Discovering the Island of stability

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Phys 494
2009

Mythical

- Image from wikipedia

Why study Super Heavy metals?

- Confirming that stable heavy elements exist will show us which nuclear models are correct or needs to be modified.
- This will help understand more about fission and will help make nuclear reactors safer.
- Possible applications in the future, example: 95, discovered in 1944 by Seaborg is used in smoke detectors and in medical radiography.

- Elements with atomic numbers greater than 92 are not found in nature and are manmade.
- The lifetime of the heavy elements are very small (fraction of a second), and we are not able to investigate them or study their chemical properties. These are in the sea of instability.

Physicists imagination.

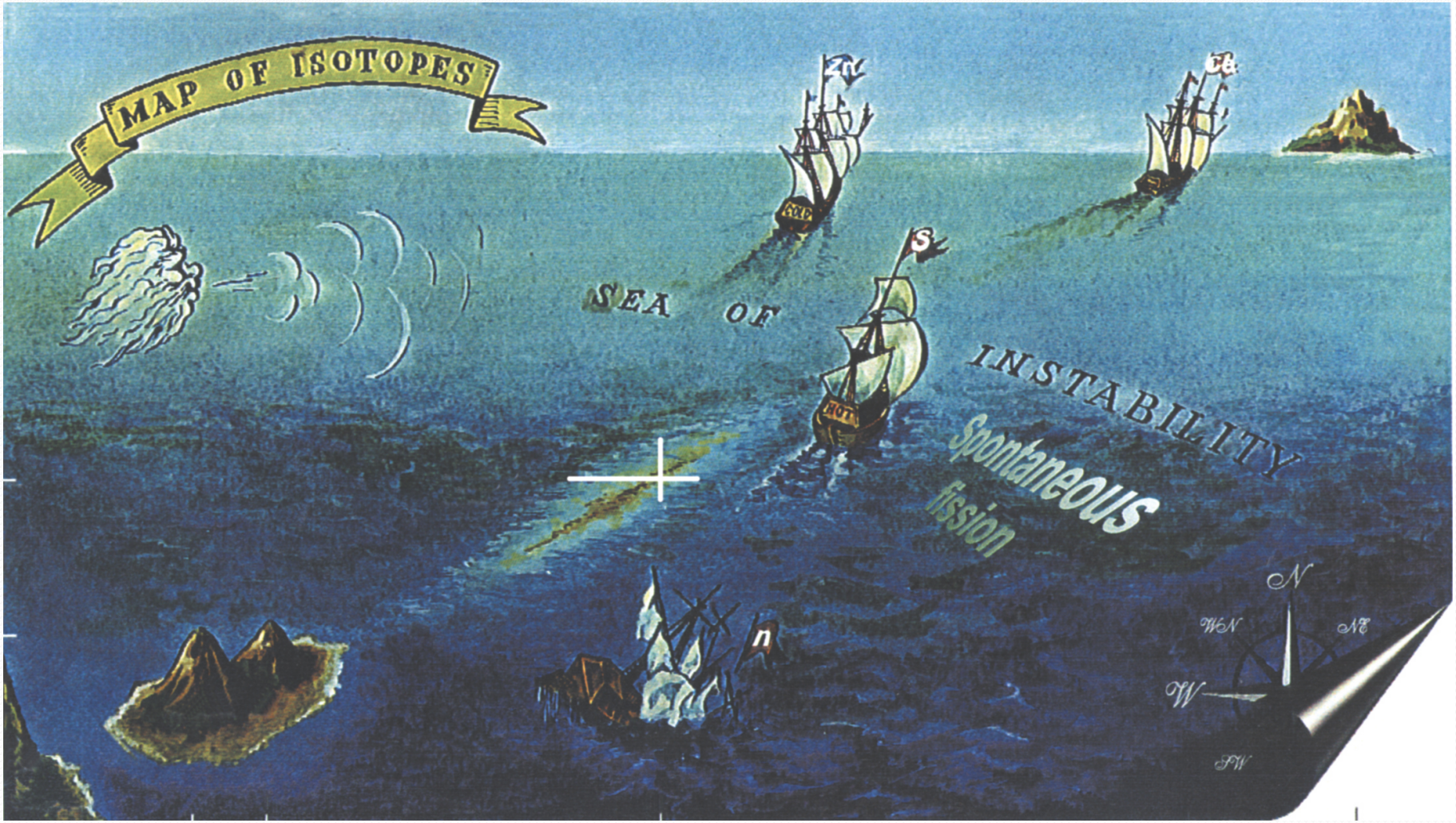
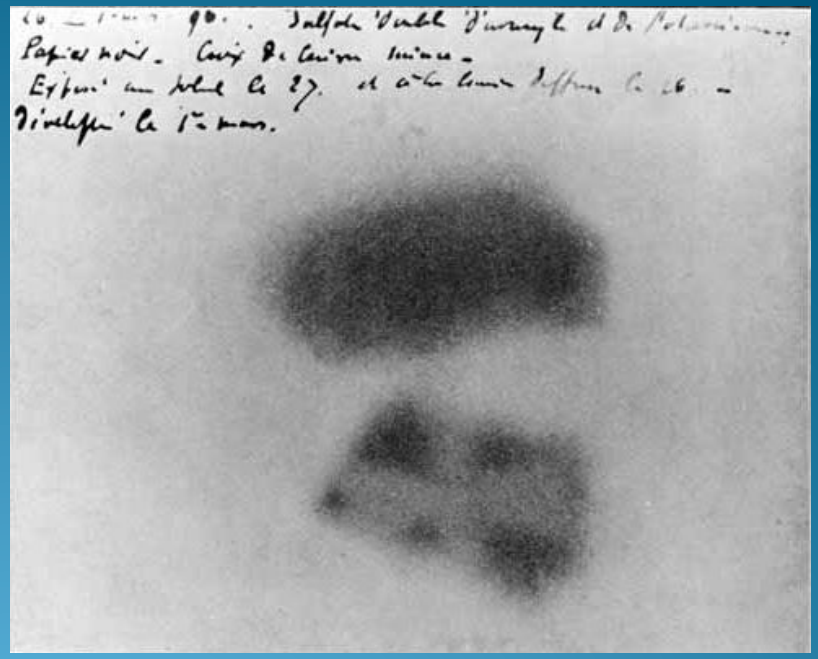


Image from physical and life sciences directorate

- Element 92, Uranium, was found to be used since year 79 in ceramic glazes.
- It was discovered in Berlin in 1789 and named after the planet.
- Discovered it was radioactive in 1896 by Becquerel.

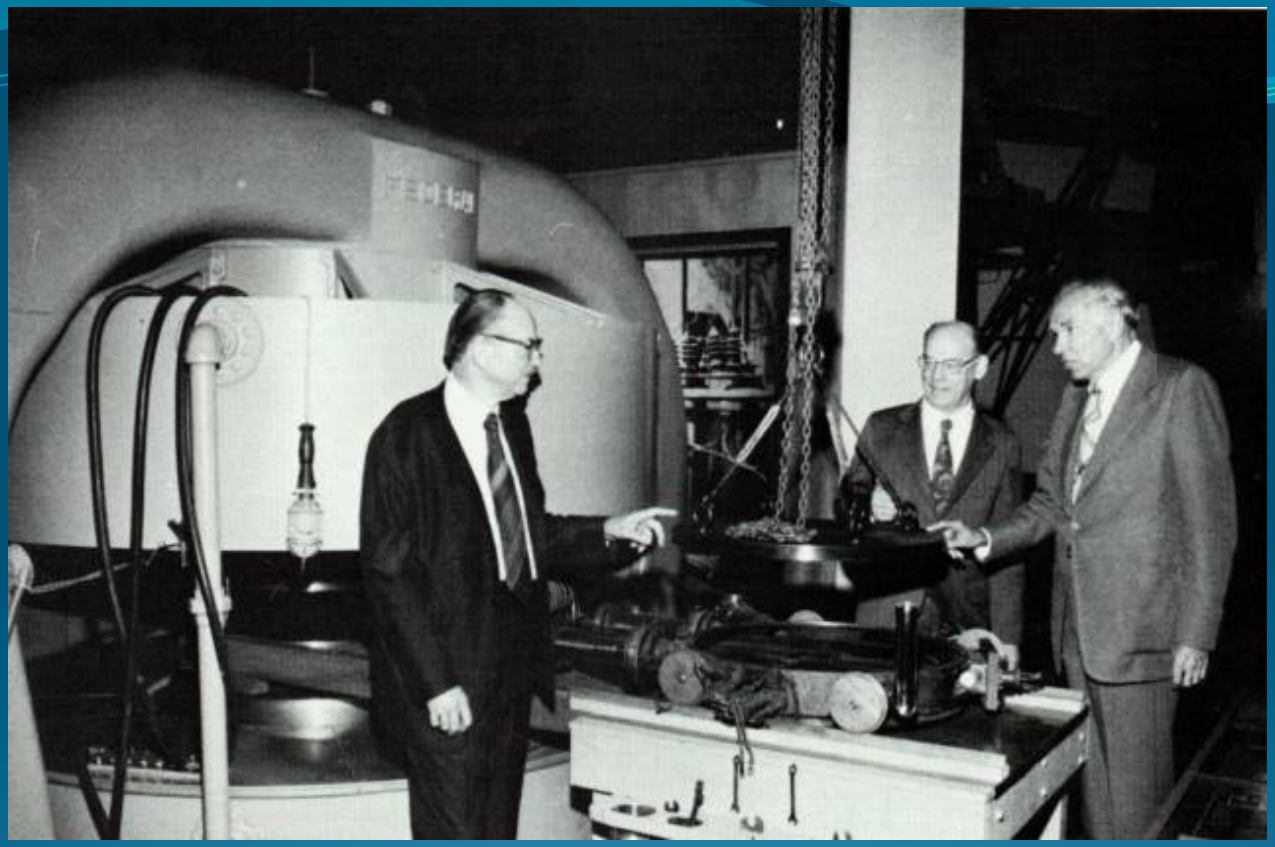


Photos from wikipedia.

- Glenn Seaborg,1912-1999
- Nobel prize in chemistry ‘51
- Chairman of the U.S. atomic
- Energy commission under Kennedy, Johnson and Nixon.
- Produced more elements than anyone else.

http://isswprod.lbl.gov/Seaborg/bio.htm

- Glenn Seaborg has produced : 94,95,96,97,98,101,102.
- Initially element 94 was claimed to be discovered in 1934 by Enrico Fermi at the University of Rome. It was named Esperio, which is the greek name of Italy, and had the symbol Es.
  - In 1938 it was discredited, and that the actual discovery was a mixture of elements.



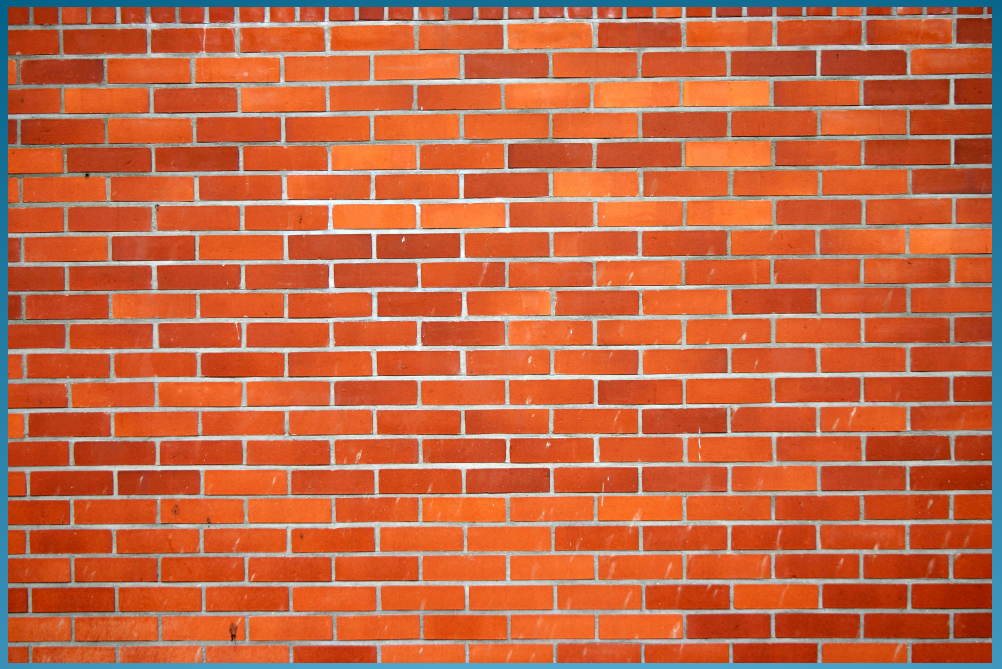
- Element 94 is discovered by Seaborg and McMillan in 1940 at UC Berkeley in the 60-inch cyclotron.
- Technique: Uranium-238 and Deuterons which contains one proton and one neutron (Neutrons were discovered in 1932 by Chadwick, England).
- Atoms accelerated to about 1/10 the speed of light.

- Photo from LBNL

184 inch cyclotron, oppenhiemer, Lawrence

- Discovery became classified and part of the Manhattan project until the end of world war II.
- McMillan had discovered element 93 in 1940 and named it neptunium, since it came next after element 92, which was uranium. He suggested naming 94 Plutium with symbol Pl, and Seaborg named it plutonium since he thought it sounded better.
  - As an inside joke, he gave it the symbol Pu, which ended up in the periodic table after it was declassified.
    - Picture from http://isswprod.lbl.gov/Seaborg/bio.htm

- Seaborg couldn’t make anymore elements after element 102.



Nuclear Shell Theory

- In the 1949 new theory of the nucleus was developed by Maria Goeppert-Mayer. 1906-1972. (Teller, Argonne)

Maria Goeppert-Mayer

- Realized that the stable elements had certain number of protons and neutrons.
- She studied the binding energies, spins, spin orbit coupling, and magnetic moments of those elements further.
  - Led her to her conclusion that the protons and neutrons were pairing up in distinct rings.
- Discovered Shell theory for the nucleus for which she received the Nobel prize with Jensen in 1963.

Magic Numbers

- Magic numbers occur when a nuclear shell is complete with neutrons or protons.
- Those that have magic number of protons and magic number of neutrons are called doubly magic. Numbers 2,8,20,28,50 are magic

numbers. Example, helium has 2 neutrons, and 2 protons.

- In light of this new discovery, Seaborg re-thought his technique. He could jump over the sea of instability onto the shores of the island of stability instead of making his way through the ocean.

- Seaborg changed technique. Instead of one particle at a time, use 20 or more. This was his idea of getting to the island of stability
- Calcium plus Plutonium to fuse together to get element 114 (20+94).

  - Picture from eteams.com

Predictions

- Stability, due to the shell model of the atom would be at 114, or 118, 120,126. He thought the peak would be at 114.
- In 1998, 114 discovered by Dubna. But feel short of the doubly magic numbers by 10 neutrons, so it was still unstable.

JINR

- Between 1999-2005 discovered 113, 114,116,118,115 and 113.
- U400 cyclotron in Dubna, russia.
- Cyclotrons accelerate ions in a circular motion to about 1/10th the speed of light. Invented by Ernest O. Lawrence.

- Image from Physical and life Sciences direcorate

114 verified 10 years later

- In September 2009, 114 verified at LBNL using their 88-inch Cyclotron.

Nuclide	Decay mode	Half-life	E_α (MeV)
$^{286}114$	$\alpha = 50\%$ SF $= 50\%$	$0.13^{+0.04}_{-0.02}$ s	10.19 ± 0.06
$^{282}112$	SF	$0.82^{+0.30}_{-0.18}$ ms	
$^{287}114$	α	$0.48^{+0.16}_{-0.09}$ s	10.02 ± 0.06
$^{283}112$	$\alpha > 10\%$ SF $< 10\%$	$3.8^{+1.2}_{-0.7}$ s	9.54 ± 0.06
^{279}Ds	$\alpha = 10\%$ SF $= 90\%$	$0.20^{+0.05}_{-0.04}$ s	9.70 ± 0.06
$^{288}114$	α	$0.80^{+0.27}_{-0.16}$ s	9.94 ± 0.06
$^{284}112$	SF	97^{+134}_{-19} ms	

PRL 103, 132502 (2009)

- In 1999 it was discovered that data was falsified for the discovery of 110,112, 116 and 118. No one could reproduce the results, and when they looked at the original data, they found no trace of the alpha decay. Elements 110,112 had enough good data to still be proved, but not 116 and 118.
- In 2006 JINR and LBNL rediscovered 118 by accelerating Calcium with californium (20+98) in the cyclotron.

- Prediction is that element 126 is the strongest magic number, and 114 is the weakest magic number with the next step at 120.
- Research is now to get to 120, and then to 126 which should be the peak on the island of stability.
- We are already at the shoreline at 114.
- The next big island after that is predicted to be at 164.

Photo from http://isswprod.lbl.gov/Seaborg/bio.htm