Zeeman Effect and Perturbations in the CO Angstrom and the N_2^+ Bands

Rosenthal and Jenkins[1] have described an interesting example of multiple perturbations in the $^1\Sigma \rightarrow {}^1\Pi$ Angstrom CO bands, particularly in the (0, 0) band at 4511A, for which they give the undoubtedly correct quantum analysis. Spectrograms recently taken by the writer show additional faint lines which extend their "resonance" curves at several of the perturbations and which emphasize the occurrence of two lines for each J value around the perturbation points. The correctness of the quantum assignments of all these lines is attested by the $\Delta_2 F'(J)$ combination relations and by the Zeeman effect observed in the present investigation. The existence of large, irregular Zeeman effects for certain lines was first noted by Crawford[2] in his work on the regular Zeeman effect in these CO bands.

As pointed out by Rosenthal and Jenkins, the fact that these perturbations are multiple would indicate that the perturbing state is not a singlet state, and the different types of Zeeman effects observed at the several perturbations bear this out. In general, the greater the displacement of the perturbed line the larger its Zeeman effect, and the effects increase rapidly with increasing field strength. The regular Zeeman effect for lines with these intermediate and high J values for this type of electronic transition is so small as to leave the unperturbed lines totally unaffected by the magnetic field. At the first perturbation point, however, the line $P_b(8)$ for example is symmetrically broadened at low field strengths and becomes a wide asymmetrical doublet with broad components at high field strengths (30,000 gauss). The effect of the field on the Q branch lines around $J=12$ is just to increase the magnitude of the perturbation, the shift of $Q_a(14)$ at $H=26{,}000$ gauss being $+0.96$ cm^{-1}, while that of $Q_b(11)$ on the other branch of the "resonance" curve is -0.55 cm^{-1}. Those Q lines having the maximum perturbation are shifted the most, but the field lines are quite sharp, there being no indication of any shading towards the no-field position. The lines $P_a(16)$ and $R_b(16)$ near the maximum of the next perturbation, on the other hand, are merely much broadened by the magnetic field at all field strengths, the uniform broad block of radiation being not quite symmetrical about the no-field line. Some of the P, R and Q lines at the perturbation around $J=28$ in the (0, 1) band as well as in this (0, 0) band become very sharp doublets, with the two components of different intensity, for the line on the one side of the perturbation point, while a line on the other side of the perturbation is uniformly broadened.

These differences in Zeeman pattern indicate that the state perturbing this $^1\Pi$ state is multiple, in violation of one of Kronig's rules that the two perturbing states must have the same multiplicity. However, this rule need not be expected to hold strictly here, for singlet-triplet combinations do occur in CO. The $d(^3\Pi?)$ level which lies just 0.09 volts below this $^1\Pi$ state may be the level whose rotational terms are responsible for these perturbations. The differences in the spread of the magnetic sublevels in the three spin components, together with the rule that only levels of the same M value perturb each other, could account for the variations in field patterns observed for these perturbed lines. An analysis of the Merton-Johnson triplet bands in the red which arise from this d level should be made to find these corresponding perturbations.

The N_2^+ bands which are a $^2\Sigma \rightarrow {}^2\Sigma$ transition are present on some of the writer's CO spectrograms. A perturbation similar to those in the $^2\Sigma \rightarrow {}^2\Sigma$ CN tail bands occurs in this system[3] in all bands with $v'=1$ for $J=13\frac{1}{2}$. All of the lines except those displaced near the center of the perturbations are insensitive to the magnetic field, whereas these perturbed lines are either shifted or become rather sharp doublets. A more detailed description of these peculiar Zeeman effects in both of these band systems, together with the possible explanations, will be submitted in the near future for publication in this journal.

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[1] J. E. Rosenthal and F. A. Jenkins, Proc. Nat. Acad. Sci. **15**, 896 (1929).

[2] F. H. Crawford, Phys. Rev. **33**, 341 (1929).

[3] M. Fassbender, Zeits. f. Physik **30**, 73 (1924).