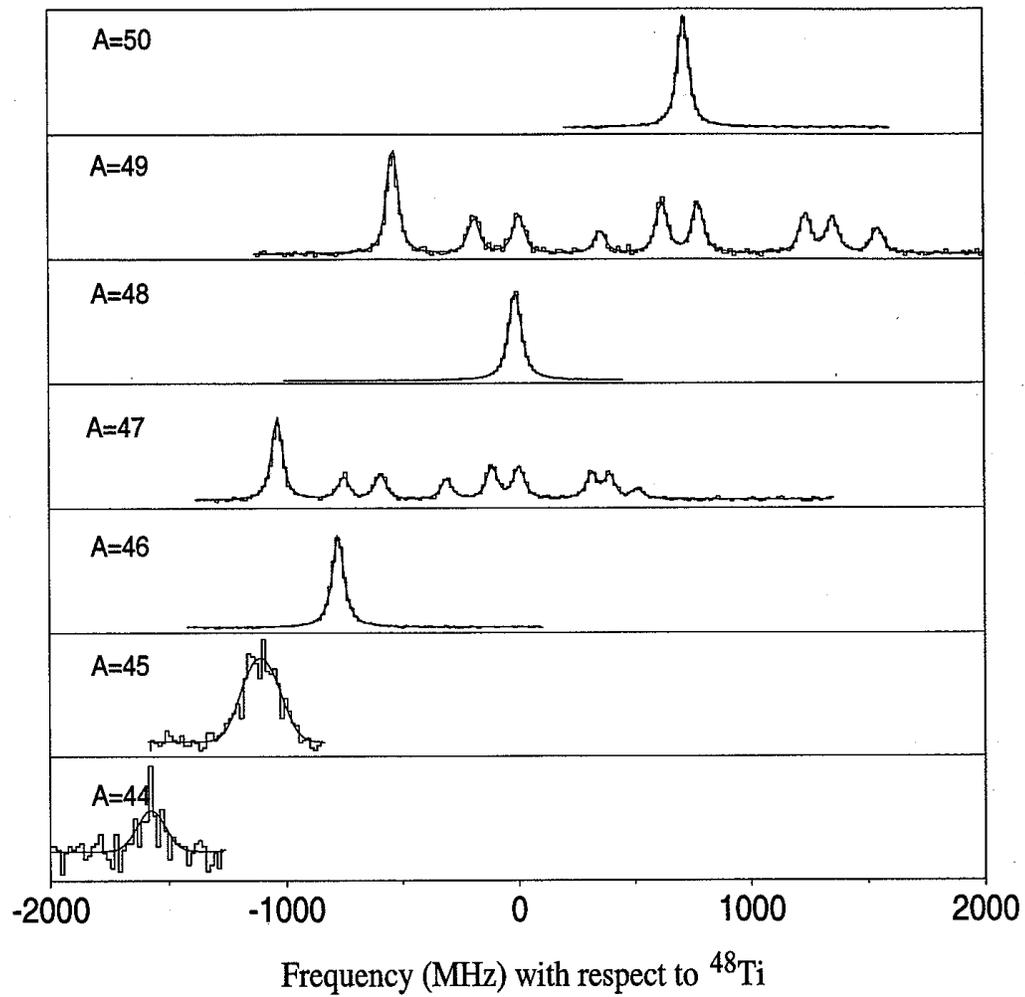


Laser spectroscopy at TITAN

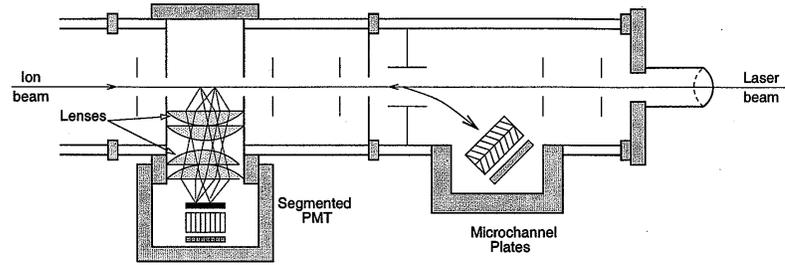
Matthew Pearson

June 11th 2005

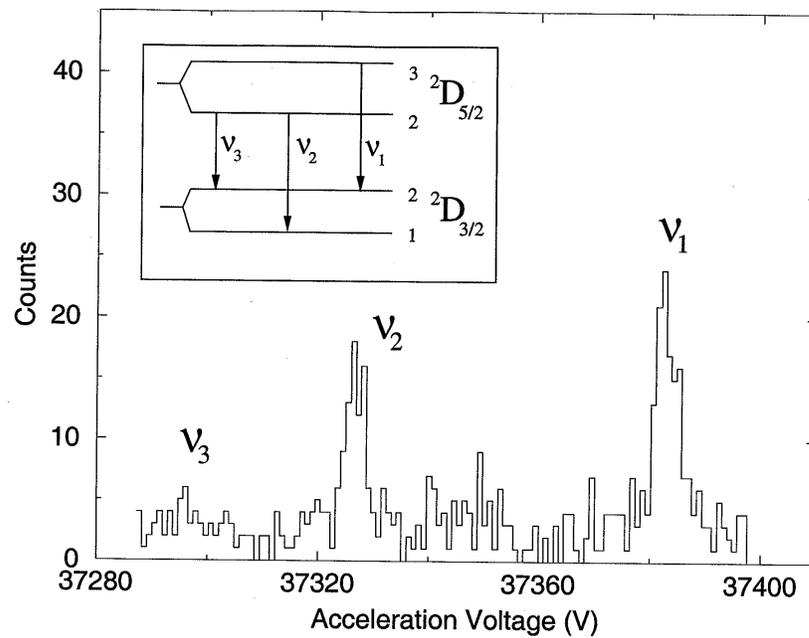
And the data is *moderately* simple to analyse



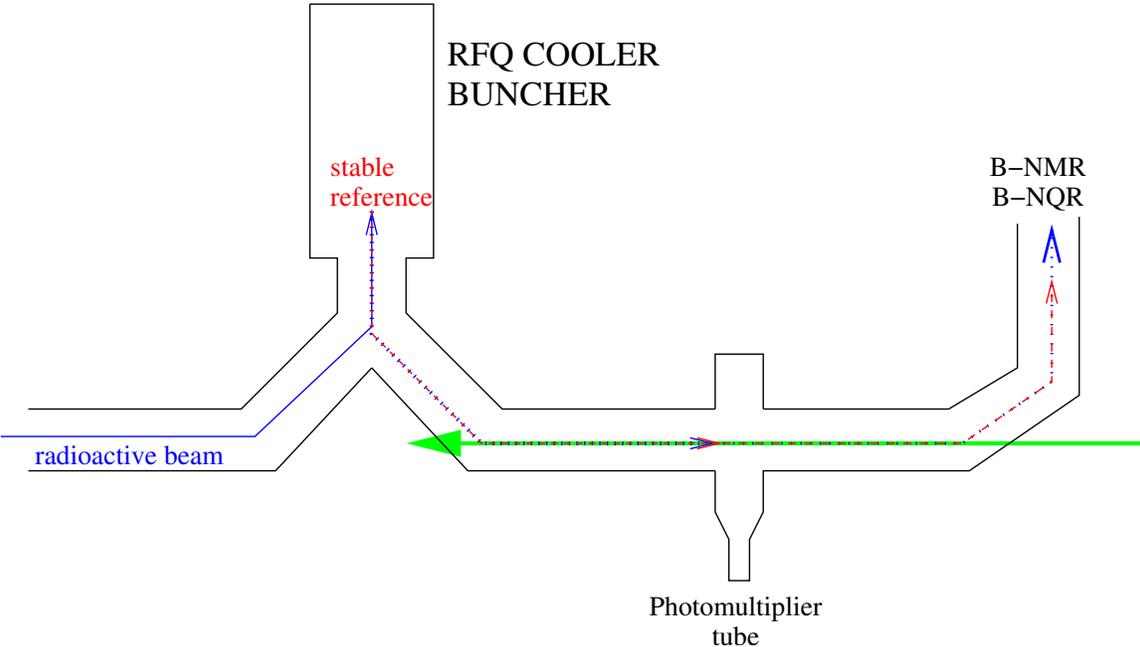
data taken in Jyväskylä by the Manchester group



Increase sensitivity by looking for the ion/atom that emitted the photon



cool and bunch using TITAN cooler and buncher

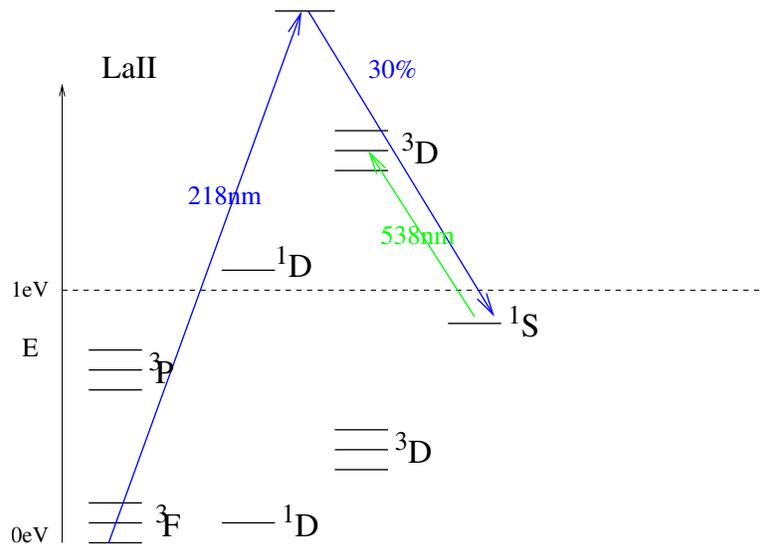
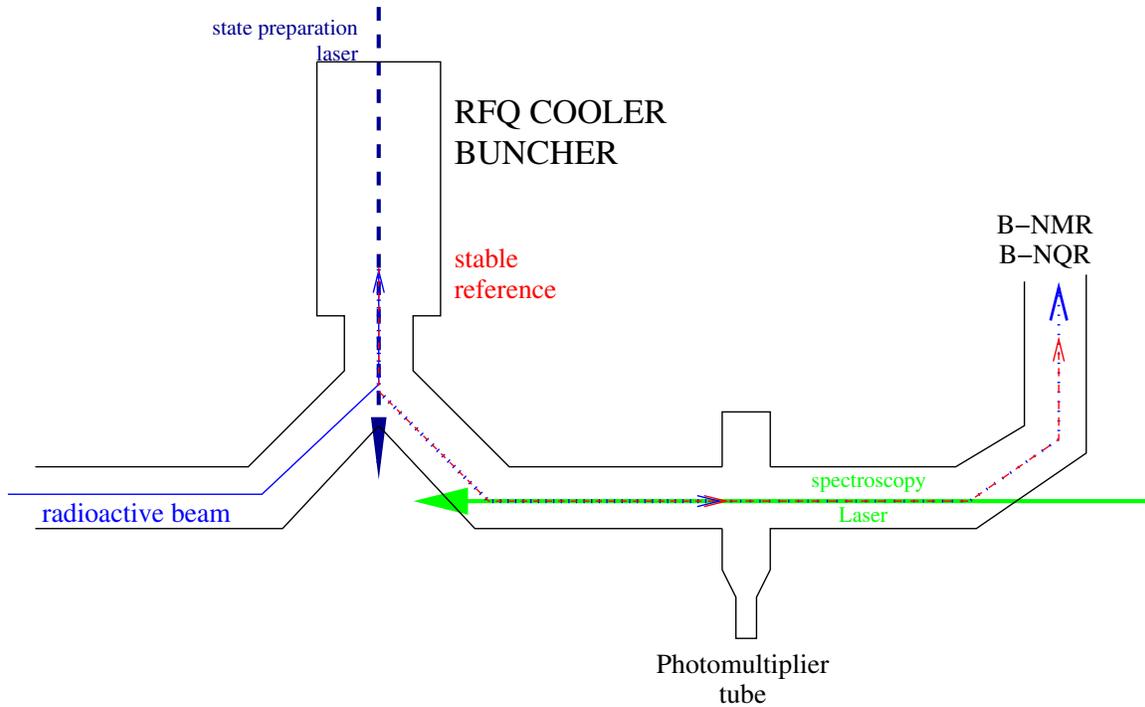


example Aluminium

	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
Si	Si22 6ms 0+	Si23	Si24 102ms 0+	Si25 230ms 52+	Si26 2.23s 0+	Si27 4.16s 52+	Si28	Si29	Si30	Si31 1573ms 32+	Si32 172y 0+	Si33 618s	Si34 277s 0+	Si35 678s	Si36 0.46s 0+				
Al	Al21	Al22 70ms	Al23 0.47s	Al24 2.63s 0+	Al25 7.83s 52+	Al26 7.62e-5s 5+	Al27	Al28 2.314ms 3+	Al29 6.56ms 52+	Al30 360s 5+	Al31 644ms 3+	Al32 33ms 1+	Al33	Al34 60ms	Al35 150ms	Al36	Al37	Al38	Al39
Mg	Mg20 98ms 0+	Mg21 122ms 0+	Mg22 387y	Mg23 11.317s 32+	Mg24	Mg25	Mg26	Mg27 9.48ms 12+	Mg28 2691h	Mg29 1.30s 32+	Mg30 358ms 0+	Mg31 230ms	Mg32 130ms 0+	Mg33 90ms	Mg34 30ms 0+	Mg35	Mg36 0+	Mg37	
Na	Na18	Na19	Na20 479ms 2+	Na21 22.9s 32+	Na22 2.609y 3+	Na23	Na24 14990h 4+	Na25 91s 52+	Na26 1.07s 3+	Na27 301ms 32+	Na28 368ms 1+	Na29 440ms 32	Na30 48ms 2+	Na31 172ms 32+	Na32 132ms (6-6)	Na33 82ms	Na34 5.5ms	Na35 1.6ms	
Ne	Ne16	Ne17	Ne18	Ne19	Ne20	Ne21	Ne22	Ne23	Ne24	Ne25	Ne26	Ne27	Ne28	Ne29	Ne30	Ne31	Ne32		

- isotopic chain runs from drip line to drip line
- Na extensively studied at ISOLDE, Mg under investigation
- N=20 neutron magic number known to not be good far from stability

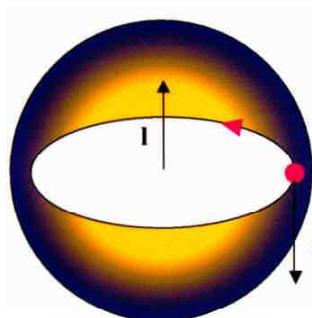
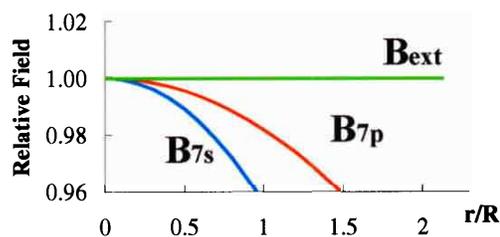
Other possibilities with the RFQ cooler and buncher.



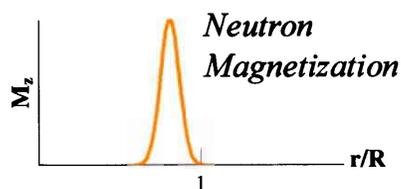
The Hyperfine Anomaly in $^{208-212}\text{Fr}$

The magnetic hyperfine structure arises from the interaction of nuclear magnetic moment and the magnetic field of electrons at the nucleus.

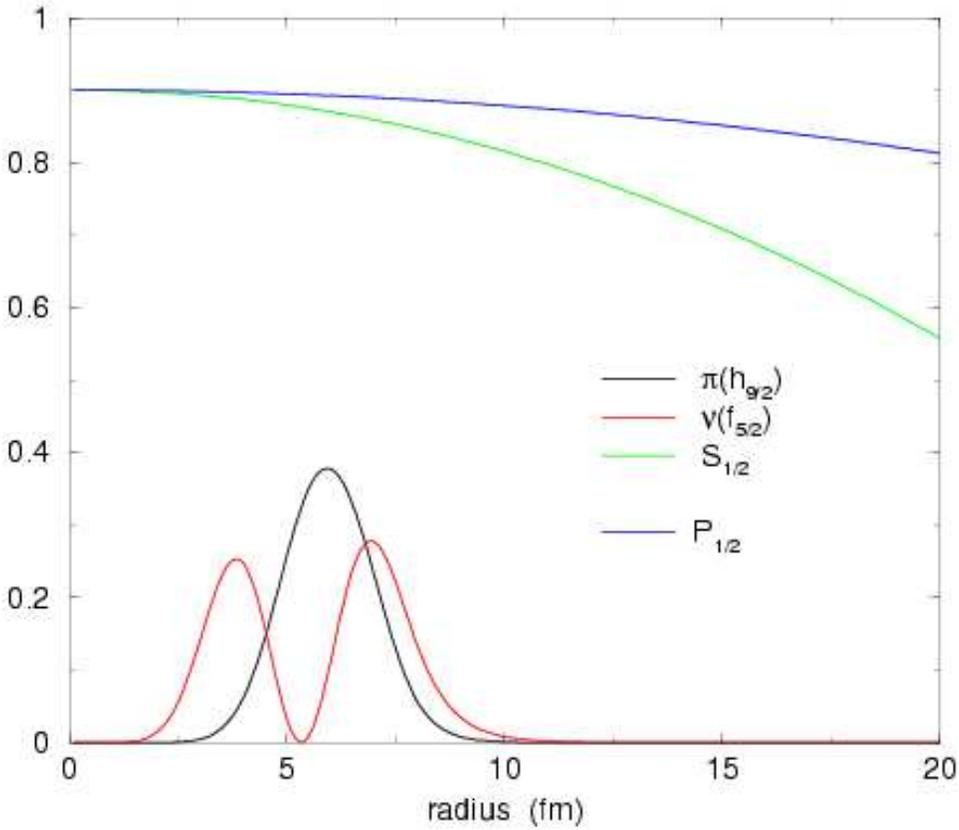
- A depends upon $\mathbf{B}(\mathbf{r}) \cdot \boldsymbol{\mu}_I$.
- $7s$ and $7p$ states have different radial wavefunctions, and thus sample the nuclear magnetic distribution differently. (hyperfine anomaly)
- Is A_{7s} / A_{7p} isotope dependent?



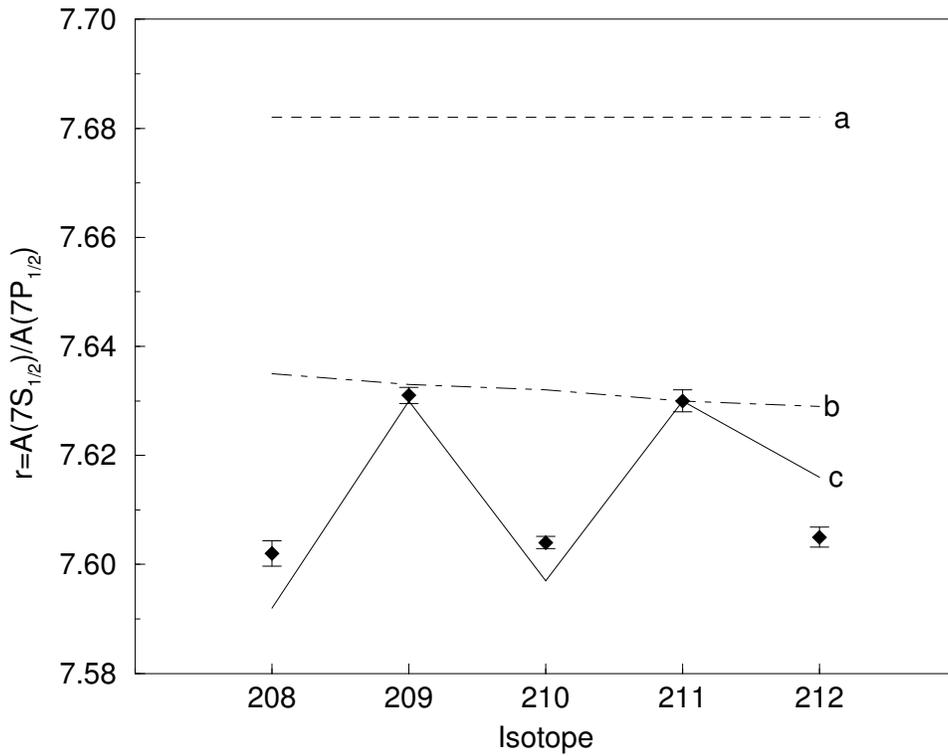
Unpaired
Neutron $2f_{5/2}$



Change in electron wave-functions across the nucleus



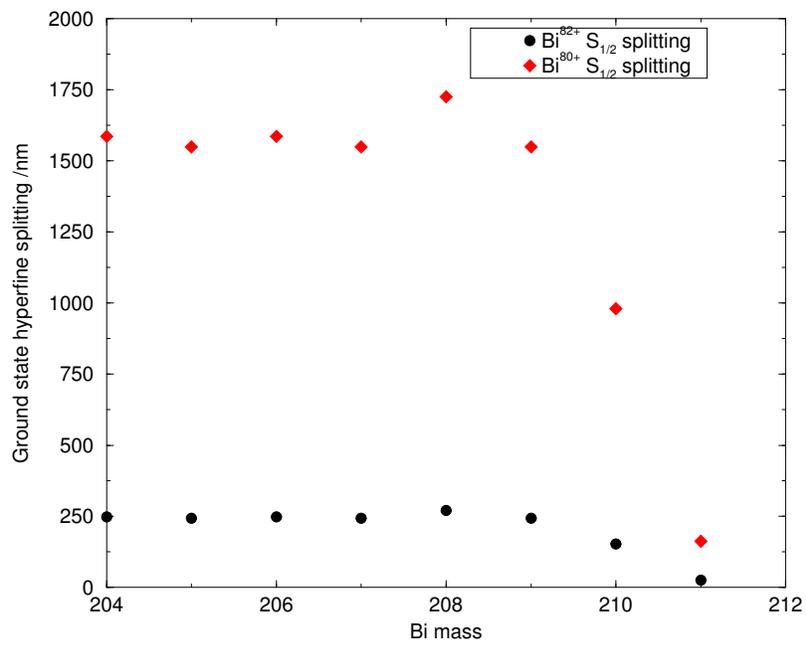
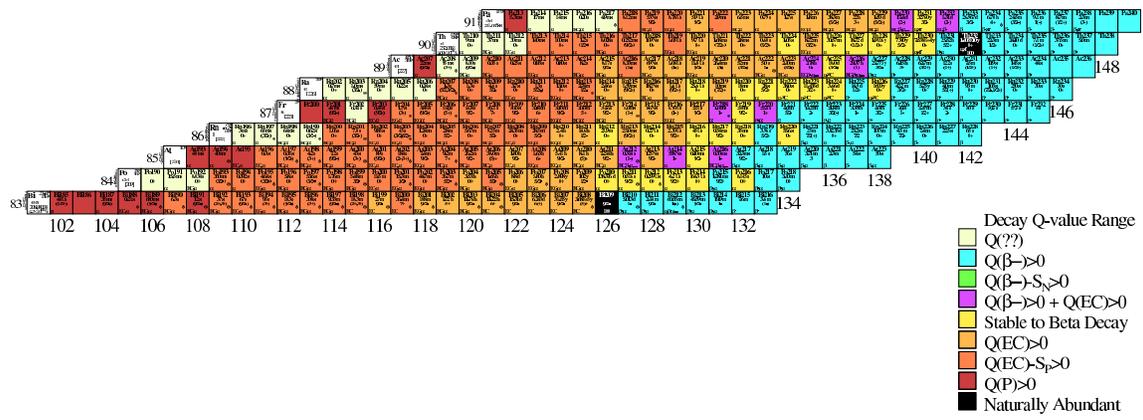
Results



Approved experiment E1010 to extend these measurements well into the next neutron shell

Using the ebit any element can be made to have an alkali like atomic structure

- H-like $1s$
- Li-like $1s^2 2s$
- Na-like $1s^2 2s^2 2p^6 3s$
- K-like $1s^2 2s^2 2p^6 3s^2 3p^6 4s$
- Cu-like $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s$
- Pm-like $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s$



Hyperfine structure of highly charged ions

for hydrogen like ions

$$\Delta E_{s_{1/2}} = \frac{4\alpha^4 Z^3}{3} \frac{\mu_I m_e}{\mu_N m_p} \frac{2I+1}{2I} \frac{mc^2}{\left(1 + \frac{m_e}{M}\right)^3} \\ \times [A\alpha Z(1 - \delta)(1 - \epsilon) + \kappa_{rad}]$$

for Li like ions

$$\Delta E_{s_{1/2}} = \frac{1}{6} \alpha (\alpha Z)^3 \frac{m_e \mu_I}{m_p \mu_N} \frac{2I+1}{2I} \frac{mc^2}{\left(1 + \frac{m_e}{M}\right)^3} \\ \times \left[A\alpha Z + \frac{1}{Z} B\alpha Z + \frac{1}{Z^2} R(z, \alpha Z) \right] \\ \times [(1 - \delta)(1 - \epsilon)(1 + \kappa_{rad})]$$