RFμSR experiments using NMR style pulse sequences

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Radiofrequency methods in μSR

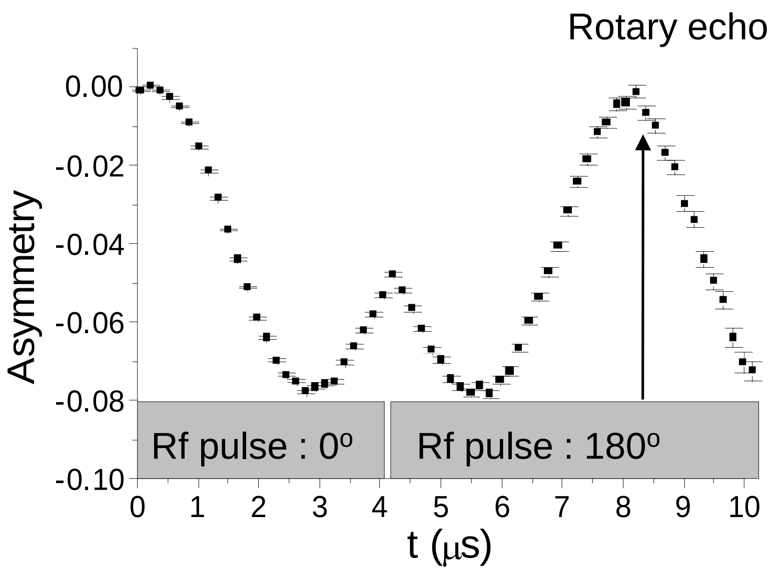
- Pulsed rf fields not required in μSR, unlike NMR and ESR
  - Indirect detection of muon spin polarisation through emitted positron asymmetry
  - Little examination of the scope for pulse rf techniques
  - Mismatch between pulse rf and continuous muon beams
  - Lifetime of the muon of the order of rf pulse lengths

- Rf methods introduced at ISIS in 1990's
  - Delayed muonium formation: μ 90^{o} pulse
  - ^{1}H, ^{19}F decoupling: > 30 μs nuclear spin pulse irradiation

Multiple pulse radiofrequency methods

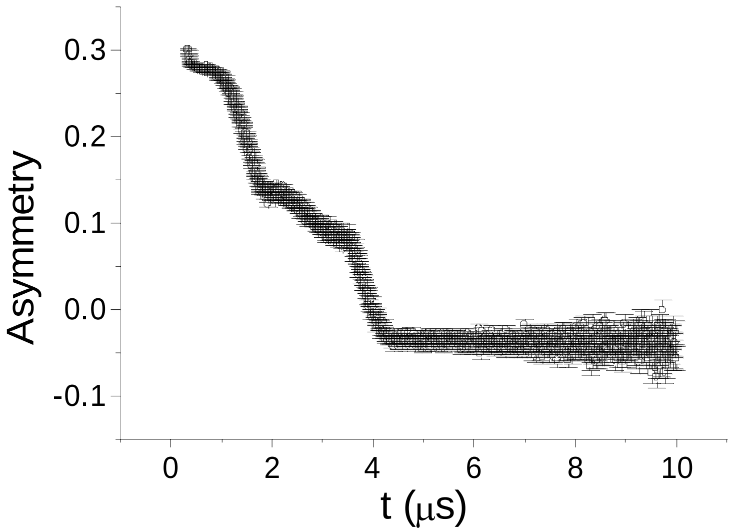
- Homonuclear NMR type pulse sequences
  - Rotary echo
  - 90º – t – 180º spin echo
  - Composite pulses
- Combined μSR-NMR pulse sequences
  - Equivalent to heteronuclear NMR
  - Destruction of muon spin polarisation by coherence transfer
  - Mutual exchange of polarisation at mK temperatures
  - Limited by need for NMR observation on a muon beam line
    - Scope for in-situ NMR and μSR experiments

Muon rotary echo in $CaCO_3$



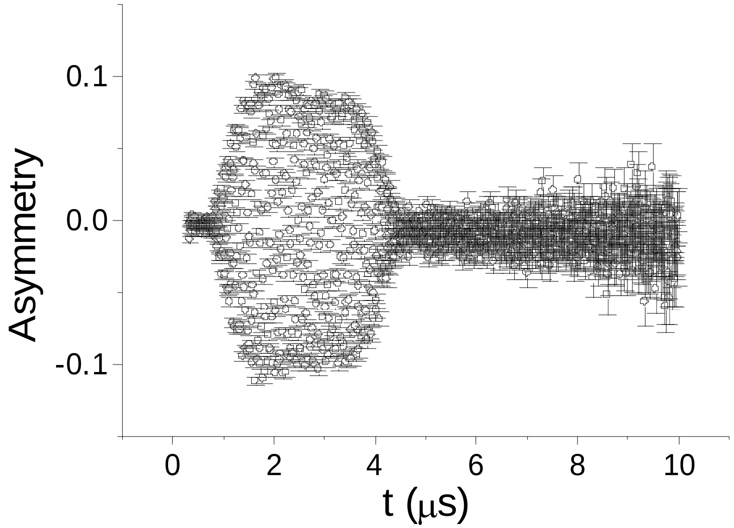
- Rf nutation during rf pulse of phase 0º
- Rf inhomogeneity causes rapid damping
- Switch rf phase brings about essentially complete refocussing in a rotary echo
- Unlike NMR can monitor spin polarisation during pulse

Muon composite pulse in $CaCO_3$:Longitudinal



- Rf inhomogeneity causes imperfect inversion with simple 180^o pulse
- Overcome using composite pulse $90^o{}_x180^o{}_y90^o{}_x$
- Z component shows more complete inversion
- Can see each the operation of each component of the composite pulse

Muon composite pulse in $CaCO_3$: Transverse



- Maximum after $90^o{}_x$ element of the composite pulse
- Rotation of transverse components about y - axis with $180^o{}_y$
- Continued inversion by $90^o{}_x$ leading to a small residual transverse component

Future plans

- Commission NMR on the muon beam line
- Detail rf behaviour of coils used in muon experiments through NMR response
- Combined μSR-NMR through coherence transfer

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