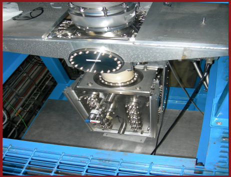
Laser spectroscopy at TRIUMF

TITAN collaboration meeting 2010

Matthew Pearson

May 26, 2010



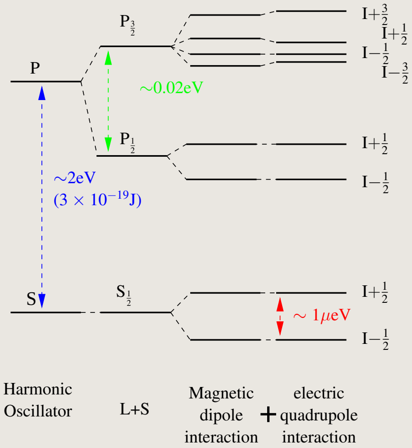
Outline

Overview
- Hyperfine interactions
- Isotope shifts

Measurements – planned and in progress
- Nuclear charge radii
- Nuclear Moments
- Nucleon distributions

Conclusion

Nuclear physics from atomic measurements



$$\Delta E_{hfs} = A\frac{K}{2} + B\frac{\frac{3}{2}K(K+1) - 2I(I+1)J(J+1)}{4I(2I-1)J(2J-1)}$$

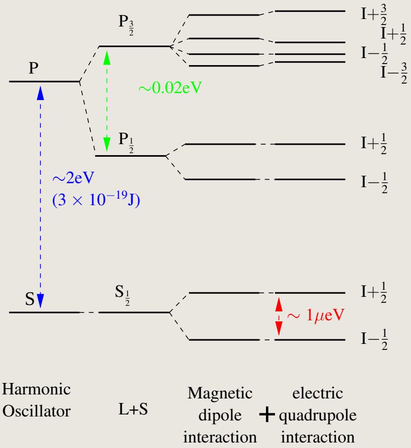
$$K = F(F+1) - J(J+1) - I(I+1)$$

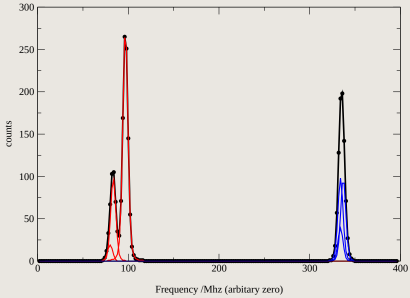
$$A = \mu_N g_I \frac{B_{el}}{J} \qquad B = eQ_s\langle \frac{\delta^2 V}{\delta z^2}\rangle$$

A photon has angular momentum 1 therefore can induce transitions

$\Delta F = 0, \pm 1$ (NOT $0 \rightarrow 0$)

Nuclear physics from atomic measurements





Atomic isotope shifts

Change in the energy of a transition due to a change in the nuclear mass

$$\delta\nu^{A,A'} = \delta\nu_{mass}^{A,A'} + F_i(Z)\delta\langle r^2\rangle^{A,A'}$$

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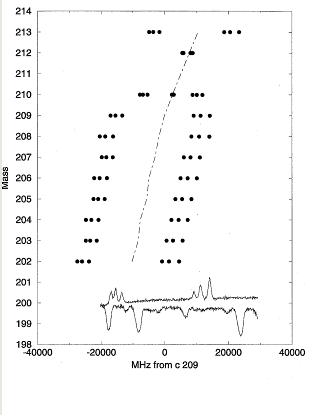
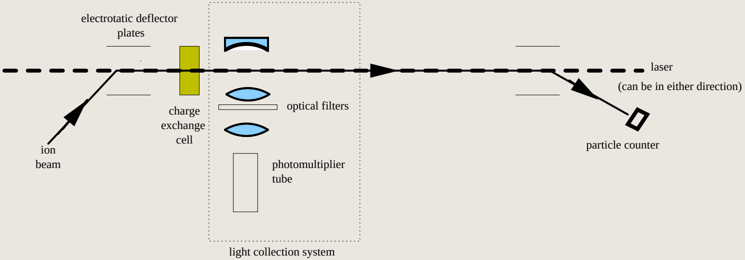
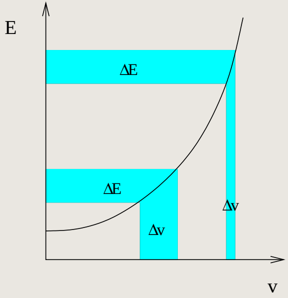
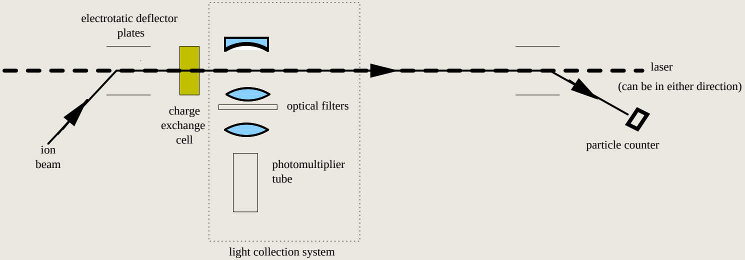


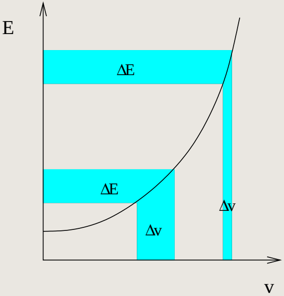
Atomic spectroscopy at TRIUMF

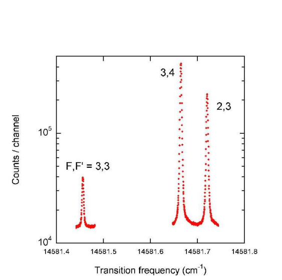




Atomic spectroscopy at TRIUMF







^{74}Rb charge radius

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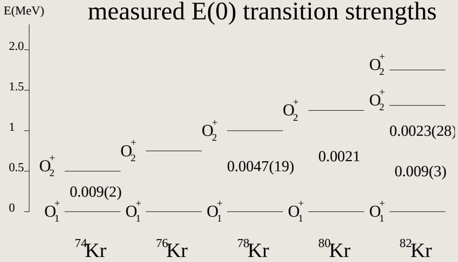
measured E(0) transition strengths

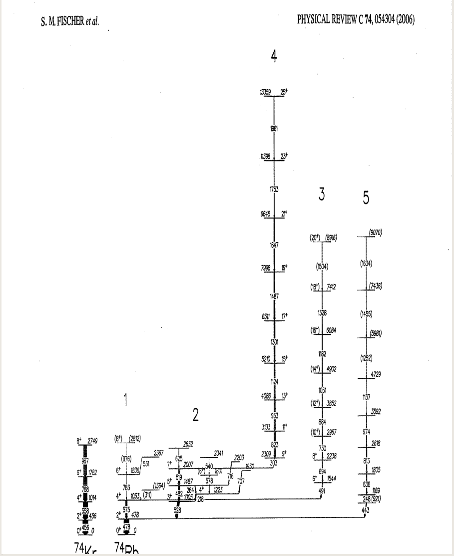


Data taken from J.L.Wood et.al. Nuclear Physics A 651 pp323−368 (1999)
and references there−in

TRIUMF

^{74}Rb charge radius

- N=Z nucleus
- Superallowed β–emitter
- ^{74}Rb is the isobaric analogue of ^{74}Kr
- Co-existence of two 0^+ configurations is known in the region
- In-beam γ-ray spectroscopy has revealed many analog states but no excited 0^+



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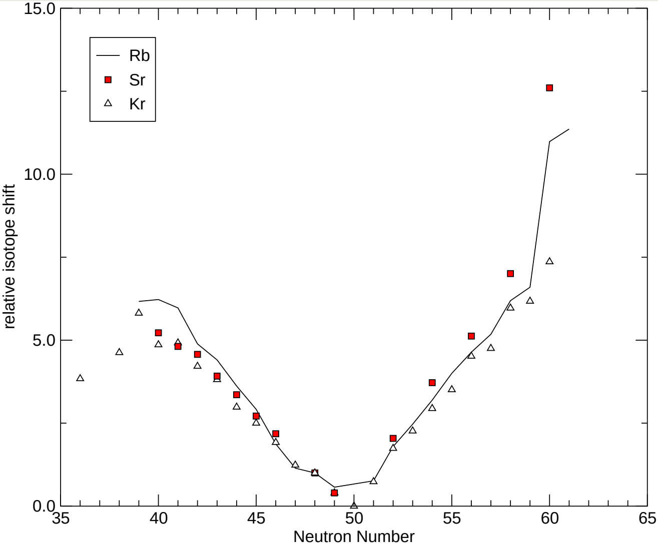

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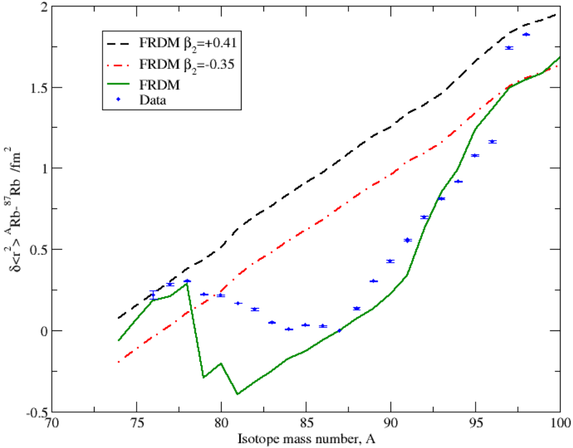
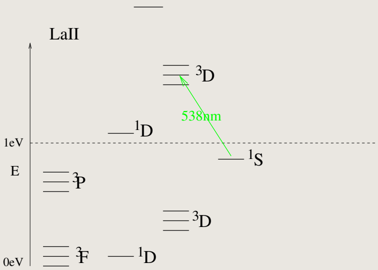


Nuclear moments



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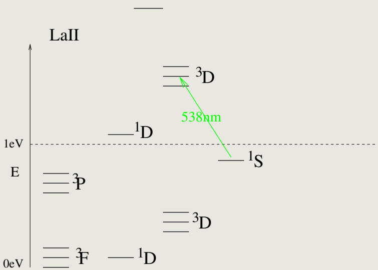

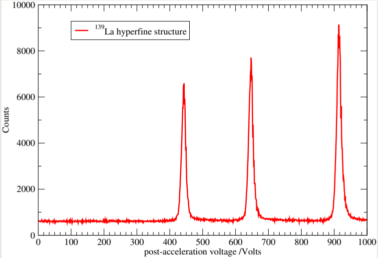

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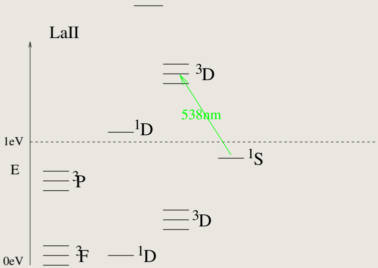

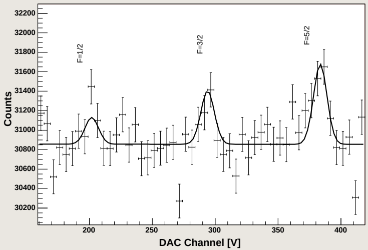

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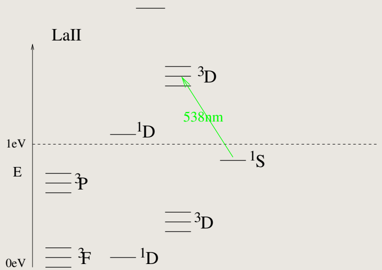
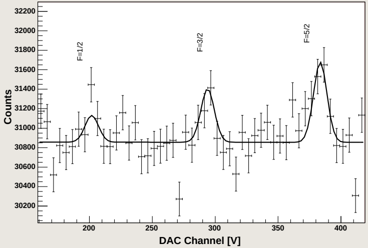
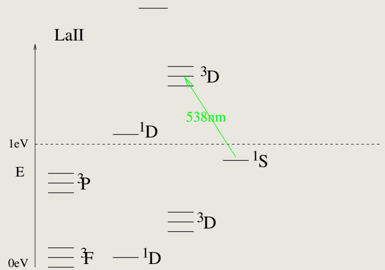
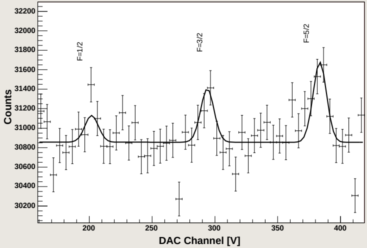


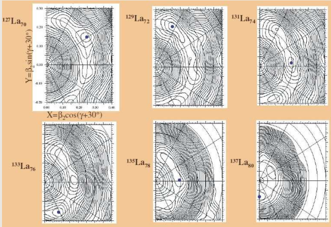


Nuclide	spin	μ/μ_N	Q/eb
^{139}La	$\frac{7}{2}^+$	+2.7830455(9)	+0.20(1)
^{137}La	$\frac{7}{2}^+$	+2.700(15)	+0.21(3)
^{135}La	$\frac{5}{2}^+$	+3.70(9)	-0.4(4)
^{131}La	$\frac{3}{2}^+$	+0.589(20)	-0.62(15)

Nuclear moments







Total routhian surfaces for the lanthanum (Z=57) isotopes at ω=0

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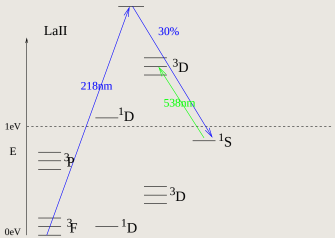
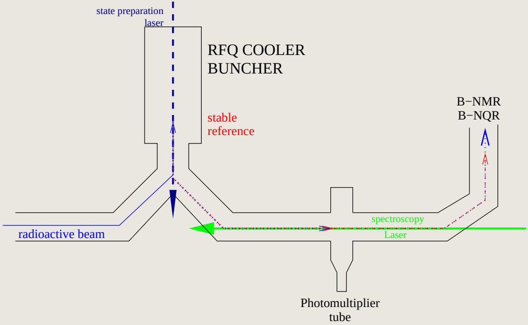
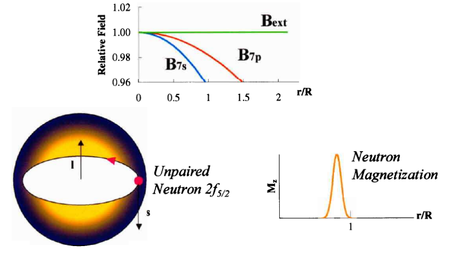




Nuclear magnetisation distribution



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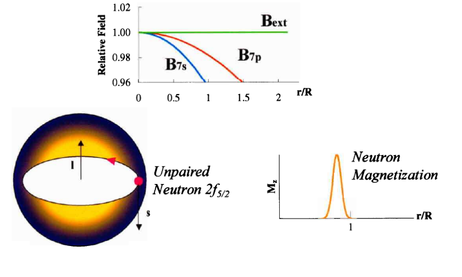
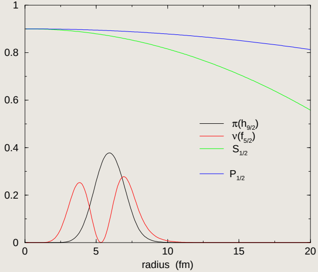
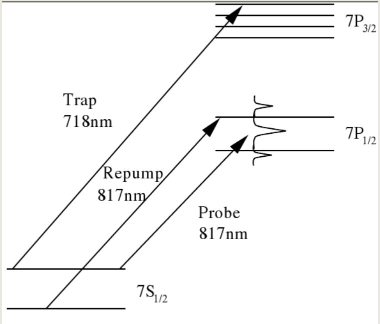




Bohr Weisskopf effect

$$A = A_{pt}(1+\epsilon)$$

$$\frac{A}{A'} = \frac{A_{pt}(1+\epsilon)}{A'_{pt}(1+\epsilon')} \approx \frac{A_{pt}}{A'_{pt}}(1+\epsilon-\epsilon') = \frac{A_{pt}}{A'_{pt}}(1+\Delta)$$



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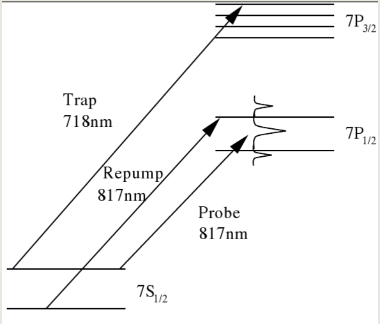

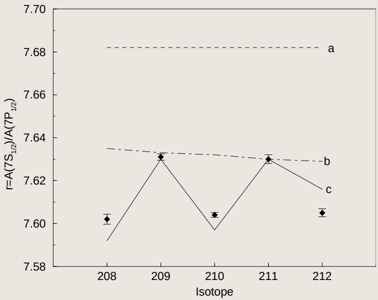

Conclusion

- Laser spectroscopy can probe many different nuclear properties
- RFQ cooler-buncher enhances the sensitivity of traditional collinear spectroscopy (see next talk)
- RFQ allows atomic state preparation to enhance signal

Collaborators

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TRIUMF

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William & Mary

Universidad Autónoma de San Luis Potosí

Texas A&M University