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II-15 The Magnetic Moment of the 3^-, 5.83 MeV Level in ^{14}N and the Blume-Scherer Model of PAC in Gas with an Arbitrary Correlation Time

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The $^{12}C(^3He, p)^{14}N$ reaction at $E_{He} = 15$ MeV was used to populate the 3^-, 5.83 MeV $\tau = 18$ ps level of ^{14}N. The 720 keV γ rays from the ^{14}N ions recoiling at $v/c = 3\%$ into vacuum and He at gas pressures up to 600 torr were detected in coincidence with protons emitted at $\sim 180°$. The unperturbed angular correlation was measured by recoiling into a gold backing yielding the coefficients

$$A_2 = -.46 \pm .01 \quad A_4 = -.03 \pm .01.$$

The interpretation of recoil into gas experiments[1] was hitherto limited by the uncertainty in the correlation time τ_c. Hyperfine information could be obtained only by relating the results to PAC measurements on a level with a known g-factor in a neighbouring nucleus, under similar experimental conditions.

The present results can be interpreted in the frame-work of the Blume-Scherer[2] model and with several simple assumptions so as to enable one to determine simultaneously τ_c and the g-factor of the excited nuclear level. Using the results of Goldring *et al.*[3] on ^{18}O we get for this experiment $.27 < \alpha < .4$, where α is the fraction of ions experiencing the magnetic field of an unpaired $1s$ electron. In the critical pressure range, near the minimum anisotropy, α is expected to be close to the value appropriate to stripping in solid. Thus the data is interpreted assuming a static $1s$ field in vacuum and a Blume-Scherer behaviour in gas. One has, however, to modify Blume's expression for $G_k^0(t)$, taking into account that only a fraction α of the ensemble emerges into the gas in a $1s$ electronic configuration. For $J = 1/2$ we write:

$$G_k^0(t) = \sum_{FF'} \exp(-i\omega_{FF'}t) \cdot C_{FF'}^{\bar{k}}, \text{ where}$$

$$C^{\bar{k}}_{I+1/2,I-1/2} = C^{\bar{k}}_{I-1/2,I+1/2} = \alpha C^k_{I+1/2,I-1/2}$$

$$C^{\bar{k}}_{I+1/2,I+1/2} = C^{\bar{k}}_{I-1/2,I-1/2} = \alpha C^k_{I+1/2,I+1/2} + \frac{1-\alpha}{2}$$

$$C^k_{FF'} = \frac{(2F+1)(2F'+1)}{2J+1} \begin{Bmatrix} I & F & J \\ F' & I & K \end{Bmatrix}^2 \text{ and}$$

$$\sum_{FF'} C^{\bar{k}}_{FF'} = \sum_{FF'} C^k_{FF'} = 1 \ .$$

The gross features of the results can be explained in a simple way. A $1s$ static field perturbes the 3^- 18 ps level of ^{14}N down to hard core. At low gas pressures charge exchange collisions tend to distribute the perturbation amongst the whole ionic ensemble, thus reducing the anisotropy below that measured in vacuum. At high pressures the familiar Abragam-Pound behaviour sets in. Assuming $1s$ fields dominate the interaction (all other fields are calculated[4] to be too weak to exhibit this particular behaviour) one obtains: $\tau_c(50 \text{ torr}) = (.8 \pm .2)$ ps and $1.0(\text{ps}^{-1}) \lesssim \omega \lesssim 1.7(\text{ps}^{-1})$ which, with the calculated[4] field $H_{1s} = 57.3$ MG implies $0.5 \lesssim |g| \lesssim 0.85$. The minimum in the pressure curve disappeared as anticipated when the ^{14}N ions were allowed to enter the gas through a gold foil, thus reducing the recoil velocity to a value $v/c \approx 2\%$ at which there are almost no unpaired $1s$ electrons. The calculated g-factor (assuming a wave function of Glendenning *et al.*[5]) is $g = 0.55$.

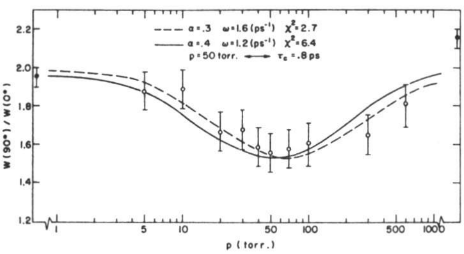

Fig. 1. The ratio $W(90°)/W(0°)$ as function of pressure and least squares fits for two values of α. The full circles refer to recoil into vacuum and recoil into gold.

References

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