TRIμP - A new facility to produce and trap radioactive isotopes

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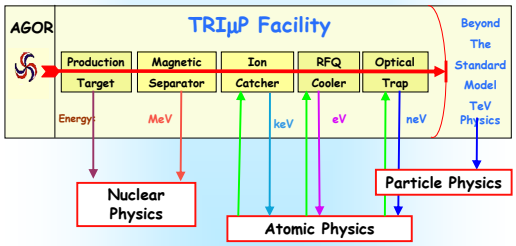
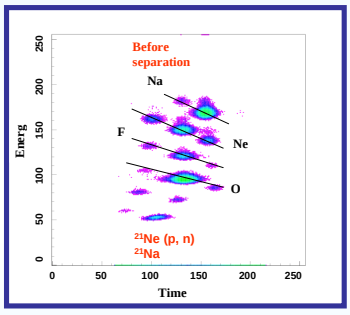
Trapped Radioactive Isotopes: μicro - Laboratories for Fundamental Physics

TRIμP

Discrete symmetries in nature offer sensitive tests of the Standard Model. Example experiments are β-ν correlations in β decay of ^{21}Na and ^{19}Ne isotopes as well as searches for permanent Electric Dipole Moments (EDM) in Radium atoms. Main goal is investigation of possible symmetry violations which are prediction in various extension to the Standard Model.



The dual magnetic separator at the TRIμP facility is in operation since mid 2004. It has various operation modes from fragmentation to gas filled mode. Secondary beam can be obtained with a high degree of purity.

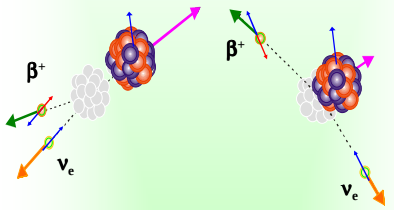


β-decay

In Standard Model: Weak Interaction is V-A

In general β-decay could happen via S , P or T

Vector (F) [Tensor] Scalar [Axial vector (GT)]



$$\frac{d^2W}{d\Omega_e d\Omega_\nu} \approx 1 + a\frac{p.q}{E} + b\Gamma\frac{m_e}{E} + \langle J\rangle.\left[A\frac{p}{E} + Bq + D\frac{p\times q}{E}\right] + \langle\sigma\rangle.\left[G\frac{p}{E} + Q\langle J\rangle + R\langle J\rangle\times\frac{p}{E}\right]$$

- *R* and *D* test both Time Reversal Violation
- *R* → scalar and tensor (*a* and EDM)
- *D* measurements gives *a, A, b, B*
- First step with *a*

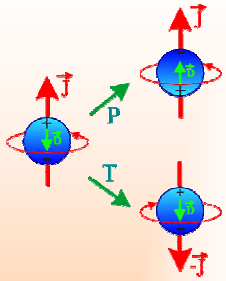
Limit D ≠ 0 ⇔ New Physics

Advantages of ^{21}Na

- ❑ Trapping of Na is well established
- ❑ Short lifetime ($T_{1/2} \approx 22.48$ s)
- ❑ Mixed F and GT transition : sensitivity to TRV

Electric Dipole Moment (EDM)

EDM violates Parity and Time Reversal

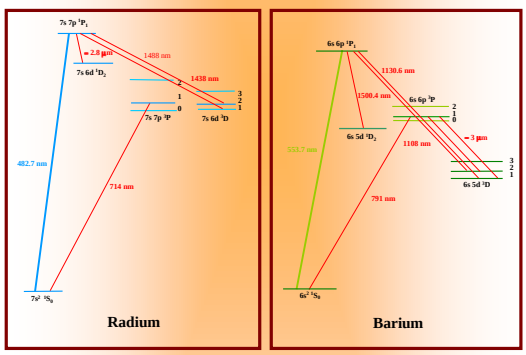


$$H = -(\vec{d}\vec{E} + \vec{\mu}\vec{B})\cdot\frac{\vec{J}}{J}$$

Permanent EDM ≠ 0 ⇔ New Physics

Why Radium is a promising candidate ?

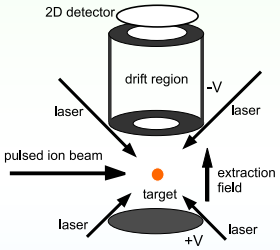
- ❑ Degenerate P & D states of opposite parity enhances EDM signal
- ❑ Some isotopes have octupole deformation
- ❑ Several 10000 enhancement is possible



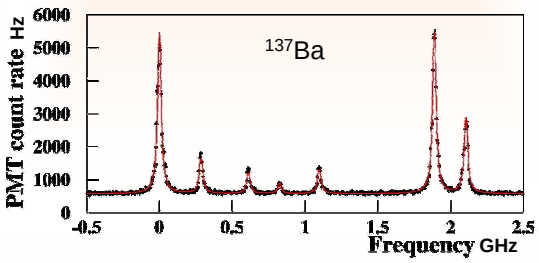
Trapping of Barium (Ba)

- ❑ Spectroscopy of Ba to pilot Ra spectroscopy
- ❑ Extend cooling and trapping to heavy alkaline earth element

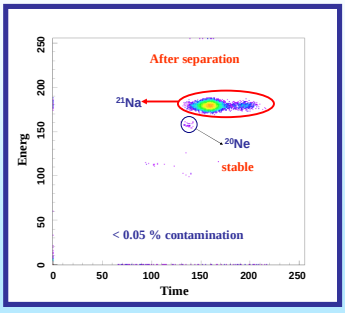
Recoil Ion Momentum Spectroscopy in a Magneto Optical Trap (MOT)



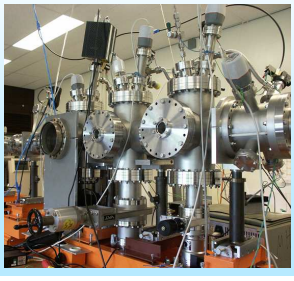
Measuring $^3D_1 \rightarrow {}^1P_1$ transition gives hyperfine splitting of P and D states in ^{137}Ba.



^{21}Na Production as a high purity secondary beam has been used to measure beta decay branching ratio.



RFQ and low energy beam line



RFQ

A segmented Radio Frequency Quadropole cooler, confines and bunches the secondary beam. (being commissioned)