Neutron Spin Filter Cells

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Cell Production

Requirements:

- •High ^{3}He polarisation
- •Long on-beam polarisation lifetime
- •Suitable dimensions for neutron scattering experiments
- •Optical pumping technologies

Results:

- •60% + Polarisation
- •T_1 100 + hours – with orientational dependence
- •Pressure 2 bars +
- •New Alkali metal Species
- •Xenon cells

Cell No.	Cell Name	Diameter (mm)	Length (mm)	Pressure (bar)	T_1 Norm (hours)	T_1 Rev (hours)
Rb 08	Llewellyn	50	50	0.8	124	65
Rb 09	Sammy	50	50	0.8	96	56
Rb 13	Cyril	50	50	0.8	6	13
Rb 14	Bob	50	50	0.8	20	100
Rb 16	Bertha	90	60	2.5	12	40
Rb18	Billy	50	50	2	50	119
Rb 23	Buttercup	60	100	1.6	9	50
K1 [1]	K1	50	50	0.8	7	35
Xe 1 [2]	Pinky	36	50	2.5	TBA	TBA
Xe 2 [2]	Perky	36	50	0.8	TBA	TBA
Xe 3 [2]	Lennon	36	50	2.8	TBA	TBA

1 – K-^{3}He Cell   2 – Rb-^{129}Xe Cells

The cell preparation procedure is performed entirely with the cell under vacuum in order to reduce the risk of contamination. Once the cell is attached to the vacuum system it is baked out for a few days to drive off contaminants, the rubidium ampoule is then broken open in the sealed system using a metal slug before being distilled into the cell. After filling the cell is then pulled off from the stem using a glass blowing torch.

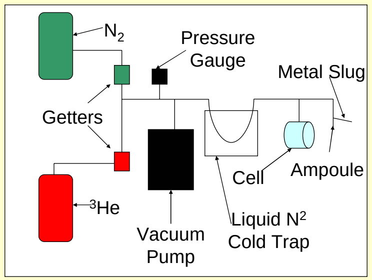

Figure 1: Cell Preparation Rig at ISIS

Orientational Dependence

Many of our cells exhibit an orientational dependence in their relaxation times. Each of the cells follows the same cycle, as seen in figure 2. The cells that exhibit this phenomena are all GE180 SEOP cells, but we have seen it in both Rb and K based cells.

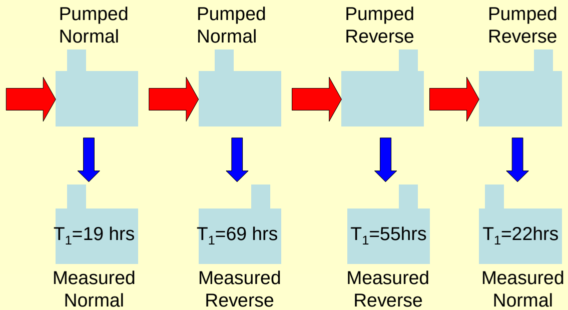

Figure 2: Typical Orientational Cycle for Rb14 "Bob/Kate"

Relaxation time is dependent on a number of factors:

$$\frac{1}{T_1} = \frac{1}{T_{field}} + \frac{1}{T_{dipolar}} + \frac{1}{T_{wall}}$$

Both field and dipolar affects are known, so the orientational dependence is likely due to be from wall relaxation. One hypothesis is that there are small ferrous areas within the cell walls. This is supported by evidence that it is possible to "perm up" and degauss cells.

40hrs → Permed Up → <2hrs → Degaussed → 25hrs

Further investigations into this effect are currently taking place. We are awaiting results on the analysis of GE180 glass, both before and after it has been made into a cell. Preliminary results have shown that spin orientation is also important. Flipping the spin orientation using AFP causes an increase in linewidth of the NMR signal. We hope to measure the T_1's before and after flipping.

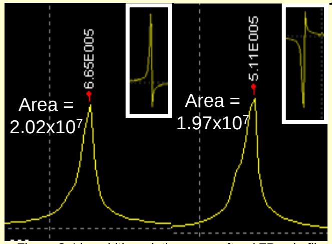

Figure 3: Linewidth variation seen after AFP spin flip

Development of Cells for Neutron Scattering

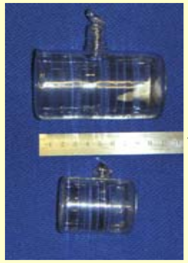

Figure 4: Cells Rb09 "Sammy" and Rb23 "Buttercup"

Polarisation Efficiency from 3He:

$$P_n(\lambda) = \tanh\left[O(\lambda)P_{He}\right]$$

Where Opacity (O) is dependant on pressure and length of the ^{3}He cell and neutron wavelength:

$$O'(\lambda) = p[bar] \times l[cm] \times \lambda[\mathring{A}]$$

To maximise neutron polarisation across all values of λ, cells will need larger pressure – length product. Future developments include the development of large high pressure "banana" cells, optimised to cover the large angle detector arrays installed on many neutron scattering instruments.

Figure 5: Banana Shaped Analyser Cell

Alternative Materials and Coatings

Although glass cells are beginning to produce high lifetimes and polarisations they are not ideal for neutron experiments. Traditionally samples for neutron experiments are contained in Aluminium cans, which are quite transparent to neutrons. However, the ^{3}He relaxation time constant of Aluminium is only a few hours.

A variety of coatings are being investigated in order to improve the lifetimes of Aluminium cells. These include ceramics, polymers, PTFE and a carbon based coating.

Figure 6: Aluminium Sample Can

CCLRC

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