segrè Visual Archives

1900

1925

1935

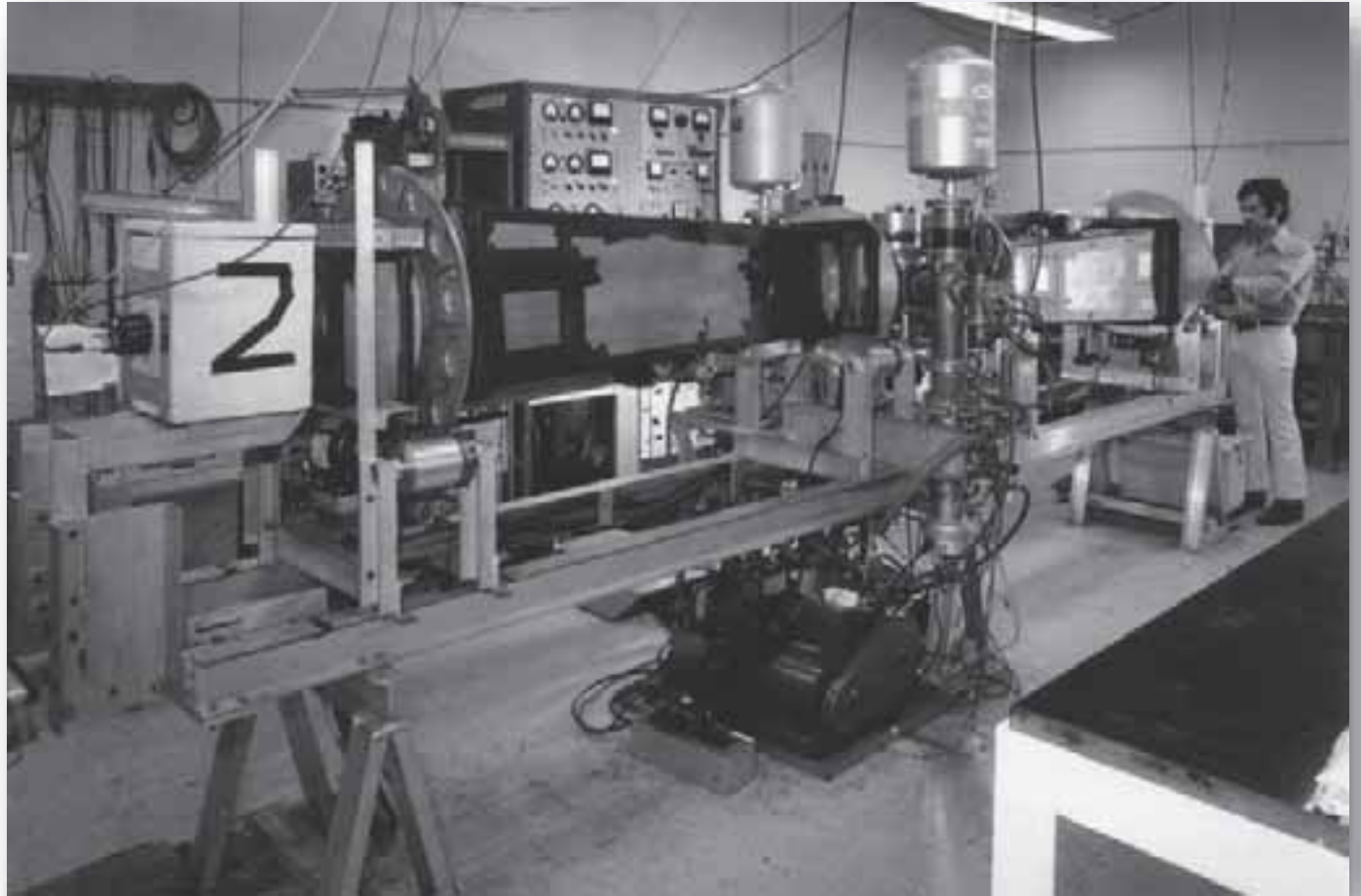
1964

1972

2022

2025

E de ENTRELLAÇAMENT



Stuart Freedman (1944–2012)
Experiments sobre entrelaçament, 1972

Imatge: UC Berkeley

1900

1905

1923

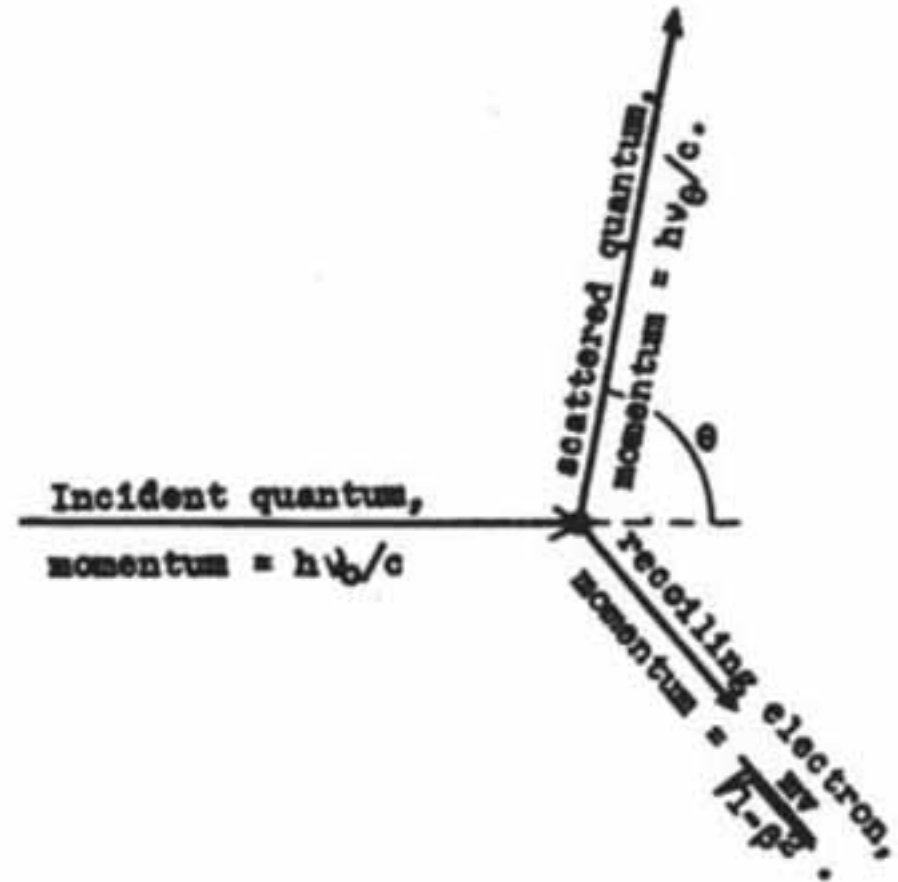
1925

1926

F de FOTÓ

2025

“Aquests experiments indiquen que la dispersió de raigs X és un fenomen quàntic i que el quantum de radiació té moment, a més d’energia”.



Arthur H. Compton, “A quantum theory of the scattering of X-rays by light elements”. *The Physical Review*, 21 (1923): 483–502



1900

1925

G de GÈNERE

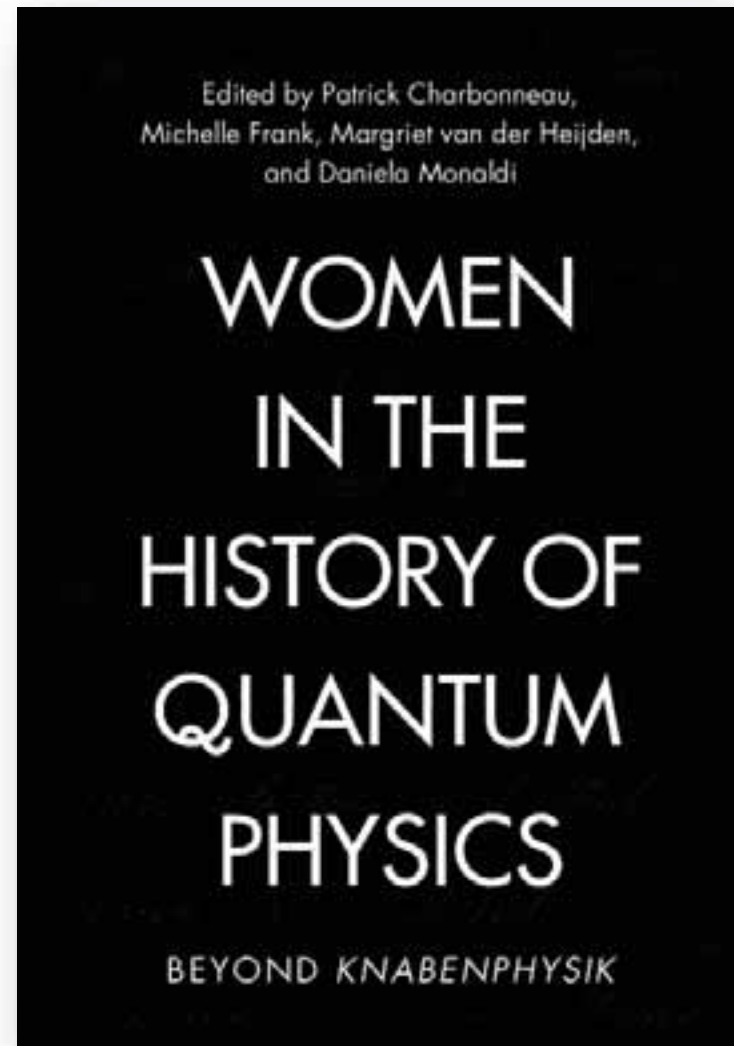
2021

2025

“Hem deixat de banda les heroines més conegudes de la física (Marie Skłodowska Curie, Lise Meitner, Maria Goeppert Mayer) perquè són figures llegendàries que, tanmateix, han perpetuat una mitologia d'excepcionalitat.”

De debò?

Cambridge University Press, 2025



1900

1925

2025

h de *h*

constant de Planck

$$6,62607015 \times 10^{-34} \text{ J}\cdot\text{s}$$

1900

1925
1927

I de INDETERMINACIÓ

2025

“En la formulació estricta de la llei causal: ‘Si coneixem el present amb tot detall, podem predir el futur’, no és la conclusió, sinó la premisa que és falsa. No podem, per principi, conèixer el present amb tot detall.”

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

W. Heisenberg, “Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik”.
Zeitschrift für Physik 34 (1927): 172–198.

1900

1925

J de JUSTÍCIA

2018

2025



These notes, the particlephysics.org website was originally intended in order to host this statement concerning systematic racism within academia. Signatories on this statement do not in any way constitute approval or disapproval of the links for Black Lives.

Statement on a Recent Talk at CERN

The statement here is based upon widely reported events, publicly available slides, and speeches accounts. All authors and signatories represent themselves and not their institutions.

On Friday, September 28th, 2018, a talk was given at CERN by Alessandro Strumia, a well known particle theorist who is a Professor of Physics at the University of Pisa and a current associate of the theory departments at CERN. In this talk he argued that the primary explanation for the discrepancies between men and women in theoretical physics is that women are inherently less capable. As particle physicists, we are appalled by Strumia's actions and his stated views on women in high energy physics.

We write here first as men, in the statement, possibly women, that the harassment of any person, regardless of

1900

1925

1941

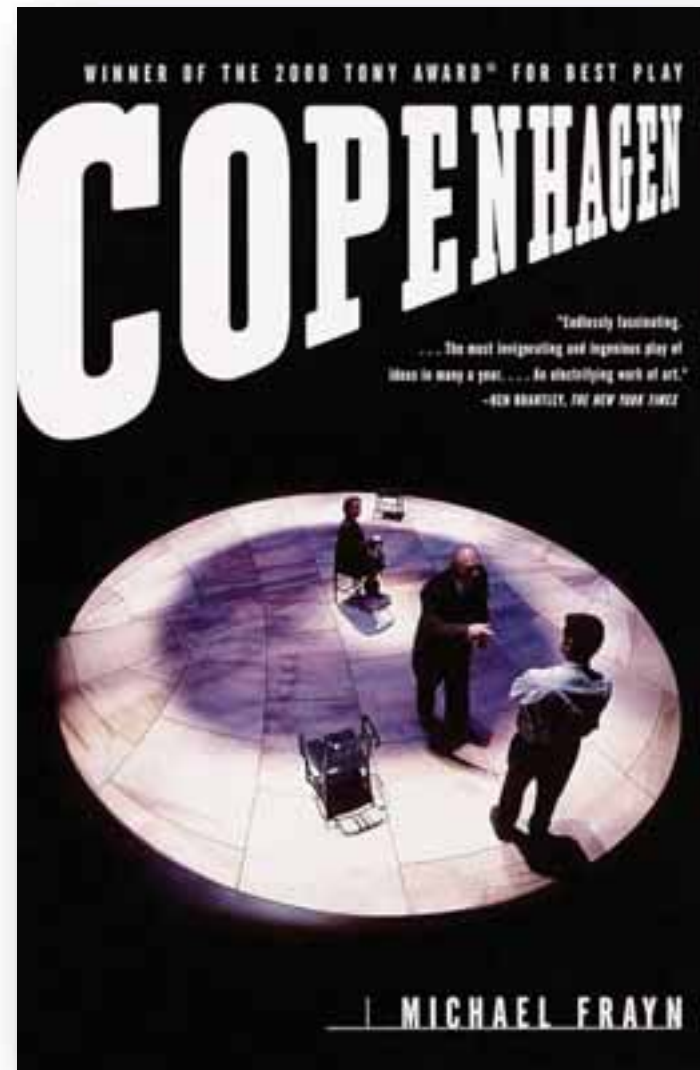
K de KØBENHAVN

1998

2025

“**Margrethe:** Tot és personal! [...] Ho sento, però vols que tot sembli heroicament abstracte i lògic. I quan ho expliques sembla que tot encaixi, sí, tot té un principi i un final. Però jo hi era, i quan ho recordo encara hi soc, i quan miro al meu voltant no veig una història! Hi veig confusió i ràbia i gelosia i llàgrimes, i ningú no sap què signifiquen les coses ni cap a on aniran.”

Michael Frayn, *Copenhagen*
London: Methuen, 1998



1900

1924

2025

L de λ

$$\lambda = \frac{h}{p}$$

1900

1917

1938

M de MEITNER

2025

Lise Meitner (1878–1968)

Amanda Hopkinson. "Introduction to Lotte Meitner-Graf:
a life". *Jewish Historical Studies* 54 (2023): 73-97.
DOI: [10.14324/111.444.jhs.2023v54.05](https://doi.org/10.14324/111.444.jhs.2023v54.05)



1900

1911

1925

1938

1945

N de NUCLI

2025

“El nucli de l’urani, en capturar un neutró, es divideix en dos nuclis de la mateixa mida que tenen una energia total de 200 MeV...

“Aquesta quantitat d’energia coincideix amb la diferència entre l’energia d’enllaç de l’urani i la d’elements al mig de la taula periòdica.

“Aquest procés l’anomenem ‘fissió’.”

Meitner, Lise and Frisch, O. R. “Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction”. *Nature* (11 Feb 1939): 239–240.

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot undertake to return, or to correspond with the authors of, rejected manuscripts sent for this or any other part of NATURE. He will not receive anonymous communications.

Three or four in each of our week's letters appear in N. 361.

Correspondents are invited to attach similar references to their communications.

Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction

Our hitherto theories with neutrons, fission and subfission? found that at least four radioactive elements were produced, two of which possess activities larger than 10^6 were ascribed. Further investigations? demonstrated the existence of at least one radioactive period, one of which was assigned to elements beyond uranium, and another was found to be associated in order to account for their chemical behaviour together with their specific activities.

In making chemical assignments, it was always assumed that these radioactive bodies had atomic numbers near that of the uranium bombarded, and only particles with one or two changes were known to be derived from nuclei. A body, for example, with activity proportional to those of uranium was assumed to be the element ($Z = 84$) rather than uranium ($Z = 92$) or plutonium ($Z = 94$).

Following up an observation of Curie and Becquerel, Hahn and Strassman? found that a group of at least three radioactive bodies, formed from uranium under various bombarding conditions, were chemically similar to barium and, therefore, presumably isotopes with valence. Further investigations?, however, showed that it was impossible to separate these bodies from barium (although spectroscopically, an isotope of radium, was readily separated in the same experiment) so that Hahn and Strassman were forced to conclude that samples of barium ($Z = 86$) are formed as a consequence of the bombardment of uranium ($Z = 92$) with neutrons.

At first sight, the result seems very hard to understand. The formation of elements much below uranium has been considered before, but was always looked for physical reasons, as long as the chemical evidence was not entirely clear cut. The element, which is a direct form, of a large number of charged particles may be regarded as indicated by the usual periodicity of the periodic system, indicated by Curie's theory of alpha rays.

On the basis, however, of present ideas about the behaviour of heavy nuclei?, an entirely different and essentially chemical picture of these new disintegrative processes suggests itself. On account of their slow fission and strong energy exchange, the particles in a heavy nucleus would be expected to move in a collective way which has some resemblance to the movement of a liquid drop. If the movement is sufficiently violent by adding energy, such a drop may divide itself into two smaller drops.

In the disintegration of the nucleus produced in the bombardment of nuclei, the concept of surface tension of nuclear matter has been used? and its value has been measured from simple considerations regarding nuclear fission. It need be mentioned, however,

that the surface tension of a charged droplet is diminished by its charge, and a rough estimate shows that the surface tension of nuclei, decreasing with increasing nuclear charge, may become zero for atomic numbers of the order of 100.

It seems therefore probable that the uranium nucleus has only small stability of form, and that after neutrons capture, divide itself into two bodies of roughly equal size (the process may of course depend on the exact structural features and perhaps partly on chance). These two nuclei will repel each other and should gain a total kinetic energy of ~ 200 Mev, as calculated from nuclear radius and charge. This amount of energy may actually be expected to be available from the difference in packing between uranium and the elements in the middle of the periodic system. The whole fission process may thus be described in an essentially classical way, without having to consider quantum-mechanical tunnel effects, which would actually be extremely small, in account of the large masses involved.

After division, the high ionization-power ions of uranium will tend to migrate first by ions closer to the lower value isotopes for lighter elements. Probably each part will then give rise to a chain of disintegrations. If one of the parts is an isotope of barium?, the other will be krypton ($Z = 36 - 38$), which might decay through rubidium, strontium and yttrium to zirconium. Perhaps one or two of the supposed barium-bombardment-series chains are then actually observed products in certain cases.

It is possible, and seems to us rather probable, that the periods which have been ascribed to elements beyond uranium are also due to light elements. From the chemical evidence, the two short periods (30 sec and 85 sec) can be ascribed to ^{90}Kr and ^{92}Rb decaying through rubidium, rhodium, palladium and silver into cadmium.

In all these cases it might not be necessary to assume tunnel penetration, but the different radioactive periods belonging to the same chemical element may then be ascribed to different isotopes of the element, their varying proportions of isotopes may be given to the two parts of the uranium nucleus.

Our hitherto theories with neutrons, activities are obtained which have been ascribed to radium and uranium isotopes? Some of these periods are approximately equal to periods of barium and thallium-actinon? resulting from the bombardment of uranium. We should therefore like to suggest that these periods are due to a "fission" of uranium nuclei in the case of uranium and roughly partly in the same products. Of course, it would be especially interesting if one could obtain one of these products from a light element, for example, by means of neutron capture.

1900

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1945

O de OPPENHEIMER

2025

CILLIAN
MURPHY

EMILY
BLUNT

MATT
DAMON

ROBERT
DOWNEY JR.

FLORENCE
PUGH

A FILM BY CHRISTOPHER NOLAN

OPPENHEIMER

7

21

23

THE WORLD FOREVER CHANGES



SHOT WITH **IMAX** FILM CAMERAS

WRITTEN FOR THE SCREEN AND DIRECTED BY CHRISTOPHER NOLAN

SYNOPSIS KODAK

UNIVERSAL
UNIVERSAL PICTURES
UNIVERSAL PICTURES
UNIVERSAL PICTURES

1900

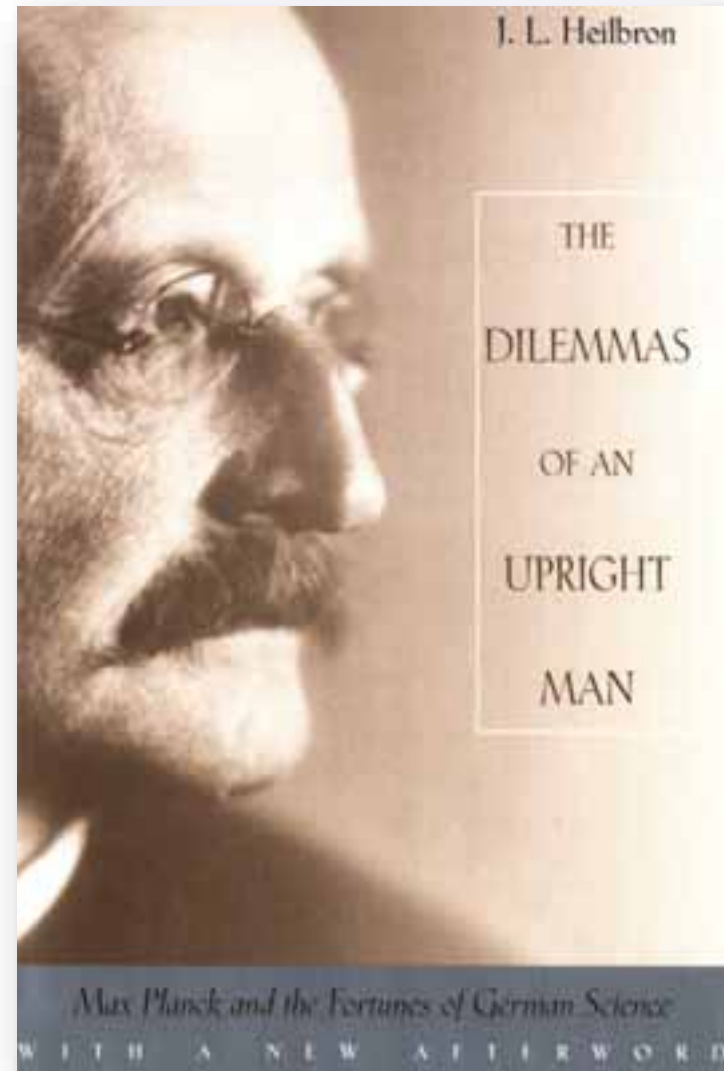
1925

P de PLANCK

2025

“L’orgull per l’Alemanya imperial
i el compromís amb l’ideal acadèmic
de la unitat del coneixement
foren els pilars de la política científica de Planck.”

John L. Heilbron, *The dilemmas of an upright man. Max Planck as spokesman for German science*. Berkeley: University of California Press, 1986. Reeditat amb nou subtítol: *Max Planck and the fortunes of German science (with a new afterword)*. Cambridge, MA: Harvard University Press, 2000.



**Physikalisch-
Technische
Reichsanstalt/
Bundesanstalt**

Berlin, 1913
J. Goldiner, Berlin
Wikimedia Commons



1900

1925

Q de QUANTUM

2025

$$E = h\nu$$

1900

1925

1930

R de RADIOACTIVITAT

2025

original - Photocopy of PLC 0393

Abschrift/15.12.56 PW

Offener Brief an die Gruppe der Radioaktiven bei der
Gauvereins-Tagung zu Tübingen.

Abschrift

Physikalisches Institut
der Eidg. Technischen Hochschule
Zürich

Zürich, 4. Des. 1930
Cloriastrasse

Liebe Radioaktive Damen und Herren,

Wie der Ueberbringer dieser Zeilen, den ich halbvollst
anzuhören bitte, Ihnen des näheren auseinandersetzen wird, bin ich
angesichts der "falschen" Statistik der N - und $Li-6$ Kerne, sowie
des kontinuierlichen beta-Spektrums auf einen verzweifelten Ausweg
verfallen um den "Wechselsatz" (1) der Statistik und den Energiesatz
zu retten. Nämlich die Möglichkeit, es könnten elektrisch neutrale
Teilchen, die ich Neutronen nennen will, in den Kernen existieren,
welche den Spin $1/2$ haben und das Ausschliessungsprinzip befolgen und
sich von Lichtquanten ausserdem noch dadurch unterscheiden, dass sie
nicht mit Lichtgeschwindigkeit laufen. Die Masse der Neutronen
müsste von derselben Grössenordnung wie die Elektronenmasse sein und
jedemfalls nicht grösser als $0,01$ Protonenmasse.- Das kontinuierliche
beta-Spektrum wäre dann verständlich unter der Annahme, dass beim
beta-Zerfall mit dem Elektron jeweils noch ein Neutron emittiert
wird, derart, dass die Summe der Energien von Neutron und Elektron
konstant ist.

"Senyores i senyors
radioactius..."

1900

1911
1913

1921

1924

1927

1930

1933

S de SOLVAY

2025

1927



1900

1925

1928

T de TÚNEL

1986

2025



Nobel Prize in Physics 2025

- Summary
- Laureates
 - John Clarke
 - Michel H. Devoret
 - John M. Martinis
- Price announcement
- Press release
- Advanced information
- Popular information
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Nobel Prize in Physics 2025



Dr. John Clarke | Nobel Prize Laureate
John Clarke
 Price share: 1/3



Dr. Michel Devoret | Nobel Prize Laureate
Michel H. Devoret
 Price share: 1/3



Dr. John M. Martinis | Nobel Prize Laureate
John M. Martinis
 Price share: 1/3

The Nobel Prize in Physics 2025 was awarded jointly to John Clarke, Michel H. Devoret and John M. Martinis "for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit"

Source: Nobelprize.org
 SCA 4026 Nobel Prize in Physics 2025 NobelPrize.org NobelPrize Laureate 2025 The Nobel Prize 2025 <https://www.nobelprize.org/prizes/physics/2025/laureates/>

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1900

1925

1938

1945

2025

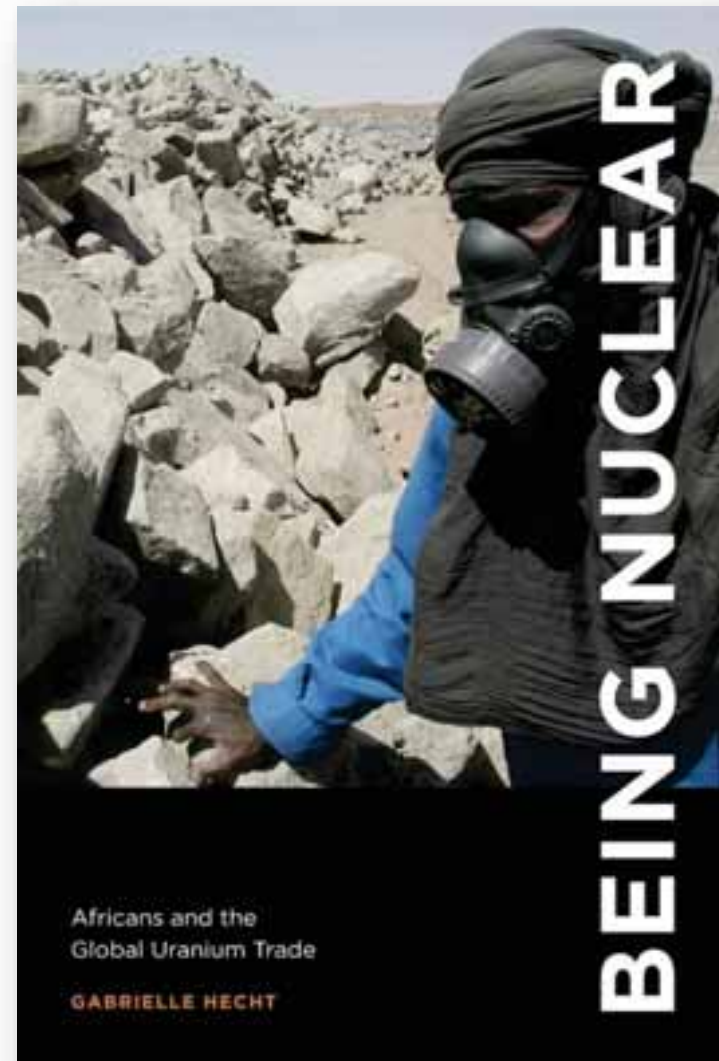
U de URANI



Planta de separació d'isòtops
Oak Ridge, Tennessee
US Department of Energy
Ed Wescott

“Hecht s’endinsa en els mons nuclears africans, fixant-se en els miners i en el risc ocupacional de l’exposició a la radiació. És una mina un lloc de treball nuclear si no es detecta ni es mesura el nivell de radiació?”

G. Hecht, *Being Nuclear. Africans and the Global Uranium Trade*.
Cambridge, MA: MIT Press, 2012



1900

1925
1927

V de VERITAT

2025

“Al cor del progrés científic hi ha la recerca de la veritat.

“Però [...] la ciència, la medicina i la tecnologia actuals pateixen l'atac de dogmes ideològics que primen la identitat de grup davant l'esforç individual [i] que injecten política al cor del mètode científic.

“Aquestes agendes no només distorsionen la veritat, sinó que han erosionat la confiança pública, han minat la integritat de la recerca, han ofegat la innovació, i han afeblit la nostre competitivitat.”

Executive Order 14177 of 23/01/2025, President's Council of Advisors on Science and Technology



1900

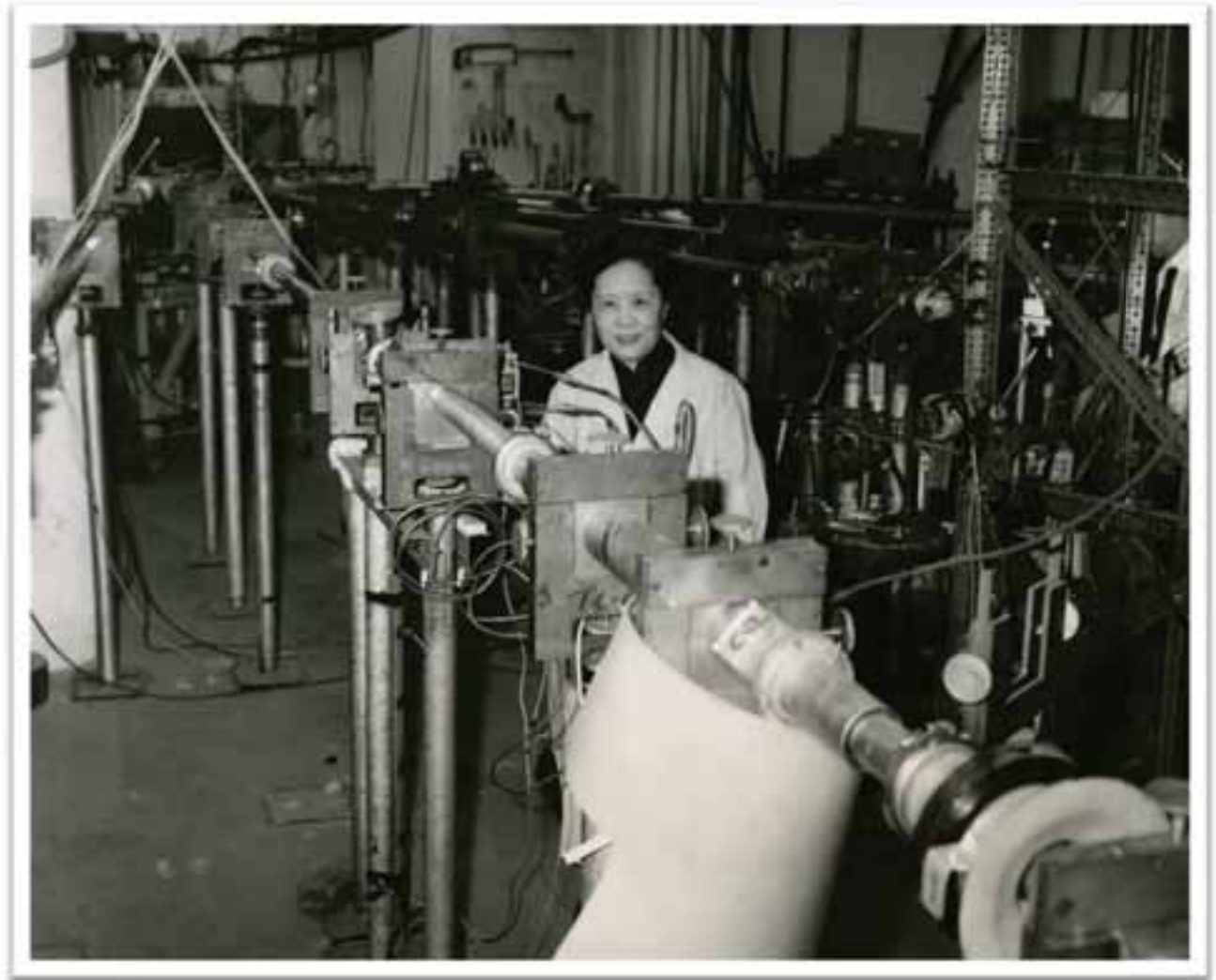
1925

1949

1957

W de WU

2022
2025



Chien-Shiung Wu (1912–1997)

Science Service (Smithsonian Institution)
Restored by Adam Cuerden, Flickr
Wikimedia Commons

Untangling Entanglement History: Early Quantum Contributions of Chien-Shiung Wu

MICHELLE FRANK

Science is not static but ever growing and dynamic. It involves not just the addition of new information, but the continuous revision of old knowledge. From a flat earth to a round globe, from classical Newtonian Mechanics to Quantum Mechanics, there are many illustrations. It is the courage to doubt what has long been established and the incessant search for its verification and proof that pushes the wheel of science forward.¹

Chien-Shiung Wu
AACW Achievement Award Acceptance Speech, 1979
& Nielsina Memorial Lecture 1981

10.1 Introduction

In October 2022, the Nobel Prize Committee in Stockholm, Sweden, released a public statement championing experimental innovation. The three physicists recognized that year – John Clauser, Alain Aspect, and Anton Zeilinger – contributed to the world’s understanding of quantum entanglement over a span of decades. Each devised increasingly sophisticated and innovative “Bell tests” to probe whether hidden

Portions of this work were originally published by *Scientific American* in Spring, 2023. Sincere thanks are due to my WHPF co-editors, Daniela Monaldi, Patrick Charbonneau, and Morgan van der Heijden. I cannot imagine a more inspiring group of partners. Thank you also to anonymous reviewers for thoughtful suggestions on this chapter developed. The gratitude is the Consortium for History of Science, Technology and Medicine, the Center for History of Physics at the American Institute of Physics, the Stuart Foundation and the Leon Levy Center for Biography for fellowship and funding support. Special thanks to Lorena Beltrame for championing this research during its early stages and to numerous team the Biography and Mentor Programs at the CUNY Graduate Center who shared guidance and advice. Ellen Crull and Charles Liu gave generosity of their time and provided important suggestions. Colleagues at the 2023 AIP Early Career Conference at the Niels Bohr Institute offered feedback on the project developed. Thank you to the extraordinary Miss Ruth Library team, archivists at Columbia University’s Rare Book and Manuscript Library, the Berkeley Bancroft Library, AIP’s Niels Bohr Library & Archives, the Nobel Archives, the Institute for Advanced Study, and the CalTech Archives and Special Collections, all of whom offered valuable research support. Thank you also to David Rouse for making time to discuss the finer points of manuscript history, and his pointing me to additional materials. Last, very grateful to Alfred Pappalardo, James Mills, Morgan Wu, and the Columbia University Physics faculty for providing insight about Wu’s years at Columbia. Most of all, my heartfelt gratitude to George Barstow and also to Chia-Ding Tin for their tireless guidance, scientific and historical insights, and encouragement along the way. Any errors that remain are my own. C. S. Wu Papers, Rare Book and Manuscript Library, Columbia University, Box 9, Folder 25. Published in Wu (2024).

Michelle Frank, a P. Charbonneau, M. Frank, M. van der Heijden i D. Monaldi, eds. *Women in the History of Quantum Physics* (Cambridge: Cambridge University Press, 2025)

Out of the Ivory Tower: Maria Lluïsa Canut and X-Ray Crystallography

MARTA JORDI TALTAVULL

15.1 Introduction

Maria Lluïsa Canut Ruiz (1924–2005) was a physicist and one of the most prominent crystallographers in Spain during the Francoist regime. Together with the natural scientist José Luis Arsuóriz Portolís (1920–2001), her partner in science and in life, she was awarded the Francisco Franco Prize in Sciences in 1963 for their joint contribution to crystallography, and she received the Research Recognition Award of the Southern Illinois University in 1968, among other accolades. Both also achieved international recognition.¹

Canut spent her scientific career in Barcelona, Madrid, and Illinois. Over the course of approximately 20 years she published more than 60 scientific papers and co-authored three books, all exploring and steadily mastering a novel and original field of research: the relationship between X-ray diffuse scattering through crystals and their thermal dynamics. X-Ray crystallography traces its origins back to a ground-breaking discovery in quantum physics made in 1912: X-rays passing through crystals produce diffraction patterns that are directly related to the microscopic structure of the crystals (Eckert, 2012). Three decades later, diffuse zones observed in X-ray diffraction patterns began to be interpreted in terms of the dynamics and non-ideal features of crystal structures. This was Canut's and Arsuóriz' field of interest.

Arsuóriz has been recognized as a prominent crystallographer since the early 1960s.² Two of his former PhD students have also written about his scientific trajectory and

¹ I thank Joan March, Agustí Cabré, and Guillem Pons for their generosity in sharing with me their archival holdings and discussions about the topic, and Maria Victoria López-Acevedo and Inés López for their hospitality at UCM. I also thank Oscar Bugar for his support as in charge of the ICM archives. Finally, I thank the editors for their admirable effort and patience in the revision of this chapter and the whole book.

² Many unclassified primary sources have been accessed to write this chapter, in particular, Canut's records at Archivo General de la Administración (AGA), General Archive for the Administration, Centro Superior de Investigaciones Científicas (CSIC), Superior Council for Scientific Research, Universidad de Barcelona (UB), University of Barcelona, Southern Illinois University (SIU), Fundación Joan March (Joan March Foundation), and Institut Milonniçol i Tèxtil (IMT), Milonniçol Institute for Studies.

³ See, for example, Fowell (1962).

Marta Jordi, a P. Charbonneau, M. Frank, M. van der Heijden i D. Monaldi, eds. *Women in the History of Quantum Physics* (Cambridge: Cambridge University Press, 2025)

1900

1912

1925

X de RAIGS X

2025

Die Untersuchungen beschließen sich seit 21 April 1912
mit Interferenzversuchen von β Strahlen beim Durch-
gang durch Kristalle. Zielgedanke war, daß Kristalle
fernerhin als Folge der Räumgitterstruktur der Kristalle
wirken, weil die Gitterkonstanten ca. 10⁸ größer sind,
als die wellenmechanische Wellenlänge der β Strahlen.
Als Beweis wird angeführt, daß β in β mit Erfolg:

Kristallstrahlkörper: Kupfererz
Kryostat 30', Strahl im Zentralstrahlischen Rohr 2.0 Millimeter,
Abstand der Platten vom Kristall: 0.13a 30 μ , 0.1460 μ ,
Abstand der Platten: λ (0.11 μ) 0.11 μ
Abstand des Ausgangspunktes des Primärstr. vom Kristall = 30 μ

Schema der Versuchsanordnung.



Abgedr. D. Knipping. M. Laue.

M. von Laue, W. Friedrich i P. Knipping, comunicació a
l'Acadèmia de Ciències bavaresa del descobriment de la
difracció de raigs X en cristalls (04/05/1912)

P. Forman, "The discovery of the diffraction of X-rays by
crystals: A critique of the myths", *Archive for History of Exact
Sciences*, 6 (1969): 38-71.

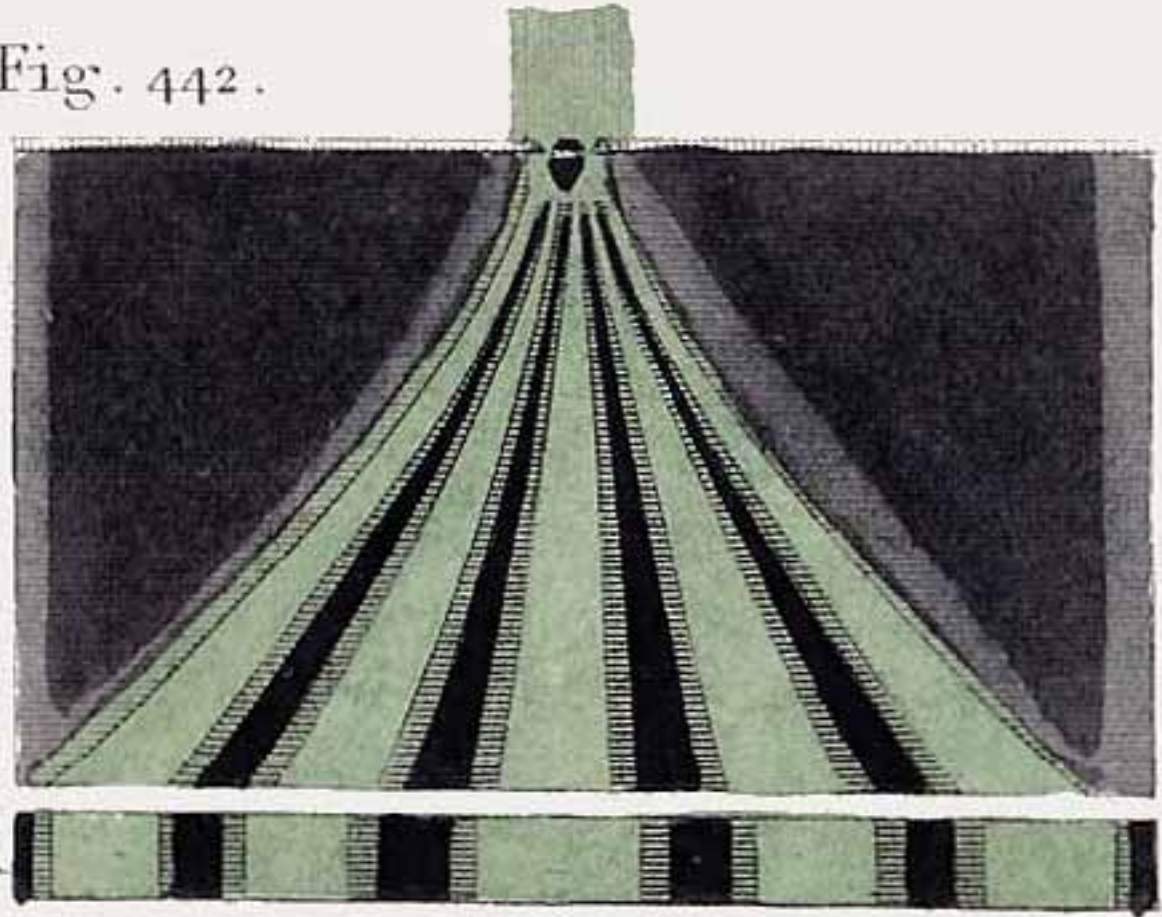
1900

1925

2025

Y de YOUNG

Fig. 442.



Thomas Young
Demostració experimental de la
lleï d'interferència de la llum

Thomas Young, *A Course of Lectures on
Natural Philosophy and the Mechanical Arts*
(1807), pl. XXX

1900

1925

1927

1957

1986

1987

2025

Z de ZÚRIC



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L	de	l
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N	de	NUCLI
O	de	OPPENHEIMER
P	de	PLANCK
Q	de	QUANTUM
R	de	RADIOACTIVITAT
S	de	SOLVAY
T	de	TÙNEL
U	de	URANI
V	de	VERITAT
W	de	WU
X	de	RAIGS X
Y	de	YOUNG
Z	de	ZÜRICH

“Canviar la percepció pública sobre el funcionament de la ciència no serà fàcil, però podem començar pels **estudiants de graus en Ciències**.

“Malauradament, la majoria dels plans d'estudi són plens d'**assignatures molt tècniques** i no inclouen la història i la filosofia de la ciència.

“Canviar aquests plans seria el primer pas per crear **un públic que entengui com es fa la ciència**.

“Això vol dir prendre **decisions dràstiques** per incorporar **una visió més àmplia i més profunda** a uns plans d'estudi atapeïts de coneixements bàsics.

És urgent que els científics facin concessions en la seva docència pel bé comú.”

Thorp, Holden H. “Teach philosophy of science”. *Science* 384 (2024): 141.



Graus

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Enviar



abecedari quàntic

Xavier Roqué
iHC i Departament de Filosofia UAB

Xerrada inaugural de la mostra **100 anys de la mecànica quàntica**
CRAI Biblioteca de Física i Química
Any Internacional de la Ciència i la Tecnologia Quàntiques
UB, 12 de novembre 2025

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J	de	JUSTÍCIA
K	de	KØBENHAVN
L	de	l
M	de	MEITNER
N	de	NUCLI
O	de	OPPENHEIMER
P	de	PLANCK
Q	de	QUANTUM
R	de	RADIOACTIVITAT
S	de	SOLVAY
T	de	TÚNEL
U	de	URANI
V	de	VERITAT
W	de	WU
X	de	RAIGS X
Y	de	YOUNG
Z	de	ZÜRICH