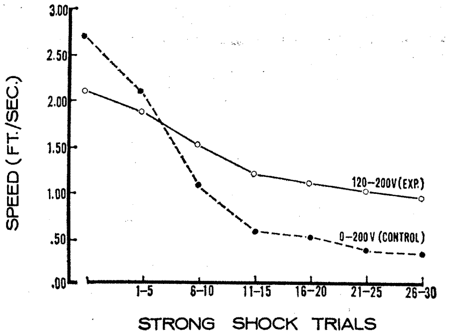

Fig. 1. Effect of strong shock (200 volts) on the running speed of rats after training with weak shock (120 volts) or no shock.

trials, shown in Fig. 2, the two control groups—those that received the *same* shock as on the first 50 trials (120 or 200 volts, respectively)—maintained fairly stable speeds, as expected. The group that was changed from weak to strong shock (from 120 to 200 volts) decreased its speed gradually below its control group (shock maintained at 120 volts), but still ran much faster than the group that received 200-volt shock in both sets of trials. Similarly, the rats shifted from strong to weak shock gradually increased their speed, but did not reach the speed of the rats that received a weak shock in the first 50 trials. The change from strong to no shock caused a greater increase during the final 30 shock trials than the shift from strong to weak shock ($F = 3.95$; $df = 6, 132$; $p < .005$).

An analysis of variance performed on the scores for the final 10 shock trials showed that both groups which received changes in shock intensity (120 to 200 volts, or vice versa) altered their speed reliably compared to their respective control groups maintained at constant shock intensity ($F = 4.49$; $df = 1, 44$; $p < .01$). However, the group that was switched from 120 to 200 volts still ran significantly faster than the group that had been maintained at 200 volts; and the group switched from 200 to 120 volts, significantly slower than the group maintained at 120 volts ($F = 8.99$; $df = 1, 44$; $p < .001$). In fact, the change in shock caused these two groups to approach a level midway between the speeds of the two unchanged controls ($F < 1$). Thus, running speed after a change in shock intensity was determined by both present and previous shock experience, with the initial experience appearing to be the more potent factor.

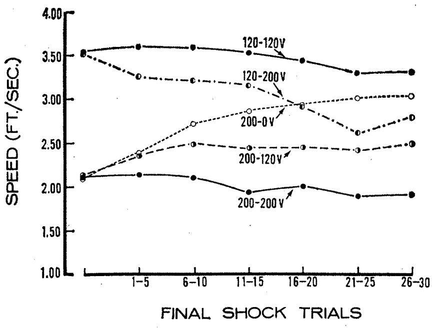

Fig. 2. Effect of strong shock, weak shock, or no shock on the running speed of rats after training with the same or a different shock intensity. Figures before the hyphens indicate shock voltage given in 50 preliminary trials. Figures after the hyphens show voltage in 30 subsequent trials.

The results clearly indicate that changes in the intensity of punishment, regardless of the direction, produce gradual, "incomplete" shifts in running speed. It is important to note that these gradual shifts in speed were accompanied by an observed response stereotypy after shock at the goal. Typically, animals receiving weak shock at the food cup shudder or lurch backward slightly, while rats getting strong shock jump back from the food cup more violently. Animals given a change in shock intensity exhibited approximately the same response to shock as observed prior to the change. That is, rats getting a weak shock after experience with a stronger one continued to jump back after the weak shock just as they had jumped after the strong one. However, rats getting strong shock after weak shock never jumped very hard. The amount of change in running speed when shock intensity is shifted appears to be strongly influenced by the response stereotypy developed during initial shock training.

The withdrawing response to shock is associated with two reinforcing events, shock termination and eating, and thus apparently becomes strongly conditioned to the goal cues. Changing the strength of shock does not produce an immediate change in the strongly conditioned withdrawal response and this could account for the gradual, incomplete shift in running speed. During the first punished trials the withdrawal response tends to become anticipatory, that is, incipient withdrawal responses occur progressively nearer to the beginning of the alley, with the result that the rats run more slowly when punished than before. Running speed during punished trials depends on the strength of the withdrawal response—the stronger the initial punishment, the stronger the withdrawal response and the slower the speed. However, when intensity of punishment is changed, the withdrawal response does not change and running speed also resists change because it reflects the strength of the withdrawal response. The development of such a persistent withdrawal response at the goal is characteristic of the punishment situation and distinguishes it from learning with reward alone (*6*).

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5. Rats in the second experiment ran faster both in training and in shock conditions than rats in the first experiment, because of an apparatus improvement which made the food more accessible and reduced the delay in obtaining reward.
6. I thank Dr. Frank A. Logan and Dr. Neal E. Miller for advice. The work was supported in part by grant M647 and preparation of the report was aided by grant MH 06951-01, both from the National Institute of Mental Health.

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13 March 1963

Dynamic Reflectance Spectroscopy: A New Thermal Technique

Abstract. *Dynamic reflectance spectroscopy, a new thermal technique, measures the change in reflectance of a sample at a fixed wavelength as the temperature of the sample is increased. The technique is illustrated by the thermal dissociation of* $CoBr_2 \cdot 6H_2O$.

Although diffuse reflectance spectroscopy, at room temperature, is an important tool in structural studies on solid coordination compounds (*1*), little work has been done with this technique at elevated temperatures (*2*). Previously, we have described a high temperature sample holder in which the reflectance spectra of solid samples could be determined from ambient temperature to 500°C (*3*). In this tech-

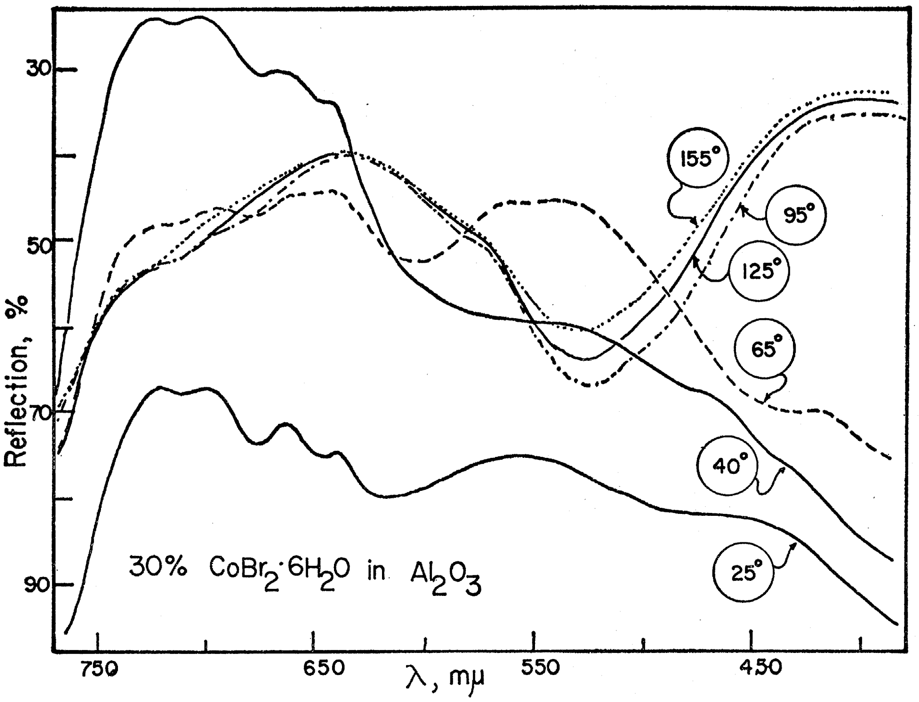

Fig. 1. Diffuse reflectance curves of a mixture of $CoBr_2 \cdot 6H_2O$ and Al_2O_3 at elevated temperatures. Reference material is Al_2O_3. Surface temperatures are given.

nique essentially static temperatures were used; the temperature of the sample was held constant while the reflectance spectrum was scanned from 350 to 750 mμ. If, however, the spectrophotometer is set on a wavelength at which a peak in the reflectance spectrum either increases or decreases with change in temperature, and the reflectance of the sample is measured as a function of increasing temperature of the sample, the technique becomes a "dynamic" one. The term "dynamic" refers to the change in reflectance of the sample with change in temperature. Because of the "dynamic" nature of this measurement, it is proposed that this technique be called "dynamic reflectance spectroscopy" (DRS).

The experimental apparatus consisted of a Bausch and Lomb Spectronic 505 spectrophotometer equipped with a standard diffuse reflectance attachment. The high temperature sample holder and power supply have been previously described (*3*). The reflectance of the heated sample, at a fixed wavelength, was measured by use of a time-rate accessory whose output was recorded on one channel of a Varian model G-22 strip-chart recorder. The temperature of the sample, as detected by a Chromel-Alumel thermocouple, was recorded on the other channel of the recorder. Mixtures of $CoBr_2 \cdot 6H_2O$ and Al_2O_3, approximately 30 and 70 percent, respectively, were studied. The reference substance was Al_2O_3.

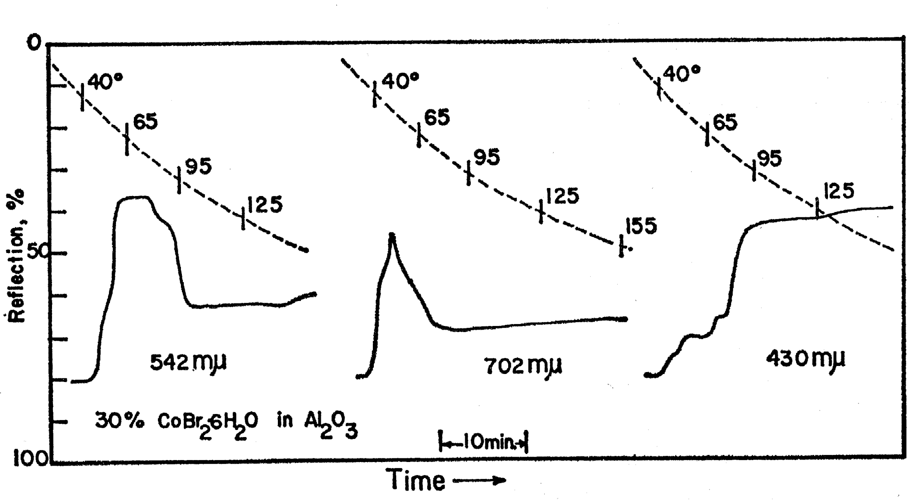

Fig. 2. Dynamic reflectance curves of a mixture of $CoBr_2 \cdot 6H_2O$ and Al_2O_3, 30 and 70 percent, respectively. Surface temperature of the sample is indicated by the dashed lines.

The reflectance curves of $CoBr_2 \cdot 6H_2O$ in alumina, at static ambient and elevated temperatures, are given in Fig. 1 while the curves obtained by the new technique at 430, 542, and 702 mμ, respectively, are given in Fig. 2.

At room temperature, the reflectance curve of $CoBr_2 \cdot 6H_2O$ had peak maxima at 550, 640, 665, 695, and 725 mμ. When the sample was heated to 50°C, all of the peaks increased in intensity, the most prominent increases were those peaks at 640, 665, 695, and 725 mμ. At 100°C, these peak maxima decreased in intensity, while the peak at 550 mμ increased. The change in intensity of these peaks with temperature is probably due to the formation of intermediate hydrates, the exact structures of which are not known at the present time. Various intermediate hydrates, from the 5-hydrate to the 0.5-hydrate, have been reported (*4*). The reflectance curves changed little from 150° to 250°C and were characterized by the presence of peak maxima at 640, 400, and a shoulder peak at 570 mμ. From these data, the curve at 150° seems to be that of the anhydrous $CoBr_2$. This conclusion is also substantiated from the thermogravimetry of a sample of $CoBr_2 \cdot 6H_2O$ in which the anhydrous $CoBr_2$ weight level was attained at about 150°C.

The dynamic reflectance spectroscopy curves show the formation and decomposition temperatures for the intermediate hydrates and the anhydrous $CoBr_2$. As the temperature is raised, the increase in the peak-intensities at 542 and 702 mμ is very pronounced. The peak in the 542-mμ curve is at a maximum at about 100°C and begins to fall off at about 125°C. The peak in the 702-mμ curve approaches a maximum at about 75°C, and then falls off rapidly with temperature. Of still greater interest is the curve at 430 mμ, which shows the formation of the anhydrous salt, $CoBr_2$, as the temperature increases.

This illustration is only one example of the application of the new technique to the study of coordination compounds. Others are the study of the thermal dissociation of colored salts and complexes, solid-state reactions in which there is a colored reactant or product, determination of thermochromic transition temperatures, and possible kinetic studies of the formation and decomposition of colored compounds. Unlike thermogravimetry and differential thermal analysis, dynamic reflectance spectroscopy can monitor only a single reaction at a time, thus eliminating the effect of reactions occurring simultaneously (*5*).

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Night Airglow Observations from Orbiting Spacecraft Compared with Measurements from Rockets

Abstract. *A luminous band around the night-time horizon, observed from orbiting capsules by J. H. Glenn and M. S. Carpenter, and identified as the horizon enhancement of the night airglow, is detected regularly in rocket-borne studies of night airglow. Values of luminance and dip angle of this band derived from Carpenter's observations agree remarkably well with values obtained from rocket data. The rocket results, however, do not support Carpenter's observation that the emission which he saw was largely the atomic oxygen line at 5577 Å, but assign the principal luminosity to the green continuum.*

Carpenter, O'Keefe, and Dunkelman described observations of the night airglow made on separate occasions by astronauts J. H. Glenn and M. S. Carpenter (*1*). The phenomenon observed was a bright band lying somewhat above the terrestrial horizon. The orbiting capsule was above the altitude where most of the visible airglow originates. Carpenter's observations of the horizon band are of particular interest because he made some astute naked-eye estimates of its luminance and dip angle which are of sufficient accuracy to stand comparison with measurements obtained from rockets. A value of the luminance, 6×10^{-7} candle/cm^2, or 6×10^{-7} lumen/cm^2 per steradian, was derived from the observation that the band appeared as bright as the moonlit terrestrial horizon. The dip angle was obtained by noting accurately the time of passage of a known star through the horizon band. The bright band was identified as principally the atomic-oxygen emission line at 5577 Å, by looking through a filter with peak transmittance at 5578 Å and 11-Å width at half-maximum. Through the filter the luminous band appeared to remain bright, while the horizon which was illuminated by the just rising sun, was not seen.

The rocket measurements with which Carpenter's observations are to be compared have been published, in part, by Packer (*2*). They were directed chiefly at finding the altitude distribution of various airglow emissions by measuring the radiance overhead during penetration of the emitting layer. However, direct radiometric measurements of the airglow horizon were also obtained. Some of these data can be transformed into luminance units, a requirement for comparison with Carpenter's visual estimates. The radiations which produce the major visual effect are the oxygen line, 5577 Å, and the green continuum. In our case the continuum was sampled at 5420 Å, which is near the wavelength region where the partially dark-adapted eye is most sensitive.

Typical horizon measurements for these emissions are shown in Figs. 1 and 2. Each curve represents the radiance seen by a photoelectric photometer whose line of sight scanned in a vertical plane and thus crossed opposite horizons. The green-line photometer of Fig. 1 had a field of view 2.2° in diameter and interference filter of 19-Å half-width (H.W.), centered at 5577 Å. The continuum photometer, Fig. 2, had a 4.4° field and an interference filter of 48-Å half-width centered at 5420 Å. The photometers were carried in an Aerobee-Hi rocket and were at an altitude of 143 km above the White Sands Missile Range when the data were recorded. This altitude is well above these airglow layers.

The figures show the striking sharpness of the airglow horizon; they also show that opposite horizons did not have the same radiance. The double peak near the nadir was caused by the town of Alamagordo and the Holloman Air Force Base nearby. Dotted portions of the curves indicate where the logarithmic amplifiers, which had a relatively long time constant at low signal levels, did not follow the photocurrent accurately.

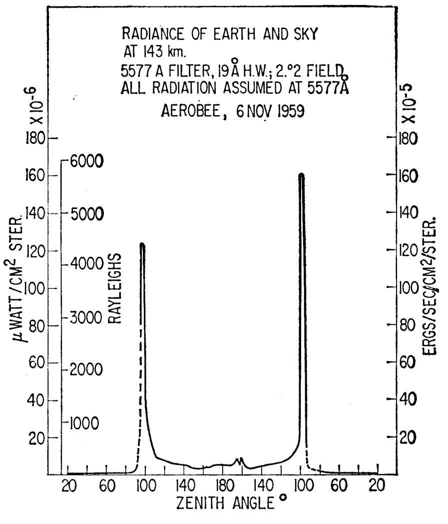

Fig. 1. Radiance of the 5577 Å atomic oxygen emission in the night airglow, as recorded by a narrow field photometer whose line of sight scanned in a vertical plane as illustrated in Fig. 4. The strong enhancement of the radiance near the horizons is shown.

Luminance values were calculated from the radiance curves of Figs. 1 and 2. The maximum value of horizon radiance of the 5577 Å radiation gives a luminance of 1.05×10^{-7} candle/cm^2. The continuum at 5420 Å corresponds

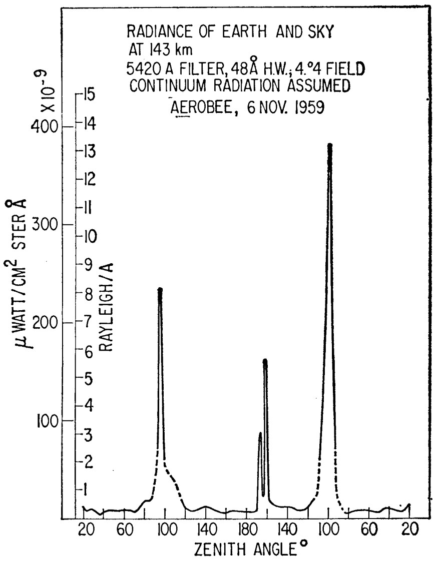

Fig. 2. The night airglow green continuum sampled at 5420 Å; measurement similar to that of Fig. 1.