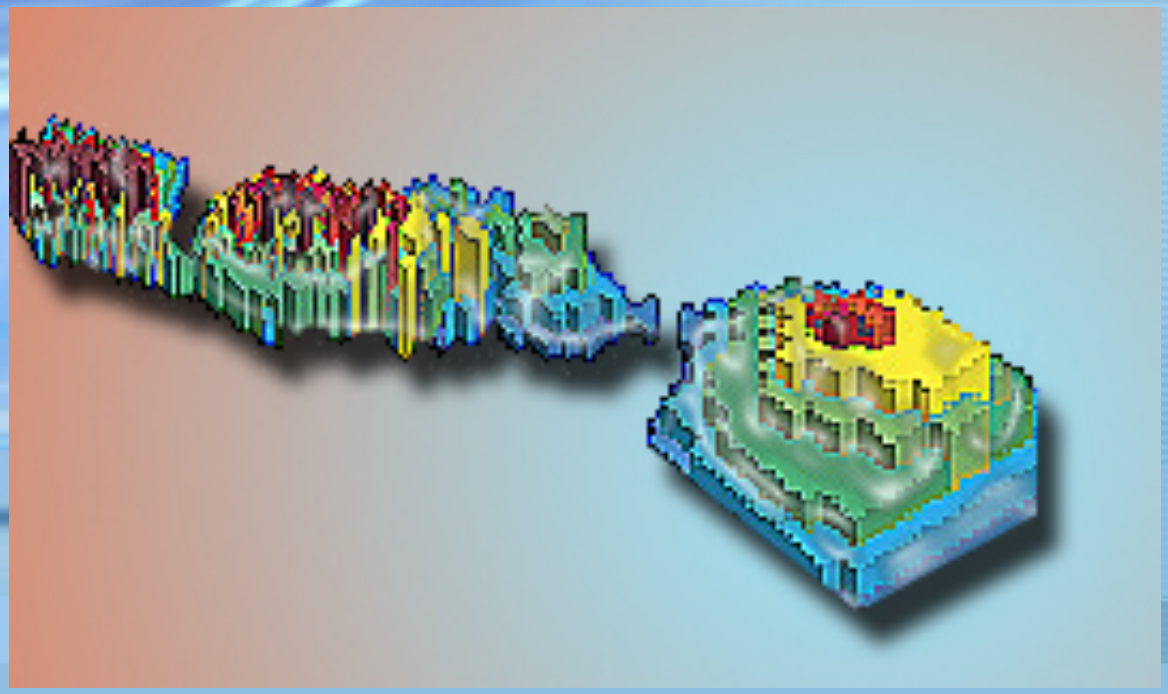
Super Heavy Elements:

The Island of Stability

Michael Spillane



newscenter.lbl.gov/press-releases/2009/09/24/114-confirmed/

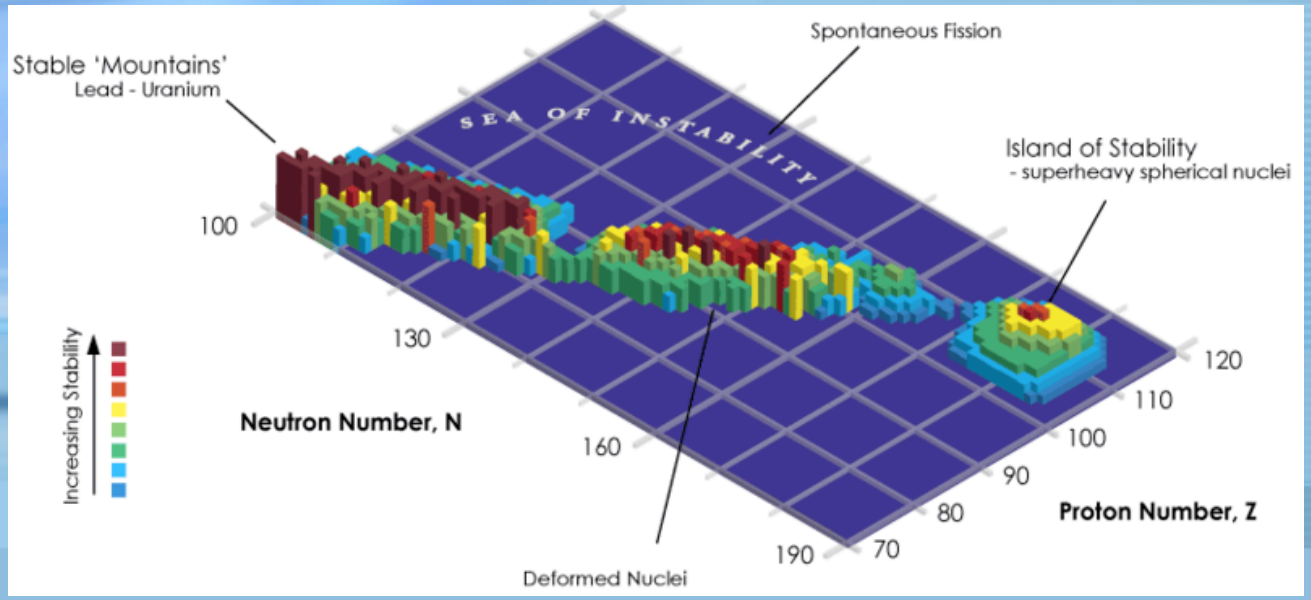
Historical notes

http://en.wikipedia.org/wiki/Niels_Bohr

- 1939 Bohr and Wheeler predict fission of SHE
- 1965 shell corrections
- 1969 island of stability predicted
- Early 1980's reach Z=107-109 (GSI Gesellschaft für Schwerionenforschung)

Island of stability

- Represents the spherically doubly magic nuclei
- Possible centers (114,184); (120,172); (126,184) depending on model
- How would we tell in the theory?



http://en.wikipedia.org/wiki/File:Island-of-Stability.png

Creation of $^{270}Hs_{162}$

- Why do we care?
  - ^{270}Hs is doubly magic deformed nucleus
  - It is element of "peninsula/island" or "swamp"
  - Testing the many different models

Tool for calculating T_α

- Rate $\Gamma = (\omega_o/2\pi)*\xi*\exp(-2\sigma)$
  - $\sigma = {}_R\int^b dr(2m(V(R)-E_\alpha))^{1/2}$
  - $\omega_o/2\pi$ is classical frequency
  - $\xi \sim 1$ (found using WKB and other methods)
- So if we measure E_α we can find half-life

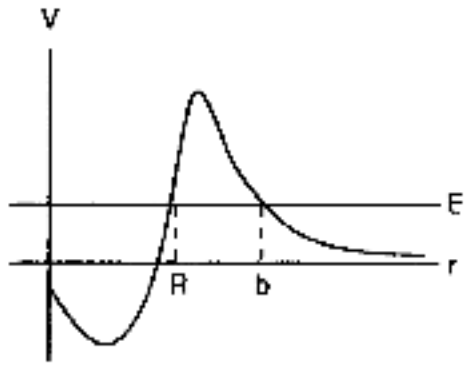


Fig. 1. Generic shape for s-wave alpha decay potential.

The experiment (GSI 2006)

- $^{26}Mg^{5+}$ beam
- Intensity .8 particles/μA
- Beam passes through Be glass, He-O_2 mixture, Be glass
- Target $^{248(246)}Cm$ 3 arc shaped pieces (one contained 2% ^{152}Gd)
- Beam energies 144-160, 135-137 MeV

Experiment Cont.

- Rapid chemical separation is done and nuclei end up in gas filled chamber 400°C
- Nuclei themalize to OsO_4 and HsO_4 (volatile)
- Pass through hot quartz wool filter
- Finally, through 8m Teflon capillary
- Separation from nonvolatile >10^6

Detectors

- 2x32 PIPS in two Invar profiles
- Active area (9.3x9.3)mm^2
- Resolution to better that 50keV

http://hasylab.desy.de/e70/e207/e674/e17333/e10638/e10654/e20366/PIPS_front_eng.jpg

The observed chains

No.	E_{beam}	E_1	E_2	Δt_2	E_3	Δt_3	E_4	Δt_4	Assignment
1	145	8.93 (16T)	8.69 (16B)	32.5 s	8.29 (16T)	32.1 s	8.29 (17B)	2.50 s	^{269}Hs
2	145	9.06 (13B)	8.68 (14T)	85.6 s	93 (14T)	4.44 s			^{269}Hs
3	145	9.11 (1B)	8.68 (1B)	2.48 s	67/13 (1T/1B)	7.09 s			^{269}Hs
4	145	8.91 (15B)	8.65 (15B)	6.75 s	29 (15T)	6.69 s			^{269}Hs
5	145	9.03 (18T)	8.60 (18T)	7.70 s	111/26 (18T/19B)	6.42 s			^{269}Hs
6	145	8.92 (19B)	8.72 (19T)	6.82 s	90/101 (19T/19B)	1.29 s			^{269}Hs
7	145	8.35 (22B)	38 (22B)	116 ms					no assignment
8	145	8.85 (14T)	100/74 (14T/13B)	1.62 s					^{270}Hs
9	136	9.08 (15B)	8.71 (15T)	8.70 s	100/74 (15T/16B)	580 ms			^{269}Hs
10	136	9.10 (14T)	80/90 (14T/13B)	96.0 s					^{269}Hs[a]
11	136	8.90 (12T)	89/55 (12T/11B)	49.6 ms					^{270}Hs
12	136	8.92 (5T)	106/82 (5T/5B)	449 ms					^{270}Hs
13	136	8.88 (19T)	96/110 (19T/19B)	444 ms					^{270}Hs
14	136	9.30 (7T)	8.20 (7T)	149 s	89/95 (7T/7B)	12.0 s			^{271}Hs[a]
15	136	8.67 (9T)	117/102 (9T/9B)	306 ms					no assignment

[a]Tentative assignment.

J.Dvorak et. al. Phys. Rev. Lett. 97, 242501

Final conclusions from experiment

Z	A	Decay mode	Half-life	E_α [MeV]
108	269	α		9.07 ± 0.03
				8.92 ± 0.03
	270	α	22 s[a]	8.89 ± 0.03
106	265	α	$14.9^{+9.1}_{-4.1}$ s	8.68 ± 0.04
	266	SF	444^{+444}_{-148} ms	

[a]Half-life calculated using a phenomenological formula [35] based on the Q_α value deduced from our experimental data.

J.Dvorak et. al. Phys. Rev. Lett. 97, 242501

Conclusions

- Nuclei have been made up through 118 (2002)
- Some isotopes of 114 have been observed but not up to 184 neutrons
- The island of stability is still out there, but where is still unclear

Works cited

- J.Dvorak et. al. Phys. Rev. Lett. 97, 242501
- N. Bohr, J. Wheeler The Mechanism of Nuclear Fission Phys. Rev. 56, 426
- Armbruster Act. Phys. Polo. B Vol. 34, 1825
- **Holstein**, Barry R. Publication: American Journal of Physics, Volume 64, Issue 8, pp. 1061-1071 (1996)
- K. Rutz et. Al Phys. Rev. C 56, 238.