

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--5qbAN2A1q1pgenc8cPWXY62>

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

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>



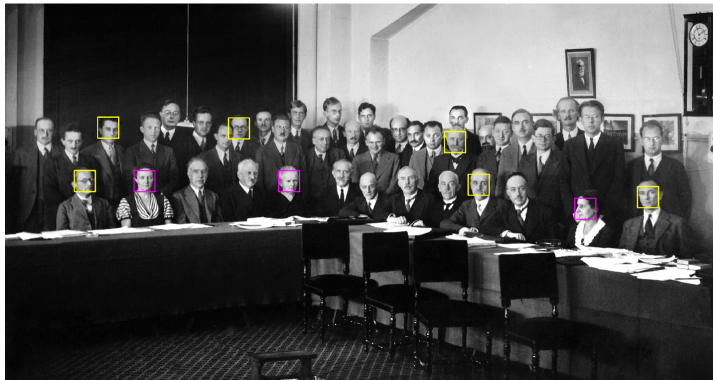
Solvay Conference 1933

Dirac, Heisenberg, Schrödinger, Pauli, Rutherford, Chadwick



Solvay Conference 1933

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

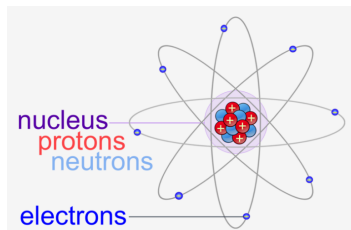


'The structure of matter preoccupied man long before the beginning of systematic natural science.'

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

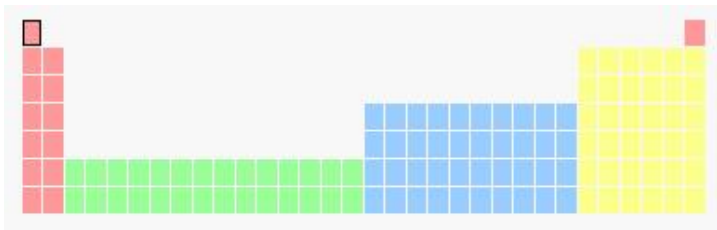
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A particular atom is determined by the number of (positively charged) protons it has: e.g., Hydrogen has 1, Helium has 2, Carbon 6, Oxygen 8, Gold 79, Uranium 92, ...

The Periodic Table – Mendeleev



With the Lanthanoids and Actinoids in place.

The Periodic Table

Hydrogen, Carbon, Oxygen

hydrogen 1 H 1.0079																	helium 2 He 4.0026						
lithium 3 Li 6.941	beryllium 4 Be 9.0122																	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305																	aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.89						
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	silver 46 Ag 107.87	cadmium 47 Cd 112.41	indium 48 In 114.82	tin 49 Sn 118.71	antimony 50 Sb 121.76	tellurium 51 Te 127.69	iodine 52 I 126.90	xenon 53 Xe 131.29	cesium 54 Cs 132.91						
francium 87 Fr [223]	barium 56 Ba 137.33	* 57-70	lutetium 71 Lu 174.967	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	wolfram 74 W 183.84	reuterium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]					
	radium 88 Ra [226]	* *	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]							

* Lanthanide series

** Actinide series

lanthanum 57 La	cerium 58 Ce	praseodymium 59 Pr	neodymium 60 Nd	promethium 61 Pm	samarium 62 Sm	europium 63 Eu	gadolinium 64 Gd	terbium 65 Tb	dysprosium 66 Dy	holmium 67 Ho	erbium 68 Er	thulium 69 Tm	ytterbium 70 Yb
actinium 89 Ac	thorium 90 Th	protactinium 91 Pa	uranium 92 U	neptunium 93 Np	plutonium 94 Pu	americium 95 Am	curium 96 Cm	berkelium 97 Bk	californium 98 Cf	einsteinium 99 Es	fermium 100 Fm	mendelevium 101 Md	nobelium 102 No

The Periodic Table – gaps in 1897

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

hydrogen 1 1.0079																	helium 2 4.0026						
lithium 3 6.941	beryllium 4 9.0122																	boron 5 10.811	carbon 6 12.011	nitrogen 7 14.007	oxygen 8 15.999	fluorine 9 18.998	neon 10 20.180
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rubidium 37 85.468	strontium 38 87.62	yttrium 39 88.906	zirconium 40 91.224	niobium 41 92.906	molybdenum 42 95.94	technetium 43 [99]	ruthenium 44 101.07	rhodium 45 102.91	palladium 46 106.42	silver 47 107.87	cadmium 48 112.41	indium 49 114.82	tin 50 118.71	antimony 51 121.76	tellurium 52 127.69	iodine 53 126.90	xenon 54 131.29						
cesium 55 132.91	barium 56 137.33	* 57-70	lanthanum 57 138.905	cerium 58 140.12	praseodymium 59 140.91	neodymium 60 144.24	promethium 61 [145]	samarium 62 150.36	europium 63 151.96	gadolinium 64 157.25	terbium 65 158.93	dysprosium 66 162.50	holmium 67 164.93	erbium 68 167.26	thulium 69 168.93	ytterbium 70 173.04	radium 88 [226]						
francium 87 [223]	actinium 89 [227]	** 89-102	thorium 90 232.04	protactinium 91 231.04	uranium 92 238.03	neptunium 93 [237]	plutonium 94 [244]	americium 95 [243]	curium 96 [247]	berkelium 97 [247]	californium 98 [251]	einsteinium 99 [252]	fermium 100 [257]	mendelevium 101 [258]	nobelium 102 [259]	actinium 89 [227]	radium 88 [226]						
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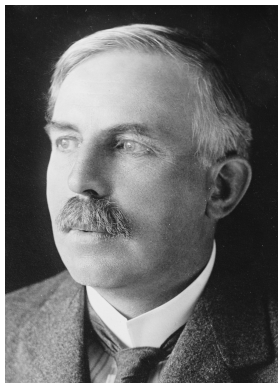
** Actinide series

The Periodic Table – filling a gap

The unusual element Protactinium has 91 protons. Hahn and L.M. Meitner 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.

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.

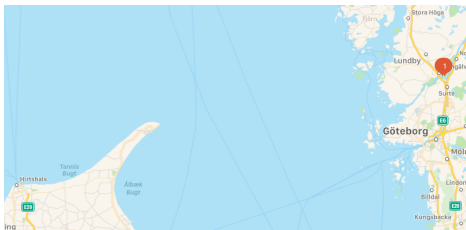
Reportedly, she met with Hahn in Denmark en route to Sweden: they discussed experiments for the study of Uranium atoms.

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=Kungälv&t=brave&ia=web&iaxm=places>

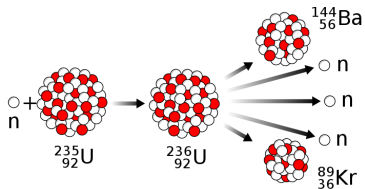
A snowy walk

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

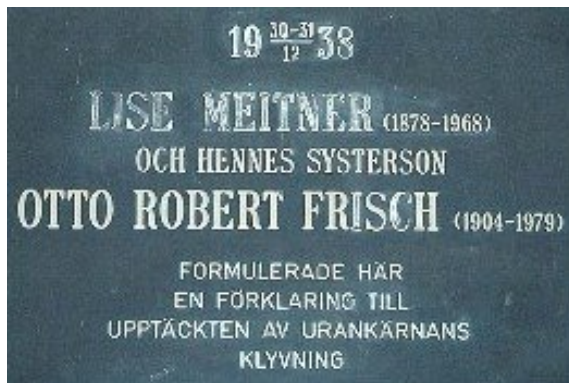
The atom splits into Barium and Krypton; there are *three* spare neutrons, **and a lot of energy**.

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

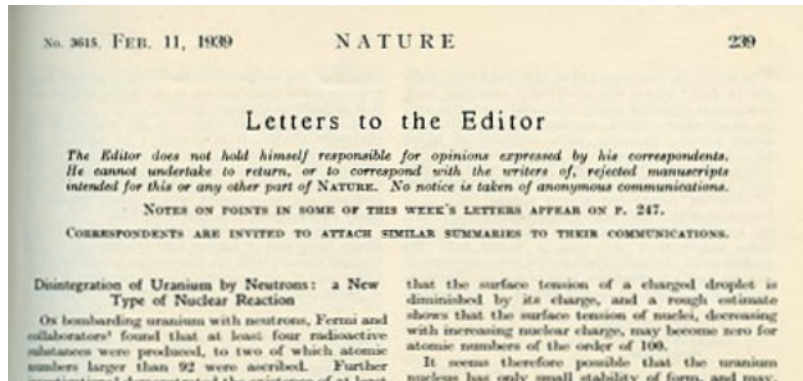


<http://www.epsnews.eu/2016/12/eps-historic-site-the-home-of-lise-meitner-in-sweden/>



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

LM and Frisch rush to publication.



... 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!

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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.

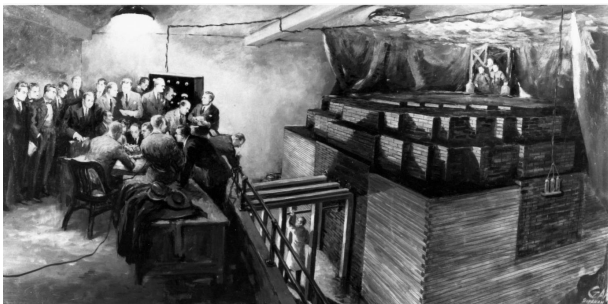
As war in Europe came closer, a rift grew between Hahn and LM.

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

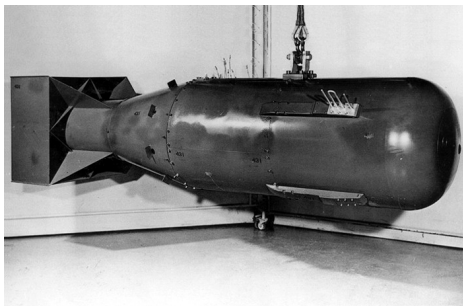
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I will have nothing to do with a bomb!

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/>

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.

LM conducted a celebrated tour in the US, but was eclipsed: her retiring personality and disconnection from the physics mainstream left her isolated.

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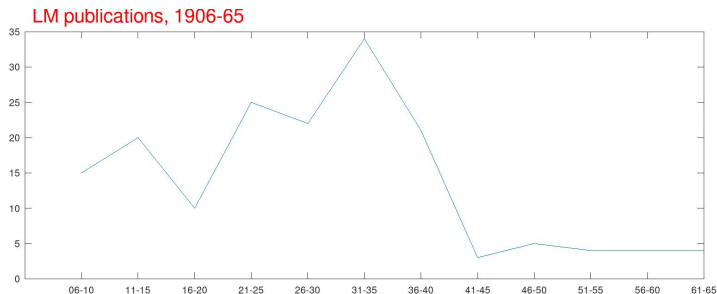
In his acceptance speech, Hahn said *The expression 'nuclear fission' [Kernspaltung, fission nucléaire, ymholttiad niwclear] is due to Meitner and Frisch.*

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

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.

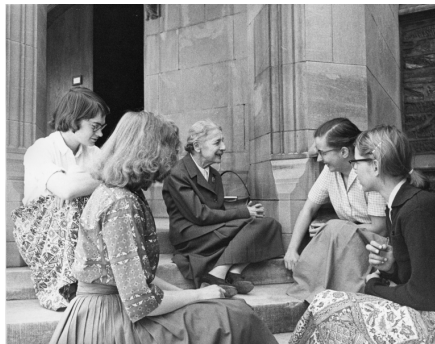


She maintains cordial relations with Hahn who continues to conduct science and organisation of science in the reconstructing (West) Germany.

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.

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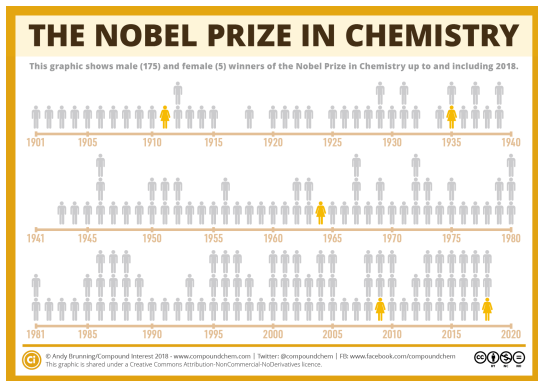
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Je mehr es sich ändert, desto mehr bleibt es das Gleiche

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.



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

Bramley, Hampshire

RG26 5NQ



Greifswald, Germany

Mecklenburg-Vorpommern



Greifswald, Germany

Mecklenburg-Vorpommern



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

Hydrogen 1 1.00794																	Helium 2 4.002602						
Lithium 3 6.941	Beryllium 4 9.0122																	Boron 5 10.811	Carbon 6 12.011	Nitrogen 7 14.007	Oxygen 8 15.999	Fluorine 9 18.998	Neon 10 20.180
Sodium 11 22.990	Magnesium 12 24.305																	Aluminum 13 26.982	Silicon 14 28.086	Phosphorus 15 30.974	Sulfur 16 32.065	Chlorine 17 35.453	Argon 18 39.948
Potassium 19 39.098	Calcium 20 40.078	Scandium 21 44.956	Titanium 22 47.867	Vanadium 23 50.942	Chromium 24 51.996	Manganese 25 54.938	Iron 26 55.845	Cobalt 27 58.933	Nickel 28 58.693	Copper 29 63.546	Zinc 30 65.39	Gallium 31 69.723	Germanium 32 72.61	Arsenic 33 74.922	Selenium 34 78.96	Bromine 35 79.904	Krypton 36 83.80						
Rubidium 37 85.468	Strontium 38 87.62	Yttrium 39 88.906	Zirconium 40 91.224	Niobium 41 92.906	Molybdenum 42 95.94	Technetium 43 [99]	Ruthenium 44 101.07	Rhodium 45 101.07	Palladium 46 106.42	Silver 47 107.87	Cadmium 48 112.41	Indium 49 114.82	Tin 50 118.71	Antimony 51 121.76	Telesium 52 127.60	Iodine 53 126.905	Xenon 54 131.29						
Cesium 55 132.91	Barium 56 137.33	* 57-70	Lanthanum 57 138.905	Hafnium 58 178.49	Tantalum 59 180.95	Tungsten 60 183.84	Rhenium 61 186.21	Osmium 62 190.23	Iridium 63 192.22	Platinum 64 195.08	Gold 65 196.967	Mercury 66 200.59	Thallium 67 204.38	Lead 68 207.2	Bismuth 69 208.98	Poisonium 70 [209]	Radon 71 [222]						
Francium 87 [223]	Radium 88 [226]	* * 89-102	Lanthanum 89 [203]	Rutherfordium 104 [261]	Dubnium 105 [262]	Seaborgium 106 [263]	Hassium 107 [264]	Meitnerium 108 [265]	Moscovium 109 [266]	Ununennium 110 [267]	Unbinilium 111 [268]	Untrium 112 [269]	Unquadrium 113 [270]	Unquadium 114 [271]	Unpentium 115 [272]	Unsextium 116 [273]	Unseptium 117 [274]	Unoctium 118 [275]					

* Lanthanide series

Lanthanum 57 138.91	Cerium 58 140.12	Praseodymium 59 140.91	Niobium 60 144.24	Protactinium 61 150.92	Samarium 62 150.36	Europium 63 151.96	Gadolinium 64 157.25	Terbium 65 158.93	Dysprosium 66 162.50	Hoium 67 164.93	Erbium 68 167.26	Thulium 69 168.93	Ytterbium 70 173.04
Actinium 89 [227]	Thorium 90 232.04	Protactinium 91 231.04	Uranium 92 238.03	Np 93 [237]	Pu 94 [244]	Am 95 [243]	Cm 96 [247]	Bk 97 [247]	Cf 98 [251]	Es 99 [252]	Fm 100 [257]	Md 101 [258]	No 102 [259]

** Actinide series

..., 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