stresses in this temperature range, however, discrepancies develop within the two splittings of the $^4I_{15/2}$ transitions and between these values and those of the $^4F_{9/2}$ transitions. We assume that these discrepancies arise because of the fact that the two lowest lying levels of the excited $^4I_{15/2}$ multiplet are close enough together to interact in the same way as the ground levels. For example in the absence of stress it is observed that these two levels are 26 cm^{-1} apart above T_D, but below T_D this splitting increases to 34 cm^{-1}. Likewise an applied stress above T_D mixes these two excited state eigenfunctions and drives the levels apart. At low stress the mixing is very small, but at higher stresses significant changes in the polarization properties can occur because of it. The combination of effects due to nonuniformity, to mixing in both the ground and excited multiplets, and also to thermal depopulation, makes this group of lines especially difficult to analyze. By contrast the two splittings of the $^6H_{15/2}$ to $^4F_{9/2}$ absorptions are in reasonable agreement with each other, and some of these values are plotted in Fig. 5.
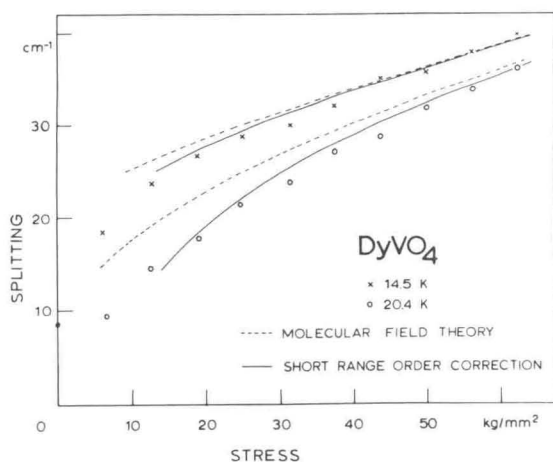
The data was found to be quite reproducible for different crystals. The errors in relative splitting at different temperatures are only of order 0·25 cm^{-1}, but the absolute error is of the order of 2 cm^{-1} because of the difficulties mentioned above. At 77 K these difficulties were substantially reduced because the stress-induced splittings were much smaller. This data is plotted in Fig. 6. Data similar in appearance to that of Fig. 6 was also taken on dilute $Dy_{0.05}Y_{0.95}VO_4$, both at 77 K and at 20·4 K, as shown in Fig. 7. In this case the lines were considerably sharper and the data is accurate to 0·25 cm^{-1}.

Experiments were also done as a function of stress between 4·2 and 1·4 K. At these temperatures the higher lying state of the ground multiplet is completely depopulated, and it is no longer possible to measure the splitting directly. Nevertheless all absorption lines shifted to higher energies as a function of stress; those due to transitions to the $^4F_{9/2}$ multiplet both moved linearly at the same rate
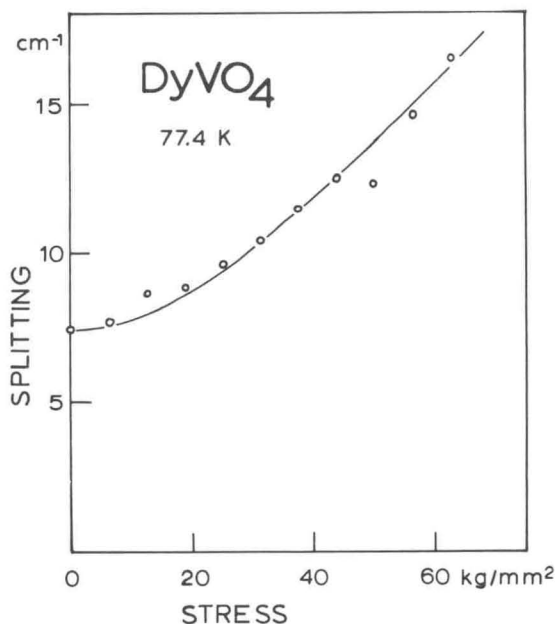

Fig. 5. Ground state splitting of DyVO$_4$ as a function of stress at 14·5 and 20·4 K. The molecular field theory curve is based on equation (4.2) with $\sigma_0 = 66$ kg/mm^2; the curve corrected for short range order is based on equation (I.3.22) with $\Gamma = 4$.

Fig. 6. Ground state splitting of DyVO$_4$ as a function of uniaxial stress along the a-direction at 77·4 K. The theoretical curve is that of equation (4.3) with the values of Δ_∞ and σ_0 given in Table 1.
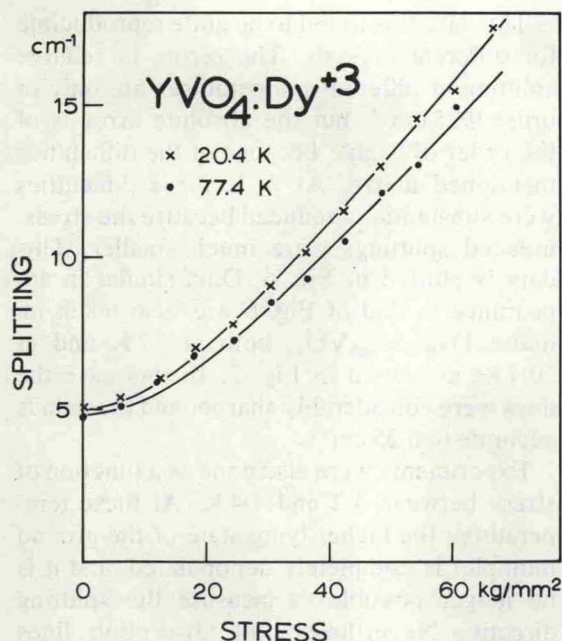
Fig. 7. Ground state splitting of 5 per cent Dy^{3+} in YVO_4 as a function of uniaxial stress along the *a*-direction at 20·4 and 77 K. The theoretical curves are those of equation (4.5) with the respective values of Δ_∞ and σ_0 given in Table 1.

Fig. 8. Shift in energy of $^6H_{15/2}$ to $^4F_{9/2}$ absorption lines of $DyVO_4$ as a function of stress at 4·2 K.

of $0·126$ cm^{-1}/kg mm^{-2}. These shifts are plotted in Fig. 8. The $^4I_{15/2}$ transitions, however, moved in a more complicated fashion which was attributed to the quadratic repulsion of the two lowest lying $^4I_{15/2}$ levels and to some repulsion of these levels from higher lying $^4I_{15/2}$ levels. For this reason we felt that the $^4F_{9/2}$ transitions provided a more reliable measure of the increased splitting in the ground state.

As will be discussed in the next section, Γ_1^+ type strain can cause a linear centre of gravity shift for two transitions from the two ground Kramers doublets which will provide a correction to the splittings deduced from the line shifts at 4·2 K. Such centre of gravity shifts were measured in $DyVO_4$ at 77 K, and in dilute Dy^{3+} in YVO_4 at 20·4 and 77 K, and were in all cases linear with a slope of $0·014 \pm 0·003$ cm^{-1}/kg mm^{-2} to higher energies.

Another series of experiments was performed in applied magnetic fields to determine

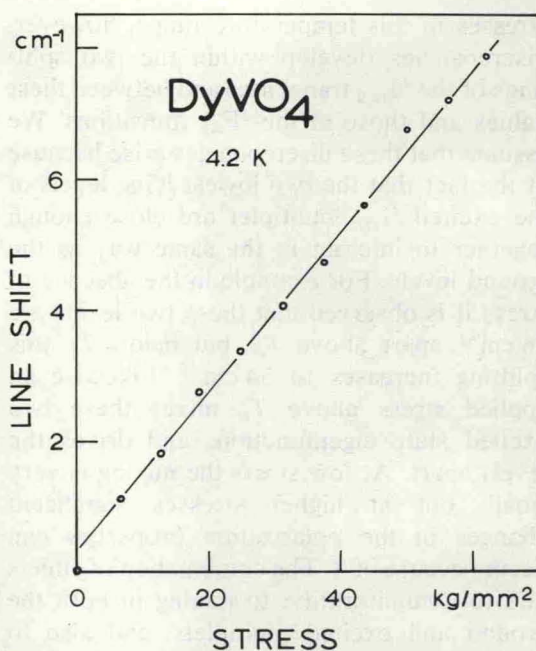the pseudospin flop phase diagram (I). It was found that in $DyVO_4$ a field perpendicular to the stress gave pseudospin flop behaviour, whereas in $TbVO_4$ the field had to be parallel to the stress. This indicates that the ground state *g*-factors of the two crystals point in different directions relative to their distortions. The experimental arrangement for $DyVO_4$ is shown in Fig. 1. The procedure was to apply a certain stress at a given temperature and to increase and then decrease the field in steps of the order of 0·5 kG through the transition. The spectrum was photographed on Polaroid film at each step with light polarized along either of the two principal directions in the basal plane. A typical result is shown in Fig. 9. Since the image of the sample was focussed on the spectrograph slit, the height of each band represents a vertical section of the actual crystal. As mentioned earlier, the two different distortions are characterized by very different polarization patterns, and the change in the pattern as a function of field in Fig. 9 is interpreted as evidence of a pseudo-