Lise Meitner, 1878-1968

Where's my Nobel prize?

Roger Boyle

February 15, 2025

Caveat

I am not a physicist or a chemist.

Lise Meitner, 1878 – 1968

LM, 1904

As a little girl

https://www.sutori.com/story/lise-meitner--5qbAN2A1q1pgenc8cPWXGY62

LM was born in Vienna (then the Austro-Hungarian Empire) in 1878, into a highly cultured, liberal and educated family. Both her parents were of Jewish ancestry, but non-practising.

She was both exceptionally intelligent and studious, with a passion for science.

Schooling

LM attended the Mädchen Bürgerschule in Czerninplatz, Vienna.

She did well, but formal education for girls ended at 14.

University

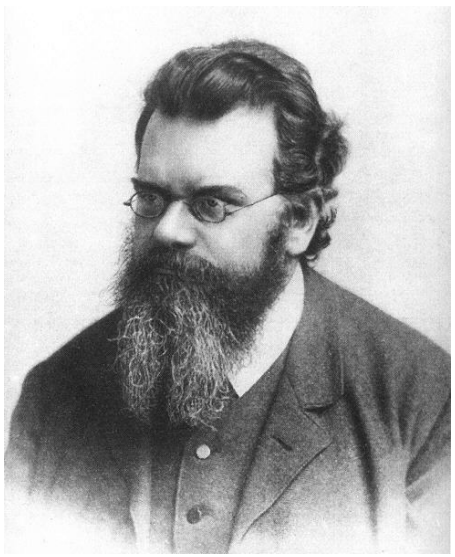
LM was lucky in that the 1890s saw a surge of interest in science in Austria, at the same time as a slight opening of university opportunities for women.

She entered the university of Vienna – the atmosphere was hostile to women and this coloured her opinions for life.

She excelled.

Physics

In Vienna, LM met and was taught by exceptionally influential men: Boltzmann (1844-1906, statistical mechanics), Planck (1858-1947, quantum theory) among them. She became interested in the new work on radioactivity (Bequerel, Skłodowska-Curie – 1896).



Wikipedia

Physics

After Vienna, she wanted to pursue research into radioactivity. An approach to Marie Curie (1867-1934) in Paris failed, but she travelled to Berlin to study under Planck who was at the heart of atomic physics.

Berlin was very unwelcoming to women students.

She was introduced to Otto Hahn (1879-1968), a rising radio-chemist. They were contemporary and got on well together.

Otto Hahn

Hahn had a distinguished record in radio-chemistry, working, inter alia, with Rutherford.

Local prejudices required that Hahn and LM could work together *if* they did not use the established laboratories, which were off limits to women.

Progress

Cutting a long story short

Together, LM and Hahn made exceptional progress, and attracted the attention and support of the physics and chemistry communities.

Over decades (interrupted 1914-18) their professional partnership flowered during a thrilling period of scientific discovery and development: Relativity, Quantum Mechanics and their own area of Nuclear Physics were all being developed fast.

They were frequent associates of the scientific pantheon: Bohr, Curie M, Curie I, Einstein, Fermi, Dirac, Heisenberg, Rutherford, Schrödinger, ... LM and the Curies were alone as women in this company.

There was no suggestion on any part that Hahn was the senior partner – LM and he were equals.

Solvay Conference 1933

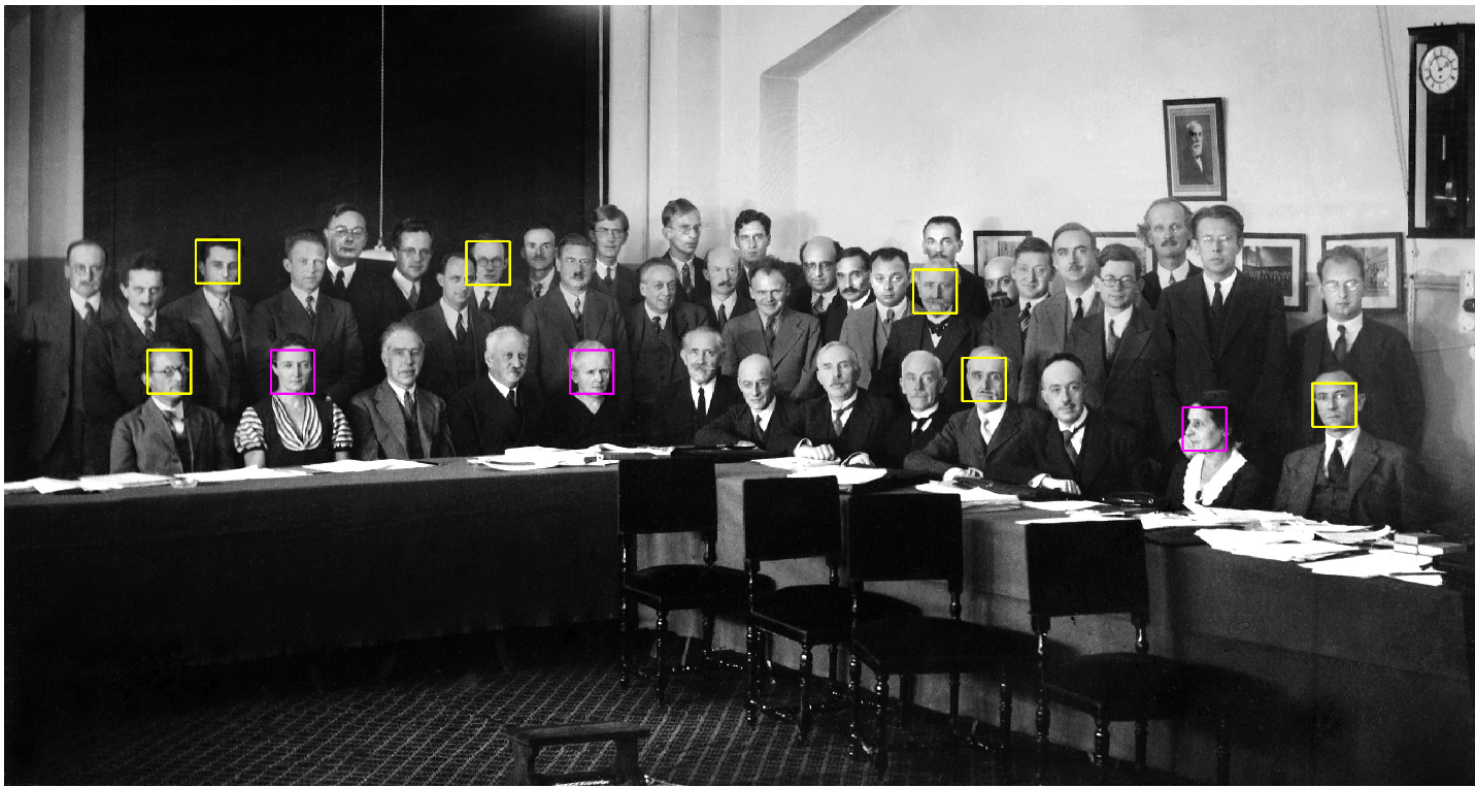
http://www.hilliontchernobyl.com

Solvay Conference 1933

Dirac, Heisenberg, Schrödinger, Pauli, Rutherford, Chadwick

Solvay Conference 1933

. . . Joliot-Curie, Skłodowska-Curie, Meitner

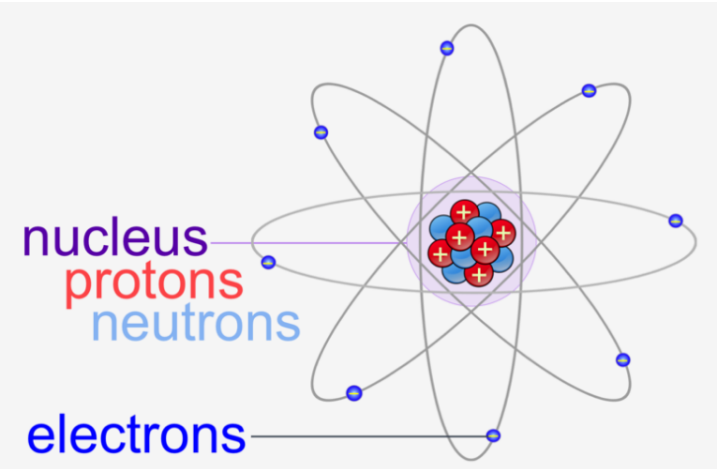


Science

'The structure of matter preoccupied man long before the beginning of systematic natural science.'
The Nature of the Atom, Lise Meitner, Fortune Magazine, 137-188, Feb 1946.

Matter is composed of *atoms*. An atom is one of a number of known *elements*, such as Hydrogen, Carbon, Silicon, Chlorine, Uranium, ... On our planet, there are 94 naturally occurring elements.

Atoms



http://thebiologyprimer.com/atoms-and-molecules/

Think of an atom as a *nucleus* of protons and neutrons, surrounded by orbiting electrons.

Atoms

An atom is tiny. Really tiny. Really really tiny.

Atoms

An atom is tiny. Really tiny. Really really tiny. The radius of a Hydrogen atom is 5.29×10^{-11} metres (about 10000 times *smaller* than the wavelength of visible light).

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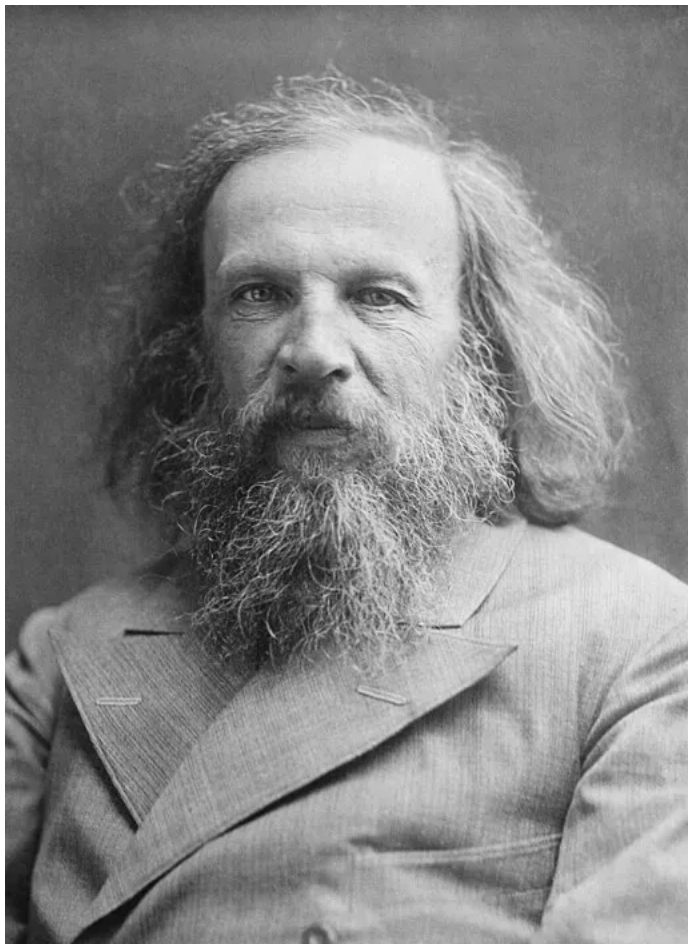
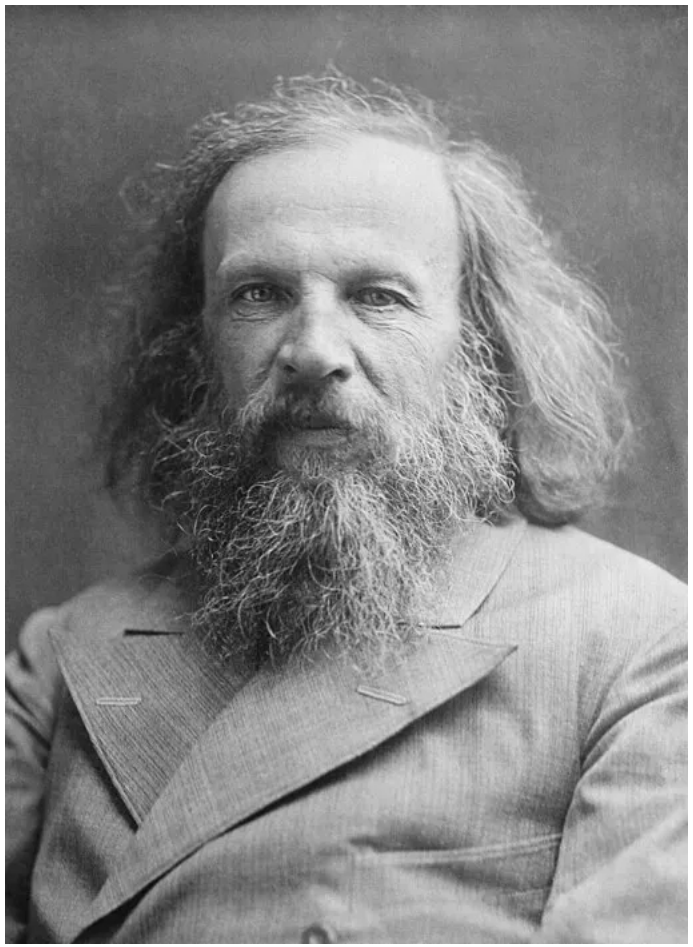
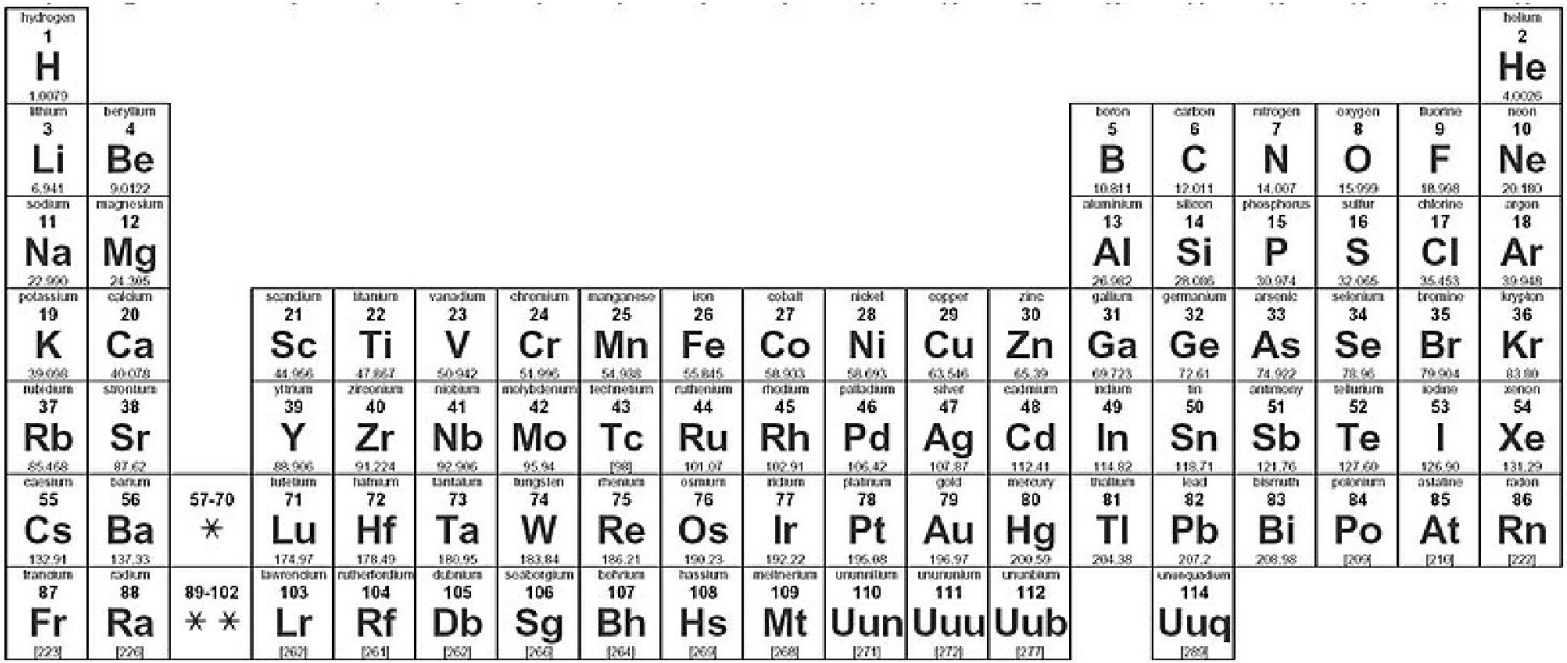
A particular atom is determined by the number of (positively charged) protons it has: e.g., Hydrogen has 1, Helium has 2, Carbon 6, Oxygen 8, Gold 79, Uranium 92, ...



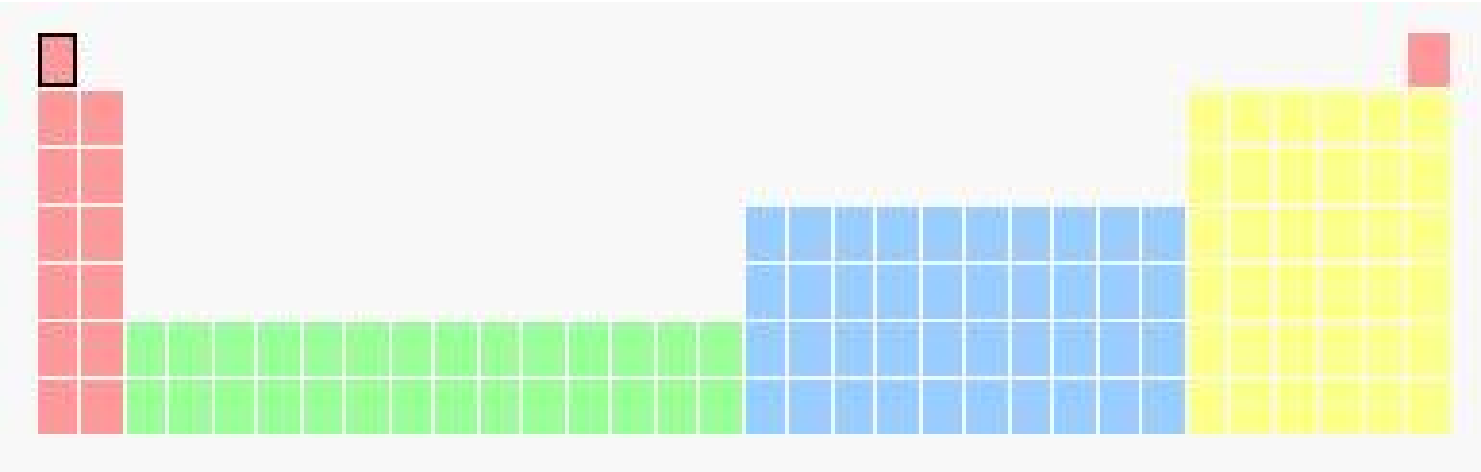
Dmitri Mendeleev, 1834-1907



The Periodic Table – Mendeleev, 1860s



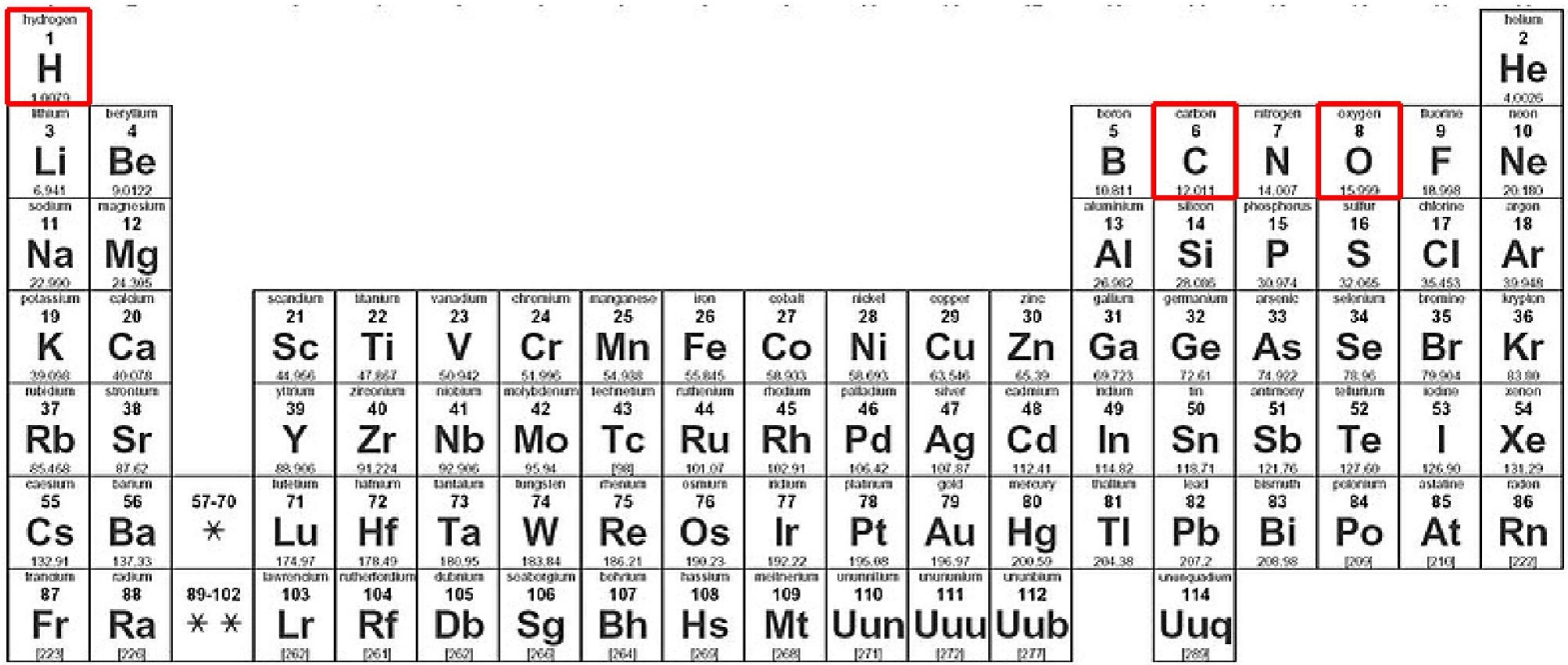
The Periodic Table – Mendeleev



With the Lanthanoids and Actinoids in place.

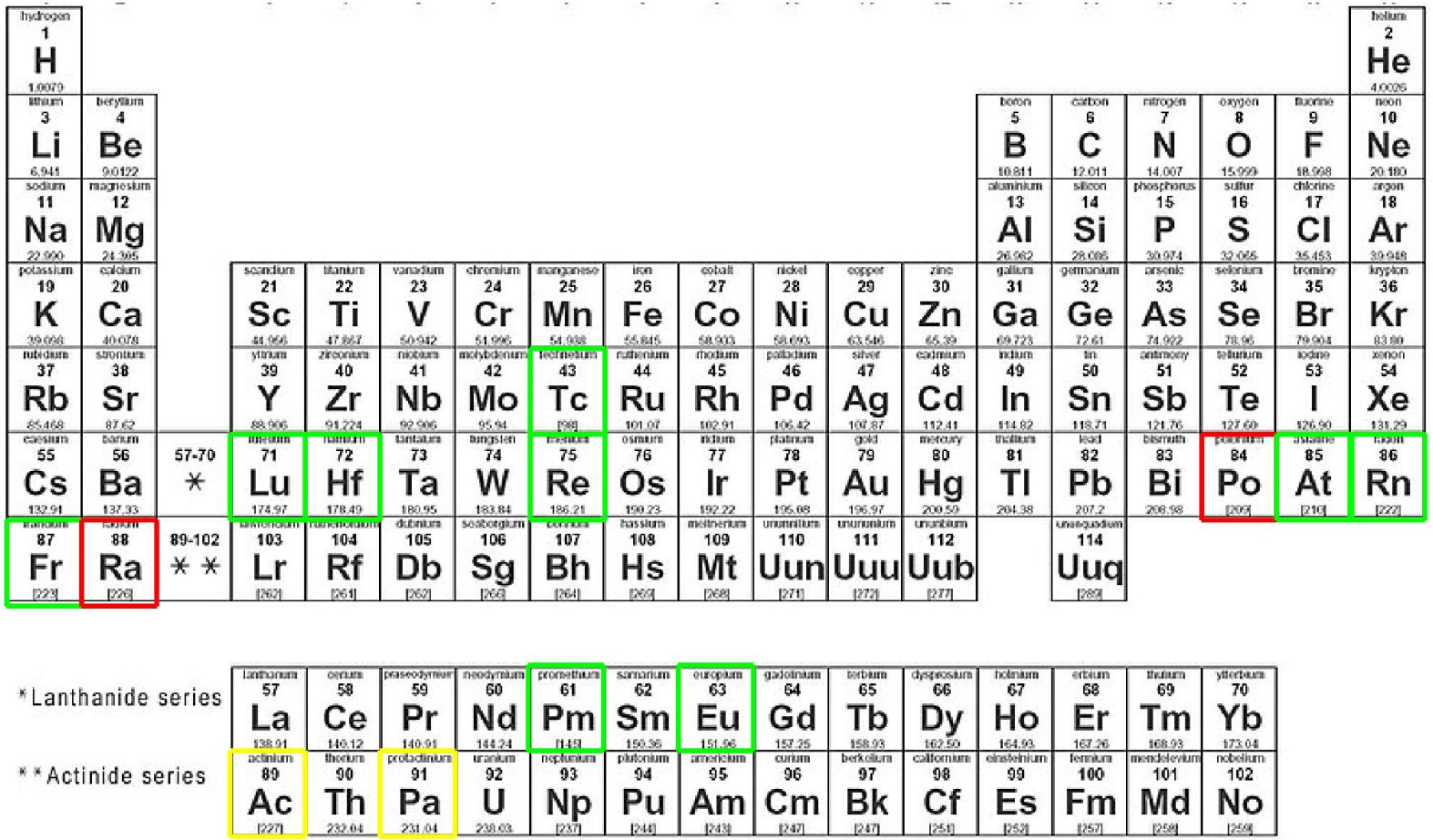
The Periodic Table

Hydrogen, Carbon, Oxygen



The Periodic Table – gaps in 1897

Curies: Polonium, 1898 and Radium 1910, Debierne: Actinium 1899

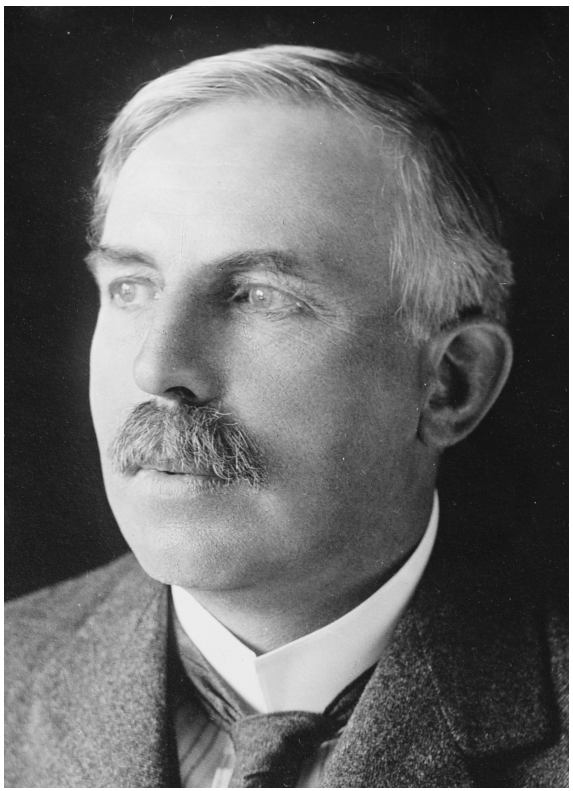


The Periodic Table – filling a gap

The unusual element Protactinium has 91 protons. Hahn and LM were first to isolate a stable form of it in 1917. Their name for it means ‘Precursor to Actinium’.

Sir Ernest Rutherford

1871–1937



Wikipedia

A theory that you can't explain to a barmaid is probably no damn good.

Neutrons

Rutherford's team identified the *neutron* 1931.

Radio-physics/radio-chemistry research groups immediately set up experiments that bombarded atoms of known elements with neutrons 'to see what happened'.

Particularly Uranium, the heaviest [biggest] known element, was studied. There were hopes of synthesising heavier, unknown elements – *transuranics*.

Results were disparate and confusing.

Germany 1933+

After Hitler's elevation to Reichskanzler, life for the intelligentsia, especially those who were deemed 'non-Aryan', became progressively less comfortable. Prominent physicists, such as Einstein and Schrödinger, had cause to worry seriously.

The Nazi regime began to develop the idea of 'German science' which excluded the fundamental ideas of relativity and quantum mechanics.

LM was unable to demonstrate Aryan credentials and became marginalised within her profession.

Germany 1938

After the annexation of Austria (the Anschluss), LM's Austrian nationality could no longer protect her from the Third Reich's laws and processes.

A clandestine operation by many of Europe's senior physicists (including Hahn) spirited her from Berlin to the Netherlands, and thence to Sweden.

Reportedly, she met with Hahn in Denmark en route to Sweden: they discussed experiments for the study of Uranium atoms.

The Swedish research community absorbed her on a low salary and without serious practical facilities: she continued correspondence with Hahn and made fundamental theoretical contributions and suggestions for experiments for transuranics.

Christmas 1938

Hahn was unable to understand how his experiments bombarding Uranium delivered traces of lighter elements such as Barium.

LM, visited by her physicist nephew Otto Frisch, considered the matter theoretically during a 1938 Christmas stay at Kungälv.

https://duckduckgo.com/?q=Kungalv&t=brave&ia=web&iaxm=places

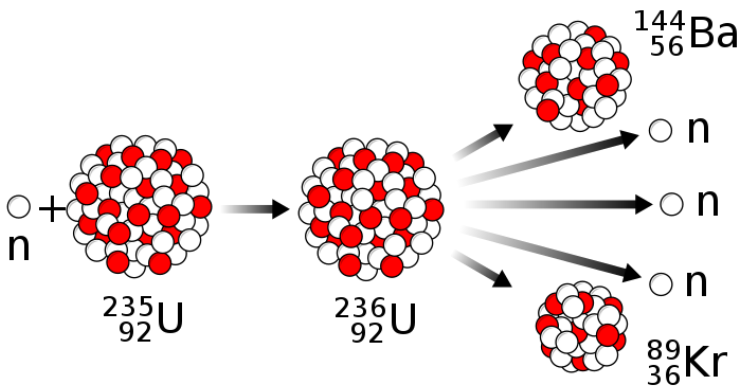
A snowy walk

On a walk in the snowy woods, LM had the brilliant insight that perhaps the neutron caused a Uranium atom to split.

She sat in the snow with paper and pencil and outlined the energy exchanges implied, and saw that they corresponded precisely with Hahn's observation.

This was the very first identification of nuclear fission and its implication for structure and energy surplus.

Fission



https://commons.wikimedia.org/wiki/File:Nuclear_fission_reaction.svg

The atom splits into Barium and Krypton; there are *three* spare neutrons, **and a lot of energy**.

The three spare neutrons are available to repeat the split of other Uranium atoms . . . and generate more energy. This would be a *chain reaction*, and is the key to nuclear power and weaponry.

Kungälv, Sweden

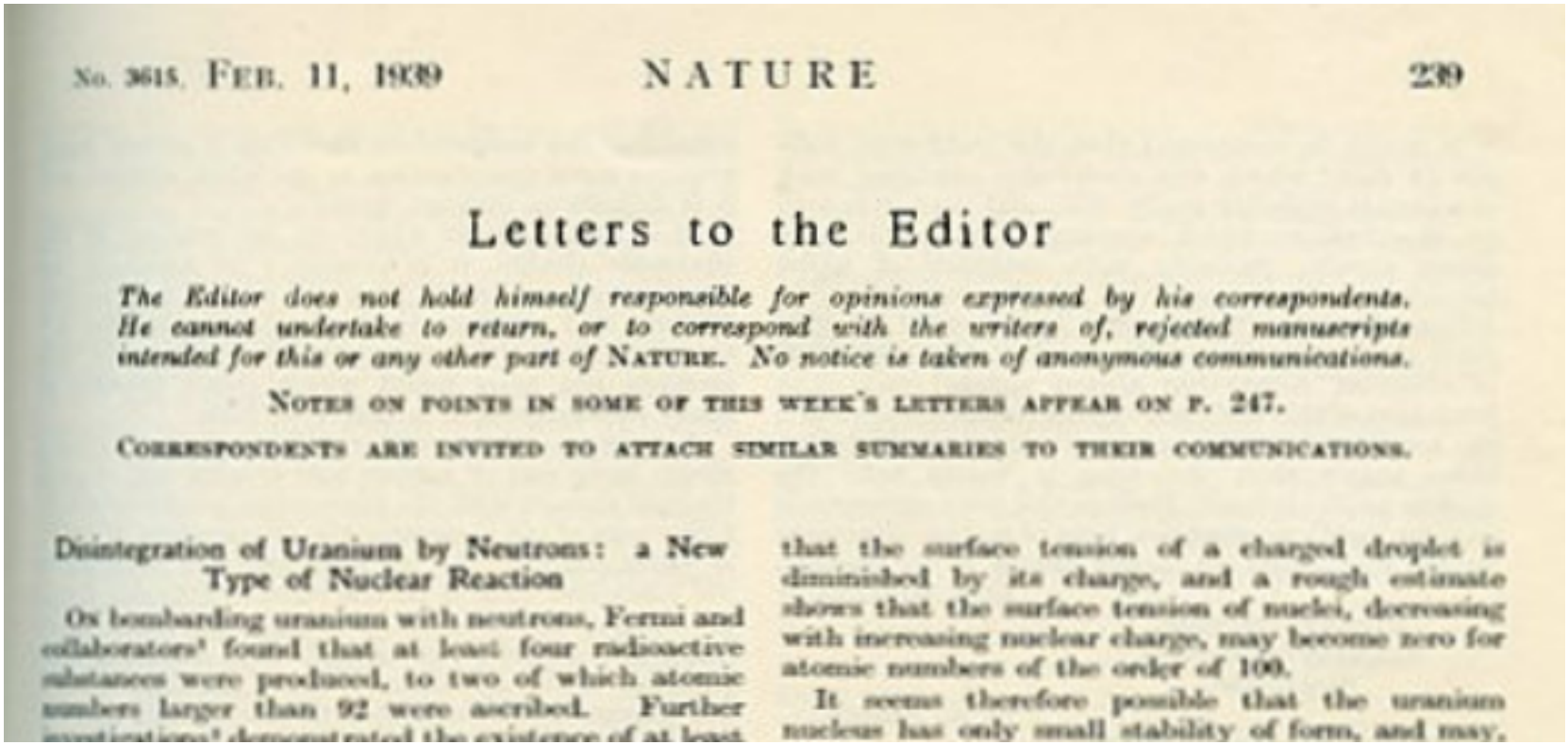
http://www.epsnews.eu/2016/12/eps-historic-site-the-home-of-lise-meitner-in-sweden/

Kungälv, Sweden

https://artikel19.blogspot.com/2006/03/atomldern-startade-i-kunglv.html

Nature, V143(3615), 239, Feb. 1939

LM and Frisch rush to publication.



No. 3615. FEB. 11, 1939 NATURE 239

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 writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 247.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

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

On bombarding uranium with neutrons, Fermi and collaborators[1] found that at least four radioactive substances were produced, to two of which atomic numbers larger than 92 were ascribed. Further

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 possible that the uranium nucleus has only small stability of form, and may,

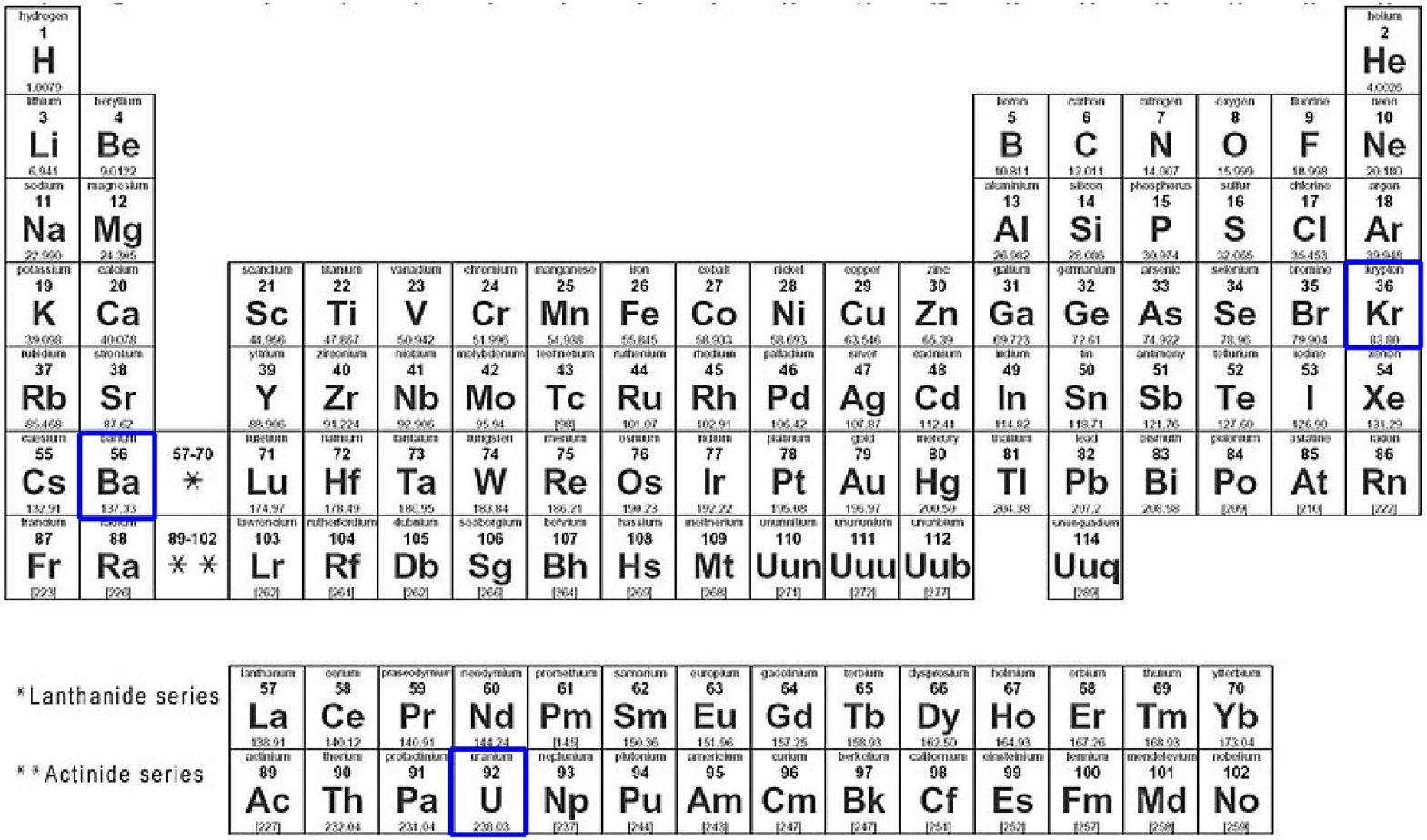
Nature, V143(3615), 239, Feb. 1939

. . . On account of their close packing 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 made sufficiently violent by adding energy, such a drop may divide itself into two smaller drops.

. . . The whole 'fission' process can thus be described in an essentially classical way, without having to consider quantum-mechanical 'tunnel effects', which would actually be extremely small, on account of the large masses involved.

The Periodic Table

Fission!



Fission

LM's theory spread with astounding speed through the Physics and Chemistry communities. It was persuasive and soon verified.

Many were quick to realise the military potential of the energy explosion: famously, when this was explained in July 1939 to Einstein he said *Daran habe ich gar nicht gedacht* [I did not even think about that]. Fearful of German exploitation, he swiftly put in place correspondence that encouraged Roosevelt to initiate the Manhattan Project.

Einstein later found himself conflicted and regretted his role in the development of atomic weapons.

Fission

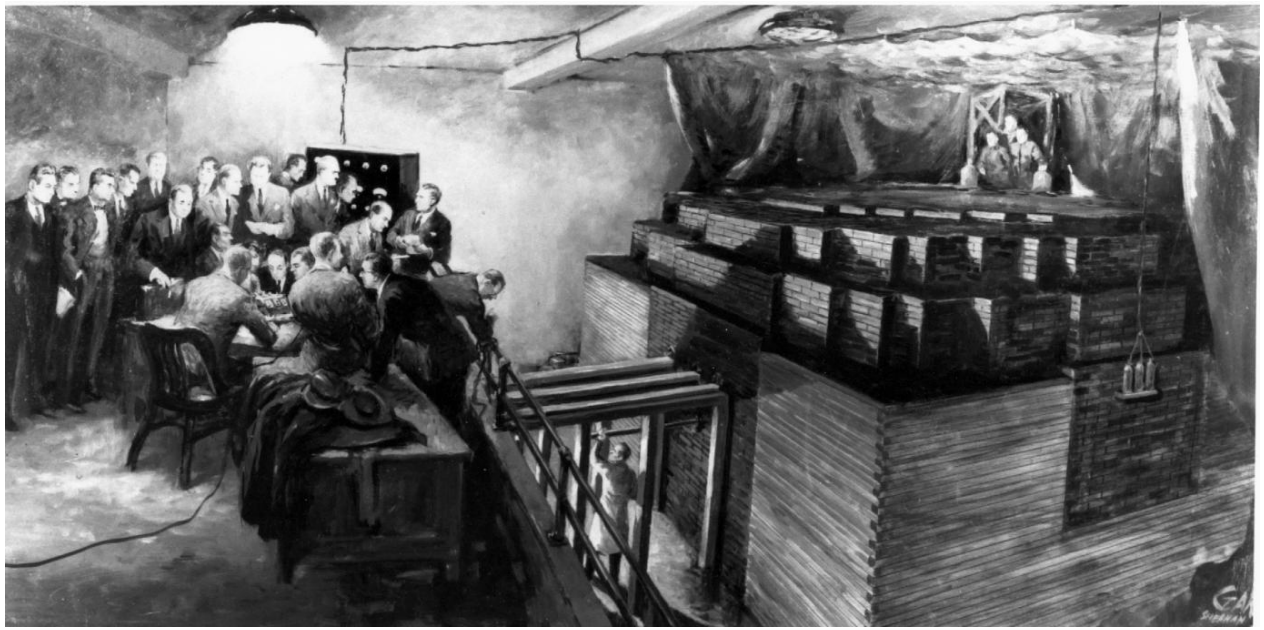
As war in Europe came closer, a rift grew between Hahn and LM.

The potential uses of the enormous energy release of fission chain reaction became clear internationally. Roosevelt, Stalin and Hitler were quickly aware of the possible military use.

On December 2nd 1942, Enrico Fermi initiated the first man-made exhibition of a controlled nuclear chain reaction at the university of Chicago.

The apparatus was called *Chicago Pile 1*.

Chicago, December 1942



https://news.uchicago.edu/story/uchicago-commemorate-75th-anniversary-first-chain-reaction

Apparatus was primitive, and the possible outcomes quite unknown!

Atomic weapons

At Los Alamos, the Manhattan Project was conducted under enormous secrecy by a large and very intellectually powerful team of American, British and emigré scientists.

In Germany, with vastly inferior resources, Werner Heisenberg led a German team with similar aims. They made significant inroads but failed to produce controlled fission. Interesting questions remain over Heisenberg's true position in this work (cf. Michael Frayn's play *Copenhagen*).

Atomic weapons

Despite being invited, LM played no role in the Manhattan Project.

Atomic weapons

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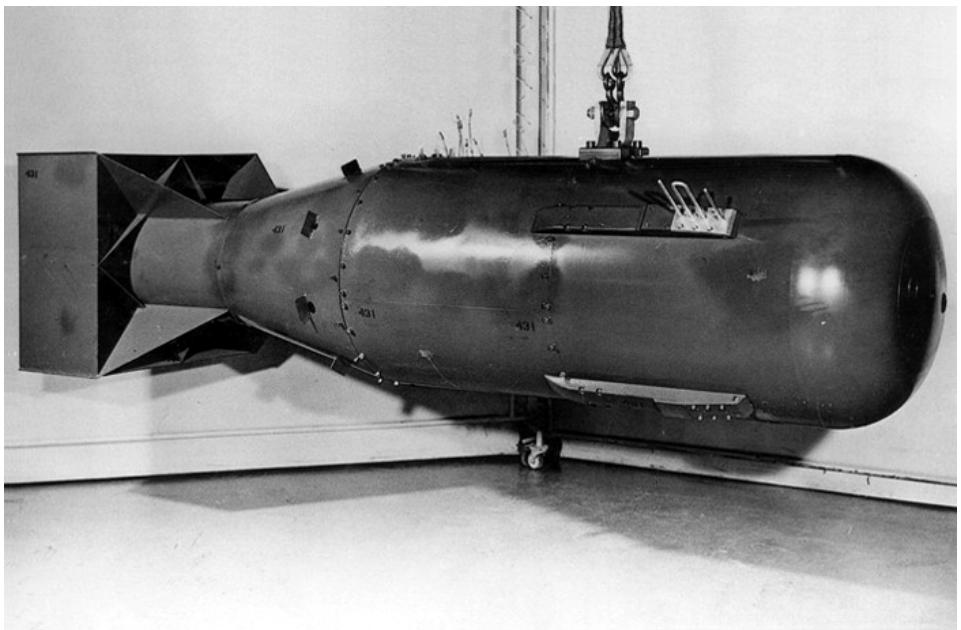
I will have nothing to do with a bomb!
On refusing an invitation to join a group of British scientists, including Otto Frisch, to go to Los Alamos in 1943.

Little Boy

On August 6th, 1945, 'Little Boy' was dropped on Hiroshima. This was the first use on our planet of an offensive nuclear weapon.



https://www.storypick.com/atom-bomb-on-hiroshima/

Post-war

Along with other significant German scientists (Bagge, Diebner, Gerlach, Harteck, Heisenberg, Korsching, von Laue, von Weizsäcker, Wirtz), Hahn was spirited away to Farm Hall near Cambridge; Farm Hall has become part of the WW2 scientific legend.

It was hoped that they would reveal secrets that could inform British nuclear research.

Hahn was soon able to resume serious scientific activity.

Post-war

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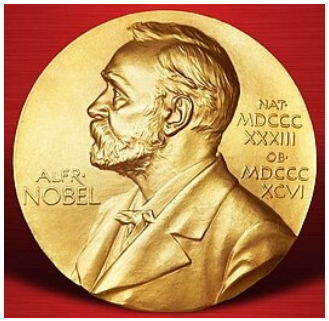
Nobel awards had been suspended during the war: in 1945 the Committees set about awarding prizes retrospectively for the wartime years.

Nobel prize for Chemistry, 1944



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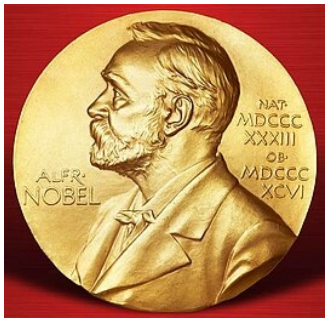

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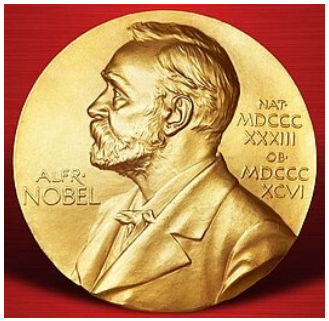

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In his acceptance speech, Hahn said *The expression ‘nuclear fission’ [Kernspaltung, fission nucléaire, ymholltiad niwclear] is due to Meitner and Frisch*.

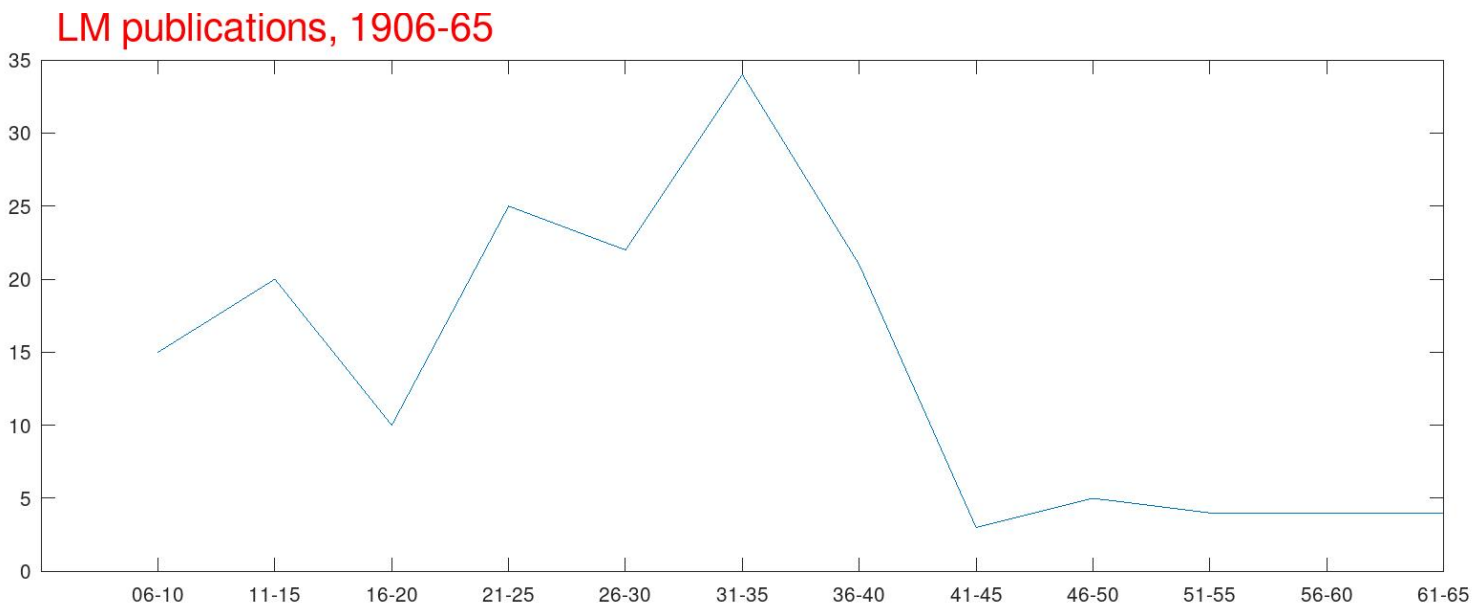
Nobel prize for Chemistry, 1944

'Meitner's exclusion from the chemistry award may well be summarized as a mixture of disciplinary bias, political obtuseness, ignorance, and haste.'

Crawford, Sime and Walker, *A Nobel tale of postwar injustice*, Physics today, 50(9), 25-32 1997

Post-war . . .

LM is now nearing 70. She remains an influential and well-liked member of the international physics community but is much less professionally productive. She has 'mild celebrity' status.



Post-war . . .

She maintains cordial relations with Hahn who continues to conduct science and organisation of science in the reconstructing (West) Germany.

LM lives and naturalises in Sweden. She never forgets her struggle as a woman, and is a vociferous champion of women in science.

Aged 81 . . .

Bryn Mawr University, April 1959

https://www.aip.org/history-programs/niels-bohr-library/ex-libris-universum/love-information

Photo by Heka Davis, courtesy of AIP Emilio Segrè Visual Archives, Physics Today Collection.

Physics Today, 13, 16-21, 1960

The status of women in the professions

- In principle, nearly all male professions have become accessible to women; in practice, things often look different.

Physics Today, 13, 16-21, 1960

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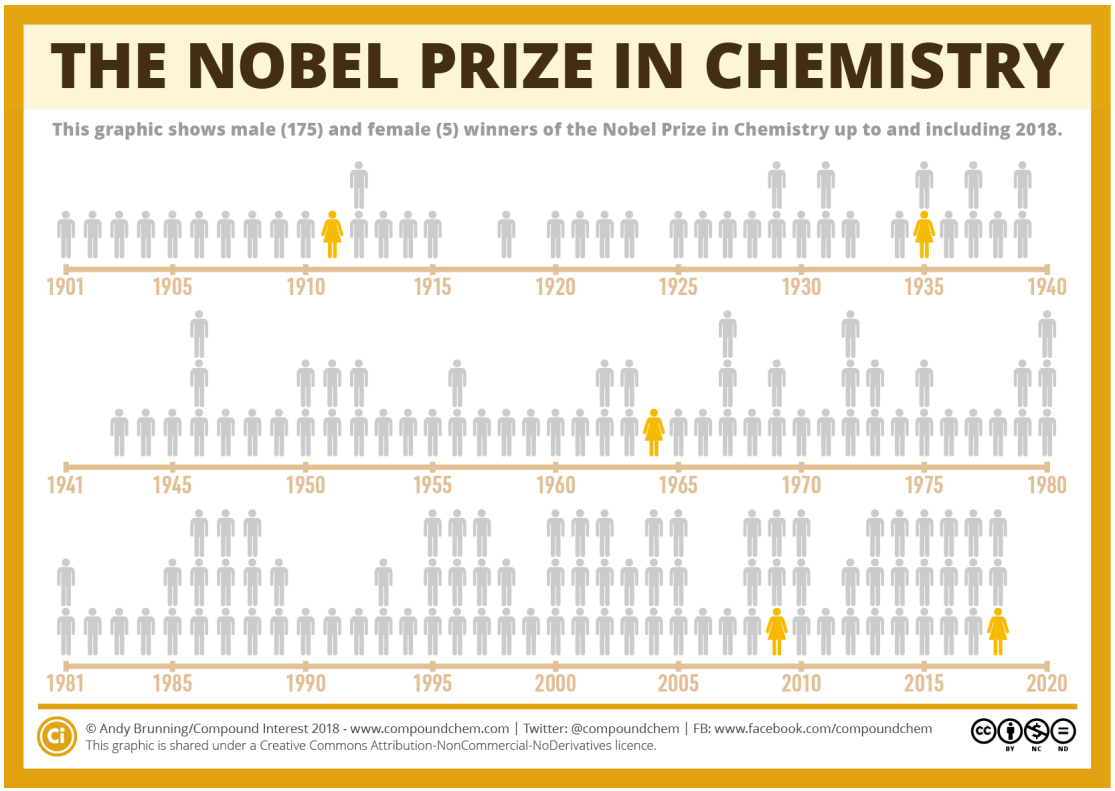
Plus ça change, plus c'est la même chose.
Je mehr es sich ändert, desto mehr bleibt es das Gleiche

Nobel prizes in Chemistry

https://www.compoundchem.com



Skłodowska-Curie, Joliot-Curie, Hodgkin, Yonath, . . .

Since 2020, there have been 13 joint Chemistry Laureates, of whom 3 are female.

Later years

As her health declined, LM moved to Cambridge where Otto Frisch was pursuing a highly successful career as a physicist. She died in 1968.

It was her wish to be buried alongside her brother in Bramley, Hampshire.

Bramley, Hampshire

'Lise Meitner, 1878-1968, A physicist who never lost her humanity'

Bramley, Hampshire

RG26 5NQ

Greifswald, Germany

Mecklenburg-Vorpommern

Greifswald, Germany

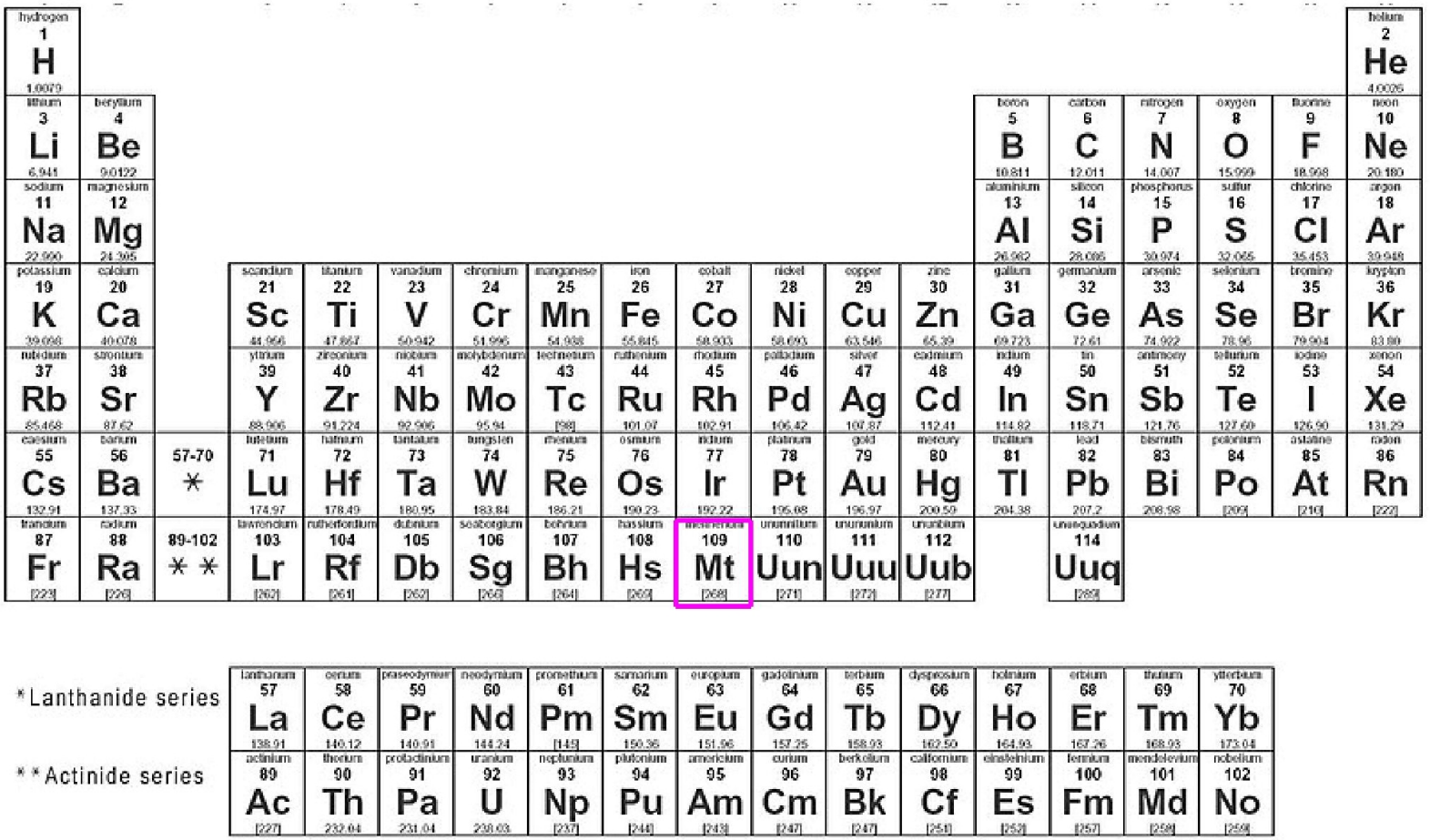
Mecklenburg-Vorpommern

Mt 109

Meitnerium is an unstable transuranic element of atomic number 109 and a half-life of 4.5 seconds.

It was first synthesised in Germany in 1982 at the *GSI Helmholtzzentrum für Schwerionenforschung*, Darmstadt.

Meitnerium 109



. . . , Bohrium, Hassium, Meitnerium, Darmstadtium, Roentgenium, . . .

Schwarzbach's statue of LM, Humboldt University, Berlin

2014: First German statue of a female scientist (http://www.jacqueslanciault.com)

'Science makes people reach selflessly for truth and objectivity; it teaches people to accept reality, with wonder and admiration, not to mention the deep awe and joy that the natural order of things brings to the true scientist.' LM, Austrian UNESCO Commission lecture, 30th March 1953