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Mossbauer Effect in the Smectic Mesophase

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Recently there has been a report⁽¹⁾ on the observation of the Mossbauer effect in the smectic phase of the liquid crystal 4,4'-bis(heptyloxy)azoxybenzene. Due to experimental difficulties, it was not possible to determine the directional anisotropy of the emitted radiation. In this note we wish to propose a qualitative prediction for this quantity.

The model we choose is that of a lattice whose restorative forces in the z direction (the ordered smectic direction) are many times stronger than the restorative forces in the x and y directions (the directions of random ordering in the smectic crystal). An alternative model, e.g., no restorative forces in the z , but one in the x, y directions, will give no Mossbauer effect. This point will be commented on shortly.

The probability of a Mossbauer line is given by the Debye-Waller factor^(2,3) e^{-2W} , where

$$W = \cos^2 \theta W_z + \sin^2 \theta W_x \quad (1)$$

$$W_z = \sum_s \frac{p^2}{2NM\omega_s} [\hat{k} \cdot \epsilon_s](2N_s + 1) \quad (2)$$

$$W_x = \sum_s \frac{p^2}{2NM\omega_s} [\hat{i} \cdot \epsilon_s](2N_s + 1) \quad (3)$$

$pc = E_0$ = energy of emitted photon

M = mass of molecule

$$N_s = (e^{\hbar\omega_s/kT} - 1)^{-1}$$

and θ measures the angle between the z axis (smectic axis) and the direction of the emitted photon.

We note that Eq. (1) can be rewritten as

$$e^{-2W} = e^{-2W_z} e^{-2 \sin^2 \theta [W_x/W_z - 1]} \quad (4)$$

W_x as defined by Eq. (3) will be large because there will be in the "s" sum a high density of states for small ω_s (lattice modes in the x, y plane will all be of low energy) times a factor ω_s^{-2} for low frequencies arising from the factor $(2N_s + 1)\omega_s^{-1}$. W_x will be approximately the same as W in the mematic phase where no Mossbauer line has been observed.

W_z will be smaller than W_x because the density of states will be very low for small ω_s since typical phonons with a z component of polarization will have large energies. Formally, Eq. (2) interpreted instead as arising from a one-dimensional crystal would be infinite because

$$\sum_s \frac{1}{\omega_s} (2N_s + 1) \sim \int \frac{d\omega}{\omega^2},$$

which diverges due to the behaviour of the integrand for small ω . The appearance of the Mossbauer effect in the smectic phase is an indication that the smectic phase is technically not a one-dimensional system.

An experimental fit to Eq. (4) will give both W_z and W_x .

REFERENCES

1. Uhrich, D. L., Wilson, J. M. and Resch, W. A., *Phys. Rev. Letters* **24**, 355 (1970).
2. Singwi, K. S. and Sjolander, A., *Phys. Rev.* **120**, 1093 (1960).
3. Maradudin, A. A., Flinn, P. A. and Radcliffe, J. M., *Ann. Phys.* **26**, 81 (1964).