intensities. This estimate depends on the $(\sigma_{He}/\sigma_H)_{back}$ ratio which is, as we have said, not very well known at energies greater than six Mev. Also the background of neutrons from other modes of disintegration is not well known. Hence the agreement is only valid in order of magnitude, but to this extent supports our interpretation.

These experiments indicate that present data may be explained on the assumption that two-stage reactions are much more probable than three-particle reactions. However, they do not give a decisive answer as to whether three-particle reactions occur with any measurable probability or not. The relative probabilities of a three-particle reaction compared to a two-stage reaction might be gotten by accurately measuring the neutron spectrum of separated Li^6 bombarded by deuterons.[23] If the reaction goes in two stages

$$Li^6+D^2\rightarrow He^5+He^3+0.8 \text{ Mev}, \qquad (4)$$

$$He^5\rightarrow He^4+n^1+0.8 \text{ Mev}, \qquad (4.0)$$

the neutrons will have a spread in energy from 0.18 Mev to 1.22 Mev (for 0.8 Mev bombarding energy) while if the three-particle reaction occurs

$$Li^6+D^2\rightarrow He^4+He^3+n^1+1.6 \text{ Mev}, \qquad (5)$$

the neutrons will have energies from 0 to 1.85 Mev. In addition, the maximum energy of the neutrons will vary much faster with bombarding energy in the case of the three-particle reaction than the two-stage reaction.

We wish to thank Mr. Tom Lauritsen for the electroscope, the Seeley W. Mudd Fund for financial support, and Dr. C. C. Lauritsen for continued encouragement. One of us (H. Staub) is very much indebted to the "Stipendienfond" and the "Jubilaumsfond der Eidgenossischen Technischen Hochschule" Zurich, Switzerland for a grant.

---

[23] Rumbaugh, Roberts and Hafstad, reference 5, have measured this neutron spectrum, but not accurately enough for this purpose.

MAY 1, 1939 PHYSICAL REVIEW VOLUME 55

The Magnetic Rotation Spectra of SO_2 and CS_2 in the Ultraviolet

P. Kusch* and F. W. Loomis
University of Illinois, Urbana, Illinois

(Received March 15, 1939)

The apparatus previously used for the study of magnetic rotation spectra in the visible and infra-red has been modified for use in the ultraviolet. The object was to see whether the simplification often found in magnetic rotation spectra will help in the analysis of the complicated spectra associated with electronic transitions of polyatomic molecules, most of which occur in the ultraviolet. The spectra of this type which have been found are those of CS_2, SO_2 and formaldehyde. In each case the band spectrum is replaced by sharp lines which may readily be correlated to band heads. These spectra occur for only limited regions of the absorption spectrum, in which the band heads are rather sharp and present a regular appearance. In the region where the band heads are irregular and confused in appearance, no effect occurs. In no case is the magnetic rotation spectrum sufficiently extensive to permit a vibrational analysis of the band system to be made, nor to give any material aid in its analysis.

Introduction

The magnetic rotation spectrum of a gas is the spectrum of light transmitted by a gas between crossed polarizing prisms when the gas is placed in a magnetic field parallel to the direction of propagation of the light beam. Several types of magnetic rotation spectra have been observed. The most usual type occurs in the region of the $^1\Pi\leftarrow{}^1\Sigma$ absorption systems of the alkali metal molecules and consists of a number of fairly sharp lines which lie near the band heads of the corresponding absorption system. These magnetic rotation spectra have been observed[1] for all

---

* Now at Columbia University.

[1] F. W. Loomis and R. E. Nusbaum, Phys. Rev. **38**, 1447 (1931); **39**, 89 (1932); **40**, 380 (1932). F. W. Loomis and M. J. Arvin, Phys. Rev. **46**, 286 (1934). P. Kusch, Phys. Rev. **49**, 218 (1936).

the alkali metal molecules with the exception of Cs_2. This type of magnetic rotation spectrum occurs only for electronic band systems in which the molecule has a magnetic moment in at least one of the two electronic states involved in the transition. It occurs because the Zeeman splitting of the rotational lines, and hence the rotation, by the molecule, of the plane of polarization of incident plane polarized light of a frequency near to that of the rotational lines, is large for rotational lines of low quantum number but decreases rapidly with increasing rotational quantum number. It may be predicted from theoretical considerations that for the case of the $^1\Pi \leftarrow {}^1\Sigma$ systems of the alkali metal molecules the rotation just outside an R line should be positive and just outside a P line negative. When, as in the case of the $^1\Pi \leftarrow {}^1\Sigma$ systems of the alkali metal molecules, the head of a band appears at low rotational quantum numbers, the effect of the many closely spaced lines in the band head is superimposed and a bright line is observed just outside the head where the effect of reabsorption is small. Under very prolonged exposures of photographic plates the magnetic rotation due to individual lines of rather high J, which do not lie in the band head, may be observed[1] but the lines so observed are not of an intensity comparable to that of the composite line near the band head. This apparent simplification of the absorption spectrum permits a very complete vibrational analysis to be made, since band heads are easily located and weak bands are not obscured by the structure of intense neighboring bands. Extrapolations of the very extensive data which may be obtained from such analyses yield more accurate values of the energies of dissociation of the alkali metal molecules than could be obtained from an analysis of the absorption spectra alone.

Unperturbed $^1\Sigma \leftarrow {}^1\Sigma$ systems should show no magnetic rotation spectrum since the molecule has a magnetic moment in neither of the two electronic states involved in the transition, and hence exhibits no Zeeman splitting. If a system which is known to result from a $^1\Sigma \leftarrow {}^1\Sigma$ transition does show a magnetic rotation spectrum, it may be inferred that one of the states involved in the transition has acquired a magnetic moment due to perturbation effects. The magnetic rotation lines observed for such a system do not correspond in any simple way to the absorption heads, nor do any obvious regularities occur in the arrangement of the lines. The magnetic rotation spectrum of the $^1\Sigma \leftarrow {}^1\Sigma$ system of Na_2 was first observed by Wood and Hackett.[2] Fredrickson and Stannard[3] have analyzed this magnetic rotation spectrum on the basis of the hypothesis that some levels of the magnetically insensitive upper $^1\Sigma$ state are perturbed by some unknown magnetically sensitive state, so that a molecule occupying these levels acquires a magnetic moment and rotational lines resulting from transitions to these levels show magnetic rotation effects. A similar spectrum of K_2 has been observed by Carroll[4] and has been explained by him in terms of perturbations of the upper state.

A magnetic rotation spectrum has been observed[5] for I_2. Modern theory ascribes this to a magnetic moment acquired by the molecule in the upper state and caused by a rotational distortion. The magnetic moment becomes large only for high rotational speeds and hence the magnetic rotation lines observed for I_2 correspond to absorption lines of high rotational quantum number. Serber[6] and Carroll[4] have given theoretical accounts of these magnetic rotation phenomena in diatomic molecules.

Because the method of magnetic rotation offers an important method of investigation of the spectra of certain diatomic molecules, this investigation was undertaken in the hope that the magnetic rotation spectra of the electronic band systems of polyatomic molecules would present a useful simplification of the enormously complicated structure observed in the corresponding absorption spectra. Since the present work was inaugurated Carroll[4] has pointed out that the probabilities of success are small and that the magnetic rotation spectra, when observed, might well exhibit the complexities rather than the simplicities of the band structure.

---

[2] R. W. Wood and F. E. Hackett, Astrophys. J. **30**, 339 (1909).

[3] W. R. Fredrickson and C. R. Stannard, Phys. Rev. **44**, 632 (1933).

[4] T. Carroll, Phys. Rev. **52**, 822 (1937).

[5] R. W. Wood and G. Ribaud, J. de phys. et rad. **4**, 378 (1914).

[6] R. Serber, Phys. Rev. **41**, 489 (1932).

EXPERIMENTAL

Only very few polyatomic molecules exhibit absorption spectra due to electronic transitions in the visible region of the spectrum. A good many such molecules do, however, possess absorption spectra in the near ultraviolet. It was, therefore, necessary to modify the magnetic rotation technique, heretofore used only in the visible and infra-red regions of the spectrum, for use in the ultraviolet.

Since the rotations which are produced by the Zeeman splittings of the rotational lines are usually very small, the intensity of magnetic rotation lines is usually weak compared to that of the corresponding absorption spectrum. A very intense source of continuous radiation is, therefore, necessary as a background for the observation of this type of spectrum. A water-cooled hydrogen discharge tube of a type described by Lawrence and Edlefsen[7] was used. When a current of about four amperes at 4400 volts was sent through the tube, it gave a very intense continuum in the ultraviolet region of the spectrum. The use of this source and a Hilger E1 quartz spectrograph permitted satisfactory plates of the magnetic rotation spectra to be obtained in exposure times varying from 15 minutes to six hours. The corresponding absorption spectra could be photographed in a few seconds.

The polarizing and analyzing prisms consisted of a pair of quartz Rochon prisms with components in optical contact. Since the angle separating the two beams of light, polarized in planes at right angles to each other, which leave the polarizing prism is only about 0.5° at 3500A, it was necessary to have a well collimated beam of light incident on the prism, so that the two polarized beams might be resolved. A lens of long focal length was used to collimate the light from the discharge tube, and the aperture of the beam was reduced by suitable diaphragms. Sufficient resolution of the beam was then obtained so that the extraordinary, refracted beam could be stopped by means of a screen and only the ordinary, unrefracted ray sent through the absorption tube. Since all the optical adjustments were made by observations on the visible light produced by the discharge tube, or, on occasion, by observations on the ultraviolet light as viewed on a fluorescent screen, the two beams often overlapped to some degree in the ultraviolet, or else the beam transmitted through the tube was improperly collimated so that reflections occurred from the inside walls of the absorption tube. Either of these two difficulties prevented extinction from being obtained in the ultraviolet and at once obviated the possibility of observing magnetic rotation spectra below about 2700A.

It is necessary that the windows of the absorption tube be free from strains so that extinction may be obtained between the Rochon prisms in the absence of a magnetic field. Fused quartz windows were entirely unusable because of the strains. Corex windows were found to be satisfactory down to about 3000A, but at shorter wave-lengths they began to absorb strongly. Eventually two crystal quartz windows of identical thickness, one of right-handed and the other of left-handed quartz, and cut with their surfaces perpendicular to the optic axis were found to be satisfactory.

The solenoid used in this work has been previously described by Loomis and Nusbaum.[1] It produced a field of about 1800 gauss under working conditions.

The magnetic rotation spectra were observed at a number of different pressures for each of the gases investigated. Since the vapor pressures at room temperatures were, in all the cases investigated, much greater than the pressures required to give well-developed absorption spectra, the pressure could easily be adjusted by pumping the tube down to suitable pressures.

Carbon disulphide

CS_2 has an absorption spectrum in the region 3900–2750A. Wilson[8] has published an extensive list of wave-lengths of band heads in this region, but has given no analysis of the system. Watson and Parker[9] have given a formula to represent the bands in this system, but the formula cannot represent a true analysis since the vibrational frequencies given for the ground state do not agree with results obtained from later work on the Raman effect of CS_2.

---

[7] E. O. Lawrence and N. E. Edlefsen, Rev. Sci. Inst. **1**, 45 (1930).

[8] E. D. Wilson, Astrophys. J. **69**, 34 (1929).

[9] W. W. Watson and A. E. Parker, Phys. Rev. **37**, 1013 (1931).

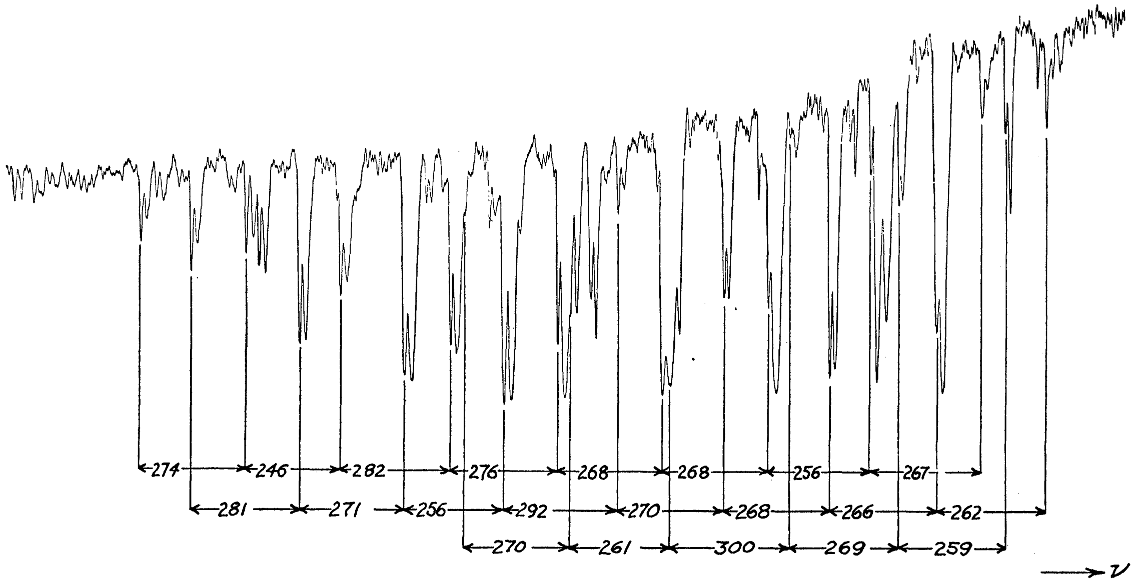

FIG. 1. Microphotometer record of the magnetic rotation spectrum of CS_2. Pressure = 6 cm.

We have found an intense magnetic rotation spectrum in the region 3355–3640A, and a very much weaker spectrum in the region 3125–3250A, the region of most intense absorption. No magnetic rotation was observed to shorter wavelengths. A weak spectrum may, of course, exist, but if it does it is of such low intensity that it cannot be observed against the weak background transmitted by the optical system. It is noteworthy that the magnetic rotation spectrum occurs in that region where the absorption bands are sharp and well defined. At short wavelengths, where the absorption bands are diffuse and irregular in appearance no effect is observed.

A microphotometer trace of the magnetic rotation spectrum in the region 3355–3640A is reproduced in Fig. 1. The most obvious feature of the spectrum is that it consists of a number of doublets, the components of each of which are separated by about 17 cm^{-1}, and in which the low frequency component is sharper than the high frequency component. This doublet structure is not apparent in the much weaker magnetic rotation spectrum observed to shorter wavelengths. Because the magnetic rotation spectrum was quite intense it was possible to take photographs of the spectrum for settings of the analyzing Rochon prism at small angles on either side of the extinction position without admitting enough background to obscure the spectrum. By comparison of several photographs taken in this manner it was possible to determine the direction of rotation of the plane of polarization at each line, since the intensity of a line relative to the background decreases as the analyzing prism is rotated in the same direction as the rotation of the plane of polarization. This effect could be observed for the more intense lines by a visual examination of the plates, and by the use of microphotometer traces, the direction of rotation could readily be determined for all the lines shown in Fig. 1 with the exception of a few very weak ones which were obscured by the continuous background admitted by the analyzing Rochon. In all cases the direction of rotation of the plane of polarization is positive for the sharp, low frequency component and negative for the diffuse, high frequency component. A positive rotation is defined as that which occurs when the rotation is in the same direction as the current producing the field, if the field itself is in the same direction as the direction of propagation of the light beam.

The absorption spectrum of CS_2 was photographed in the first order of a 21-ft. grating under a dispersion of about 1.25A/mm. This permitted the accurate measurement of absorption edges, a good many of which are very sharp. The usual

Table I. *Observed magnetic rotation lines of* CS_2.

i Mag. Rot.	ν Mag. Rot.	Rot. Sign	i Abs.	ν Abs.
*d*4	31986			
2	31955			
1	31945			
*d*1	31543			
1	31533			
2	31369			
*d*1	31211			
0	31196			
*d*1	30912			
*d*1	30898			
1	30781			
1	30770			
*d*2	29800			
*d*2	29780		7	29777.6
2	29765		4	29765.2
*d*4	29679	−		
3	29667	+	10	29666.1
*d*1	29618	−		
1	29604	+	8	29605.3
*d*8	29518	−		
5	29503	+	10	29500.6
*d*2	29417	−		
2	29408	+	9	29407.2
*d*4	29377	−		
7	29355	+	6	29360.4
2	29337		10	29336.6
2	29297	−		
1	29284	+		
*d*6	29250	−		
6	29237	+	8	29234.6
1	29152	−		
1	29139	+	5	29141.9
*d*9	29104	−		
4	29081	+	10	29080.9
2	29056			
*d*3	28982	−		
3	28969	+	5	28968.7
4	28856	−		
3	28839	+	4	28837.7
*d*9	28832	−		
10	28813	+	8	28815.8
2	28714	−		
2	28699	+	3	28697.2
4	28643	−		
3	28628	+	3	28632.9
4	28594	−		
4	28578	+	4	28579.4
*d*10	28563	−		
5	28545	+	10	28543.5
*d*2	28449			
*d*10	28427	−		
9	28407	+	7	28408.1
*d*1	28383	−		
2	28368	+	5	28367.2
*d*1	28323			
1	28308			
*d*5	28286	−		
4	28269	+	7	28269.9
1	28250			
*d*2	28220	−		
*d*2	28206	+	5	28205.8
*d*7	28171	−		
6	28151	+	7	28154.4
*d*3	28005	−		
3	27987	+	4	27987.1
*d*4	27896	−		
4	27880	+	4	27878.4
*d*3	27792	−		
3	27776	+	4	27774.4
*d*2	27759	−		
2	27741	+		
1	27709	−		
1	27694	+		
*d*2	27615	−		
2	27599	+	5	27599.7
*d*2	27527	−		
2	27508	+	3	27507.5
*d*2	27484	−		
2	27467	+	4	27467.1

intensity variation observed in absorption bands is not in evidence, and many of the observed features have more nearly the character of absorption lines. An excellent correlation exists between the sharp, low frequency member of the magnetic rotation doublets and the sharp absorption edges. No absorption edges were observed corresponding to the high frequency component of the doublets, nor was it possible to find absorption edges which correspond to the weaker magnetic rotation lines in the region 3125–3250A. The frequencies of the observed magnetic rotation lines, their estimated intensities, directions of rotation, and the frequencies of the corresponding heads measured in absorption are given in Table I.

The obvious regularities in the magnetic rotation spectrum and the excellent correlation which may be established between the sharp magnetic rotation lines and the absorption heads indicate that this spectrum is of the type observed for the $^1\Pi \leftarrow {}^1\Sigma$ systems of the alkali metal molecules. That is, the molecule possesses a magnetic moment along the axis of the molecule in the upper of the two electronic states involved in the transition. The ground state can possess no magnetic moment since CS_2 is known to be diamagnetic. The rotational lines are, therefore, subject to a Zeeman splitting and a large rotation of the plane of polarization results near the band head where the effect of many closely spaced lines is superimposed and the effect of reabsorption is small. The occurrence of the diffuse components of the doublets is rather puzzling; from the fact that the diffuse components do not correspond to structure in the bands in a manner similar to that observed for the sharp components and from the different directions of rotation of the plane of polarization by the molecules for the two components, it may be inferred that the diffuse and sharp components have their origins in a different type of structure in the band. Until a detailed analysis of the structure of the absorption spectrum is available, no explanation of these observed magnetic rotation effects seems possible.

The observed magnetic rotation lines fall into several progressions. These are marked in Fig. 1 and it is seen that the intensities in most of the progressions vary smoothly. The differences between successive members of these progressions are about 270 cm^{-1} and converge to high frequencies. Jenkins[10] has pointed out one of these progressions which is very prominent in absorption. The progressions are tabulated in Table II. The frequency of about 270 cm^{-1} has been noted by Wilson[8] and by Watson and Parker[9] as well. It seems probable that this frequency corresponds to ν_1 in the excited state.

Sulphur dioxide

Sulphur dioxide has an intense absorption spectrum in the region 2600–3900A. This absorption system of SO_2 is much more intense than the corresponding system of CS_2. For the same path length of absorbing gas the pressure of CS_2 must be roughly ten times as great as that of SO_2 to give the same absorption. Watson and Parker[11] have made a partial analysis of this system but the analysis is untenable for reasons discussed by Clements.[12] Clements has investigated the variation of the intensities of the bands in absorption as a function of temperature and has proposed an analysis on the basis of his results. Asundi and Samuel[13] have proposed an alternative analysis which disregards the results of the temperature variation and has other defects discussed by Price and Simpson.[14]

A magnetic rotation spectrum has been found in the region 2939–3164A. The intensity of this spectrum is much lower than that of the magnetic rotation spectrum of CS_2 for a gas density such that the absorption spectra of the two are of about equal intensity. As in the case of CS_2, the magnetic rotation spectrum occurs in the low frequency region of the absorption spectrum where the absorption edges are fairly sharp and well defined and in which the bands appear quite regular. At higher frequencies, where the bands appear confused and irregular, no magnetic rotation spectrum has been observed of an intensity great enough to permit of its observation against the continuous background transmitted by the optical system. No effect was observed at longer wave-lengths where the bands are regular but appear only at much higher gas pressures.

TABLE II. *Progressions in the magnetic rotation spectrum of* CS_2.

28308	27599	27467
270	*281*	*274*
28578	27880	27741
261	*271*	*246*
28839	28151	27987
300	*256*	*282*
29139	28407	28269
269	*292*	*276*
29408	28699	28545
259	*270*	*268*
29667	28969	28813
	268	*268*
	29237	29081
	266	*256*
	29503	29337
	262	*267*
	29765	29604

TABLE III. *Magnetic rotation lines observed for* SO_2.

i	ν(MAG. ROT.)		ν(ABS.)	i	ν(MAG. ROT.)		ν(ABS.)
2	34017	*L*	34030	3	32782		
2	33800	*J*	33760	3	32763		
2	33792			3	32742		
*d*6	33336	*G*	33313	*d*1	32632	*D*	32607
2	33314			*d*1	32621		
5	33298			*d*1	32579		
4	33286			*dd*1	32457	*C*	32377
4	33272			*dd*1	32421		
4	33257			*d*5	32200	*B*	32161
4	33241			4	32194		
4	33223			2	32183		
4	33203			3	32174		
2	33182			1	32162		
2	33157			3	32153		
1	33076	*F*	33080	1	32141		
1	33066			3	32127		
1	33050			3	32112		
1	33034			3	32093		
1	33017			3	32077		
1	32999			2	32057		
*d*6	32878	*E*	32850	*d*3	31960	*A*	31949
3	32868			*d*3	31950		
2	32860			*d*2	31681		
4	32849			*d*2	31661		
2	32838			1	31636		
3	32827			2	31613		
3	32812			1	31592		
3	32797						

The frequencies of the lines observed in magnetic rotation are given in Table III. The relative intensities were estimated from visual observations made while the plates were measured in the comparator. No measurements were made in absorption, but the frequencies which Clements[12] has published for the band heads, together with the symbol which he used to designate them are included in the table. Clements remarks that his frequencies of the

---

[10] F. A. Jenkins, Astrophys. J. **70**, 191 (1929).

[11] W. W. Watson and A. E. Parker, Phys. Rev. **37**, 1484 (1931).

[12] J. H. Clements, Phys. Rev. **47**, 224 (1935).

[13] R. K. Asundi and R. Samuel, Proc. Ind. Acad. Sci. **2**, 30 (1935).

[14] W. C. Price and D. M. Simpson, Proc. Roy. Soc. **A165**, 272 (1938).

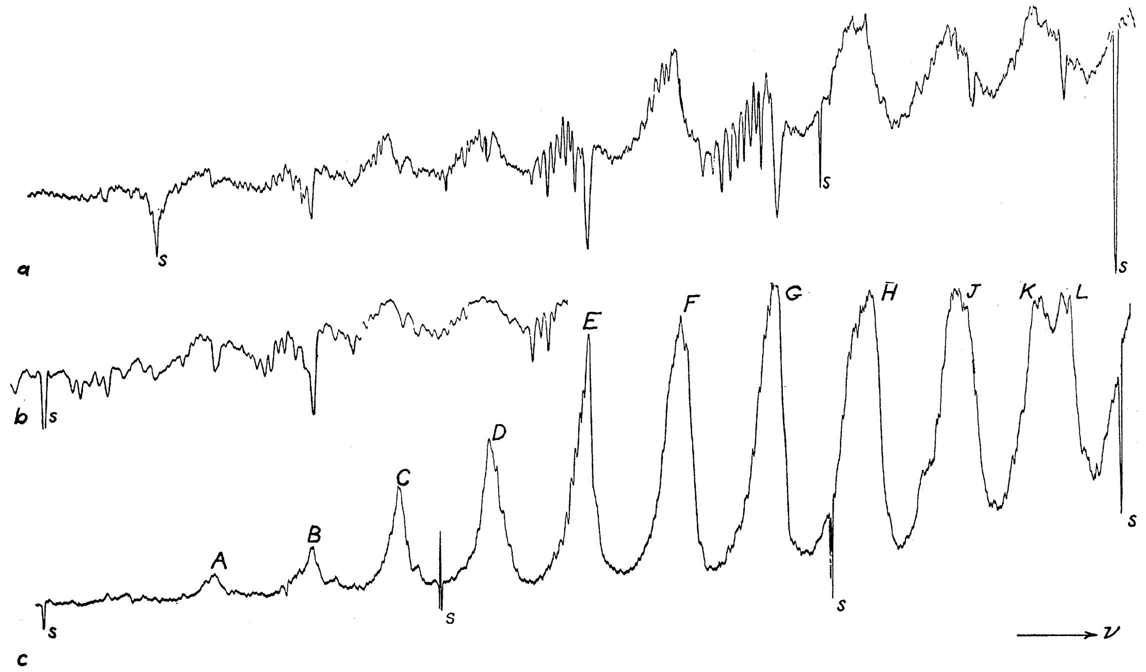

FIG. 2. (*a*) Microphotometer record of the magnetic rotation spectrum *od* SO_2. Pressure=0.5 mm. (*b*) Pressure=3 mm. (*c*) The absorption spectrum of SO_2. Pressure=4 mm.

band heads as determined from different plates are consistent to about 15 cm^{-1}. In the present case, where it is possible to measure fairly sharp lines instead of broad bands, the frequency measurements are consistent to about 2 cm^{-1}.

Microphotometer traces of the magnetic rotation spectrum of SO_2 are reproduced in Fig. 2(*a*) and (*b*). These were observed at pressures of 0.5 and 3 mm, respectively. The corresponding absorption spectrum, at a pressure of 4 mm is shown in Fig. 2(*c*). Reference scratches, accidental scratches, and other plate defects are marked with an *s*. The letter designating the band head is the same as that used by Clements. Because of the long exposure time required to photograph the magnetic rotation spectrum, the absorption spectrum produced by the background transmitted by the polarizing apparatus is present with a considerable intensity.

Since the magnetic rotation spectrum is so weak, it has not been possible to determine the direction of rotation of the plane of polarization for the lines. Any small rotation of the analyzing Rochon introduced enough background to obscure the magnetic rotation spectrum quite effectively.

The most obvious feature of the magnetic rotation spectrum is the appearance of the bands *B*, *E* and *G*. In each of these cases an intense diffuse line appears at the position of the band head. To the long wave-length side of this line appears a series of sharp lines which corresponds to the subheads in the absorption bands. The intervals between successive subheads increases to low frequencies; in the case of the band *G* they increase from 12 cm^{-1} near the band head to 25 cm^{-1} between the two furthest subheads measured. It is evident from the traces that the absorption subheads are best defined in the case of those bands which show the subheads in magnetic rotation most clearly. The band *F*, whose absorption subheads are not as well defined than those of *B*, *E* and *G*, shows a somewhat similar magnetic rotation spectrum consisting of several faint lines whose spacing increases to low frequencies. The intense line which occurs near the band heads, *B*, *E* and *G* does not occur for *F*. The frequencies of the lines in *F*, listed in Table III, were obtained from the microphotometer traces since the lines are too weak to be measured from the original plates.

Magnetic rotation structure of some sort occurs for all the other bands in Fig. 2 as well. In some cases it is sharp enough to be measured, and otherwise its presence may be inferred by noting the difference between the intensity distribution in the absorption spectrum and in the absorption background transmitted by the analyzing prism.

The series of bands, $A-KL$, in which the magnetic rotation spectrum occurs has been assigned by Clements[12] as the $(000)''-(0v_20)'$ progression in which the band A is the $(000)''-(000)'$ band. This progression is partly overlapped by the $(000)''-(1v_20)'$ progression whose first member is the band G. The frequency $\nu_2{}^1$ is approximately 225 cm^{-1}. From the point of view of the present work it is difficult to see why bands lying in a single progression should show such widely varying magnetic rotation spectra. It is, of course, impossible to place bands which do show similar structure, such as B, E and G, into a single progression because the separations between such bands vary too greatly to represent a vibrational frequency. It does not seem likely that the structure can be explained on the basis of perturbations because of the great regularity in the appearance of the spectrum.

Other molecules

An electronic band spectrum due to formaldehyde appears in the region 2750–3750A. Dieke and Kistiakowsky[15] have given a complete rotational analysis of this system. A magnetic rotation spectrum was found for the 3260A band only. This consists of a number of lines which do not fall into any regular series and among which no other regularities are apparent. No correlation can be established between the observed lines and the structure observed in absorption. Evidently the appearance of the spectrum precludes the possibility that it arises from a magnetic moment characteristic of the upper state, for in that case a somewhat similar structure might be expected for several bands. It seems probable that the observed effect is due to a perturbation of the upper state by some unknown state which does possess a magnetic moment. Dieke and Kistiakowsky have found perturbations in some of the bands but the band at 3260A is entirely regular in its behavior. Presumably the perturbation does not disturb the rotational energy levels sufficiently to permit of its detection by an observation of the displacement of the rotational levels. The frequencies of the lines and their estimated relative intensities are listed in Table IV.

TABLE IV. *Magnetic rotation lines of formaldehyde.*

i	ν	i	ν	i	ν
6	30719	1	30637	10	30557
1	30709	1	30632	3	30531
*d*5	30695	8	30617	*d*2	30515
*d*1	30691	0	30604	2	30489
5	30679	6	30563		

Two other molecules, acetaldehyde and acrolein, of the same general type as formaldehyde, have well-defined absorption spectra in the near ultraviolet which have been investigated by Eastwood and Snow.[16] Neither of these two molecules show any sign of magnetic rotation. Ozone, which shows a strong absorption spectrum in the region 2900–3660A, has no observable magnetic rotation spectrum.

NO_2 is known to have a magnetic moment in the ground state and Wood and Dieke[17] have found an intense magnetic rotation spectrum. This spectrum was readily obtained but consisted of an apparently hopeless confusion of structure which gave no useful simplification of the absorption spectrum.

It seems difficult to obtain any useful information about the absorption spectrum of a polyatomic molecule from a study of its magnetic rotation spectrum for the cases here investigated. A complete understanding of the magnetic rotation spectrum seems rather to require a more detailed knowledge of the structure of the absorption spectrum than seems at present available.

---

[15] G. H. Dieke and G. B. Kistiakowsky, Phys. Rev. **45**, 4 (1934).

[16] E. Eastwood and C. P. Snow, Proc. Roy. Soc. **A149**, 434, 446 (1935).

[17] R. W. Wood and G. H. Dieke, Nature **128**, 545 (1931).