Polarised Neutrons from ^{3}He

S. Boag, S.R. Parnell, C.D. Frost, R.S. Eccleston, D.M. Bebb and P. Phillips

The University of Nottingham

^{3}He Neutron Spin Filters

Advantages

- Simple transmission filter
- Not strongly wavelength dependent
- ^{3}He Spins easily manipulated

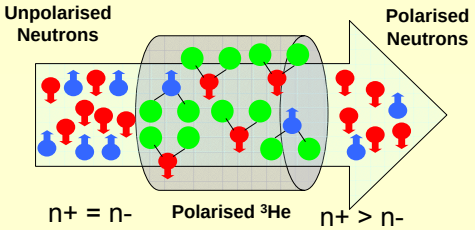
Disadvantages

- Depolarisation with time
- Sensitive to magnetic field homogeneities
- Loss in transmission

Critical For Time of Flight

Two particular properties of NSF's critical to TOF instruments are that they cover large detector angles and polarise a broadband energy range of neutrons.

Use ^{3}He Spin dependant absorption cross-section

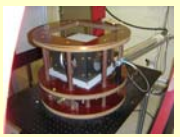


Methods of Production

Metastability exchange

- P^{3}He~80%
- Polarisation time quick
- Low pressure for optical pumping
- Requires compressor for cell filling

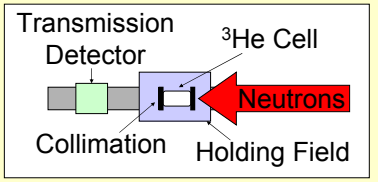
Spin exchange



- P^{3}He~70%
- High Pressure Cells
- Pressure Fixed
- Polarisation time up to a day
- Online Pumping

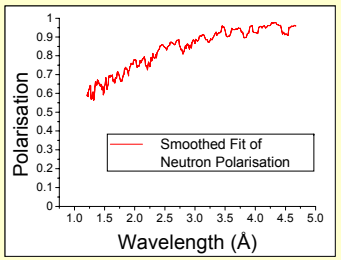
^{3}He Neutron Transmission Tests

- Determine P_{He}
- Monitor with time to find T_1
- Determine ^{3}He pressure

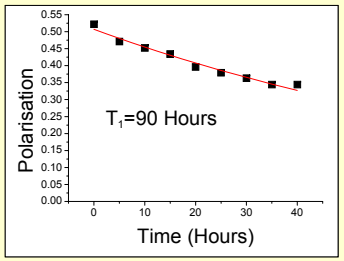


$$P_n(\lambda) = \left(1 - \frac{T_0^2(\lambda)}{T_n^2(\lambda)}\right)^{1/2} = \tanh\left(P_{He} n \sigma_0 \lambda l\right)$$

$$T_0(\lambda) = T_E \exp\left[-n\sigma_0 \lambda l\right]$$

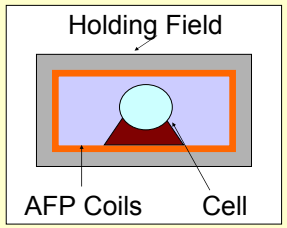


Neutron transmission experiments have taken place on the modified ROTAX beamline. With a series of 30 minute runs we were able to determine an initial ^{3}He polarisation of ≈ 65 – 70% and a ^{3}He pressure of 2 bars in the cell Rb 18 "Billy." By analysing the polarisation decay over time we calculated a ^{3}He relaxation time (T1) of 90 hours in the ILL "Magic box." All values were produced using the "Poltax" fitting software.

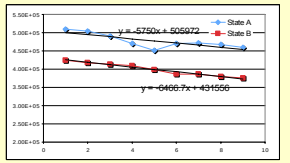


Future Developments

AFP ^{3}He "Fliperizer"



- Reverse ^{3}He Spin direction using AFP
- Acts as both spin flipper and polarizer



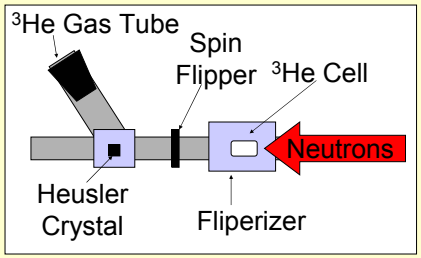
- Tests with lab kit show ≈1.5% destruction per flip
- Need more power!!

Flipper Test Station

- Single λ
- Use flipping Ratio to find P_n:

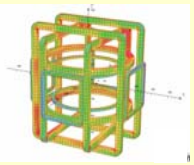
$$P_n = \frac{(n_+ - n_-)}{(n_+ + n_-)}$$

- Calculate Flipper Efficiency



^{3}He Neutron Spin Filters at TS2

With large detector angles and a broad wavelength band TS2 instruments will benefit from polarisation analysis. ^{3}He NSF's could provide a viable solution for these instruments and are planned for some Day One instruments. One particular technique in development is X Y Z neutron polarisation analysis for Time of Flight Instruments, based on the PASTIS concept from the ILL. This will utilise a large angle ^{3}He analyser cell.



CCLRC

ISIS