approximately equivalent such that a term having a period P and two terms having a period $\approx P\cos 60°$ in H^{-1} exist in the susceptibility. However, if, as was actually the case in this study, H differs from perpendicularity to the 1-axis by a small angle δ as a result of inexact orienting techniques, then the observed periods will be given approximately by $P\cos\delta$ and $P\cos(60°\pm\delta)$.

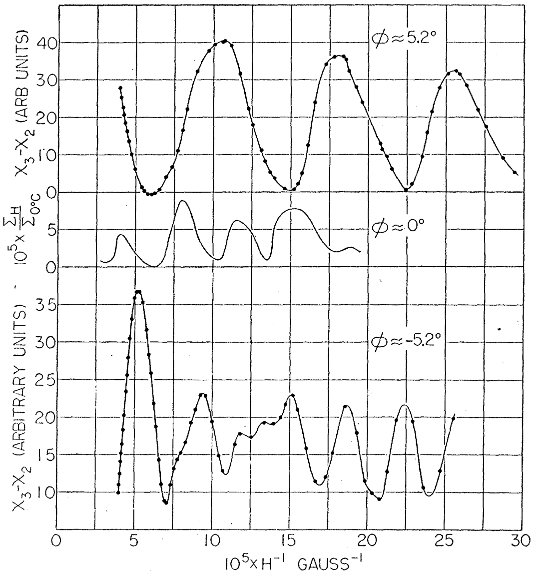

FIG. 1. The oscillating portion of the conductivity (as observed by Alers and Webber for $\phi=0$) and $\chi_3-\chi_2$ plotted as functions of H^{-1} for $T=4.2°$K.

In Fig. 1 the susceptibility data (which show essential agreement with Shoenberg's[3] lower field measurements) obtained at 4.2°K are plotted along with the data for the oscillating portion of the conductivity as observed by Alers and Webber also at 4.2°K. In the susceptibility curves the long period term ($P\cos\delta$) is most important for $\phi\approx5.2°$, while two shorter period terms ($P\cos[60°\pm\delta]$) predominate for $\phi\approx-5.2°$. A more illuminating means of comparison is provided in Fig. 2. The solid line is obtained by plotting values of H^{-1} for which maxima and minima in $\chi_3-\chi_2$ occur in the long period term for $\phi\approx5.2°$ against odd and even integers, respectively, and the dashed lines are obtained for the two short period terms derived from an analysis of the susceptibility curve for $\phi\approx-5.2°$. (This analysis also yielded a value of $\delta\approx2.5°$ illustrating the sensitivity of the short period oscillations to slight errors in orientation.) The open circles represent values of H^{-1} for which Alers and Webber (see Table II of reference 2) observed maxima in the oscillating portion of the conductivity. The proximity of these points to the dashed lines despite slightly different geometries supports the belief that the magnetoresistance oscillations have the same period as the short period susceptibility oscillations, and that both phenomena arise from a common electronic structure. Exact correlation would require that the open circles fall midway between the dashed lines. Then for H along the 2-axis a maximum in diamagnetism would correspond to a maximum in conductivity in the 3-direction. In the case of the long period term the conductivity data do not justify critical comparison, and it appears that effort toward a more rigorous correlation might profitably be devoted to an investigation of graphite in which the relevant de Haas-van Alphen electronic structure is less complicated.

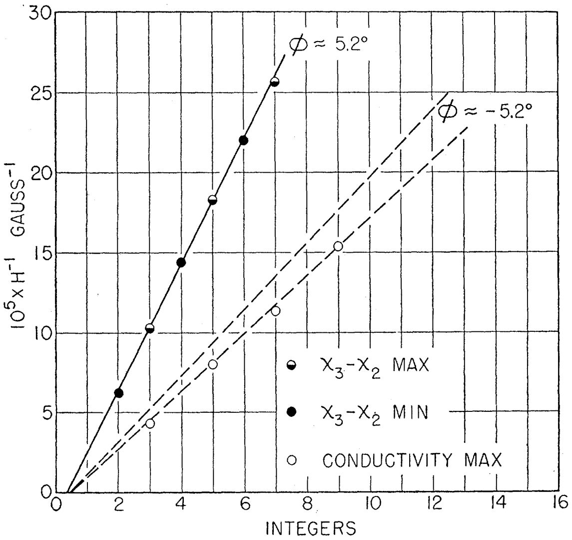

FIG. 2. Values of H^{-1} for which susceptibility and conductivity maxima and minima occur plotted against odd and even integers, respectively. The dashed lines represent the short period susceptibility oscillations.

I wish to express my thanks to Mr. P. B. Alers and Dr. R. T. Webber for the bismuth crystal and much helpful discussion.

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[4] The notation is that of Shoenberg in reference 3. The 1, 2, and 3 axes are orthogonal.

Lyman-Alpha Radiation in the Solar Spectrum

E. T. BYRAM, T. CHUBB, H. FRIEDMAN, AND N. GAILAR
U. S. Naval Research Laboratory, Washington, D. C.
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THE intensity of the Lyman-alpha line of hydrogen (λ1216A) in the solar spectrum was measured by means of photon counters flown in three Aerobee rockets at the White Sands Proving Grounds, New Mexico, during May 1952. Each flight provided a continuous telemetered record of the intensity *versus* altitude up to about 128 kilometers. A preliminary study[1] of the data showed that HL_α was first detected[2] at approximately the same altitude in each flight, 74±2 km (18°–20° sun elevation). From the variation of intensity with residual air path, an absorption coefficient was computed, 0.046 cm^{-1} (base e, NTP) which compares well with 0.063 cm^{-1} obtained in laboratory measurements of the attentuation of HL_α in dry air at low pressures.[3,4] The discrepancy between these two absorption coefficients is equivalent to an altitude error of 2.2 kilometers or a 27 percent difference in pressure. Pressure data were taken from the Rocket Panel report[5] and are estimated to have a probable error of ±15 percent in the neighborhood of 80 kilometers.

The photon counters used in these flights were sensitive to a narrow band of wavelengths from 1180A to 1300A. Although the spectral sensitivity curve between these limits had a jagged appearance due to the absorption lines of chlorine gas, which was one of the gas components in the photon counter, the sensitivity over a range of several angstroms in the immediate neighborhood of HL_α was fairly constant. The conversion from counting rate to flux of incident energy was obtained by comparison with the response of photomultiplier tubes coated with sodium salycilate or vacuum pump oil,[6,7] which were in turn compared with a calibrated mercury lamp at λ2536A. By a stroke of good fortune, the photon counter tube used in the most satisfactory flight was recovered undamaged. It was subjected to careful recalibration during the past year and no significant drift in characteristics from its preflight calibration was detected. The measured solar intensity based on this tube was 0.10±0.02 erg cm^{-2} sec^{-1} at the top of the atmosphere. No unusual solar activity was observed during the flight. The present result is lower than the 0.4 ergs cm^{-2} sec^{-1} previously reported by Tousey, Watanabe, and Purcell[8] based on exposure of a thermoluminescent powder, responsive to the wavelength band 1050–1240A. Pietenpol *et al.*[9] recently reported photographic detection of HL_α in a flight that exceeded 80 km and estimated the intensity to be of the order of magnitude of 0.3 erg cm^{-2} sec^{-1}.

The straight line character of the plot of logarithm of intensity *versus* residual air path shown in Fig. 1, is evidence for the monochromatic nature of the radiation that was measured. Hopfield's spectrograms[10] revealed the existence of a deep window in the O_2 absorption spectrum at HL_α and Watanabe, Marmo, and Inn[3] recently published quantitative measurements of the absorption coefficients in the neighborhood of this window. Within ±1.0A on either side of HL_α, the absorption coefficient increased by at least 200 percent. The constancy of the measured absorption coefficient over the entire altitude range of the rocket therefore indicates that the breadth of the solar emission line must certainly be less than one angstrom unit. Pietenpol[9] judged the width of his photographed line to be about 6A. In view of the narrowness of the O_2 window, such an observed line width at 80 km would be difficult to explain except as instrumental broadening.

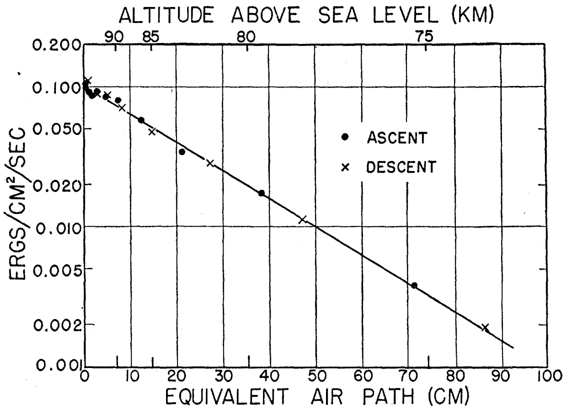

FIG. 1. Log incident energy *versus* the equivalent air path at NTP traversed by solar radiation as measured with a photon counter sensitive in the 1180–1300A region.

At the peak of the flight, 128 km, the rocket was above the molecular oxygen atmosphere. Figure 1 does not indicate all the data points obtained near the top of the flight. The rocket spent 140 seconds above 105 kilometers during which time the roll of the rocket exposed the photon counter to the sun 28 times. The rms deviation of the counting rates measured for these 28 exposures was ±6 percent, and the average value of the intensity fell within one percent of the straight line plot of Fig. 1. Any appreciable intensity outside the HL_α wavelength would have appeared in excess of the intercept of the HL_α characteristic at zero residual air path. It may be concluded from these observations and the spectral sensitivity curve of the photon counter that the continuous solar emission background in the neighborhood of 1200A must have been less than 0.01 erg cm^{-2} sec^{-1} per 100A. This is equivalent to a black body temperature less than 4600 degrees K.

It has been suggested that absorption of HL_α by NO may provide the observed *D*-layer ionization.[11, 12] The present rocket data do not exclude this possibility. Although the rocket data have been explained by attributing all the absorption to O_2, a weak absorption due to nitric oxide or water vapor could have been present within the experimental error. If we assume that the contribution of H_2O or NO to the absorption observed in the rocket experiment was less than ten percent, the maximum concentrations relative to air must have been less than 1.6×10^{-5} and 9.4×10^{-5}, respectively, using absorption coefficients[3, 4] of 390 cm^{-1} and 67 cm^{-1} for H_2O and NO. The latter concentration is equivalent to an upper limit of 0.007 cm (NTP) of NO above 75 km, well below the value of 0.02 cm (NTP) given by Migeotte and Neven[13] as the maximum possible abundance based on their studies of the solar spectrum in the infrared. Watanabe *et al.*[3] have found that approximately 50 percent of the absorption of NO at the wavelength of HL_α leads to photoionization. If only one percent of the HL_α intensity observed in the rocket experiment were absorbed by NO, the rate of ion production in the *D* layer would average about 15 ion pairs cm^{-3} sec^{-1}, which is of the order of magnitude required to produce the *D* layer.[11]

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The Shape of Exchange Narrowed Paramagnetic Resonance Lines*

R. T. WEIDNER AND C. A. WHITMER
Department of Physics, Rutgers University, New Brunswick, New Jersey

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THE theory of Anderson and Weiss[1] on exchange narrowing in paramagnetic resonance absorption predicts that the line shape in the case of large exchange interaction is of the resonance or Lorentz type in the observable center of the line. Organic free radicals, having very narrow absorption lines, are suitable substances for testing the validity of the line shape prediction. Measurements at 3.2-cm wavelength do indeed show that the diphenyl picryl hydrazyl absorption follows the resonance line shape.

The absorption curves were derived from recorder tracings which were made by a procedure that has been described.[2] The

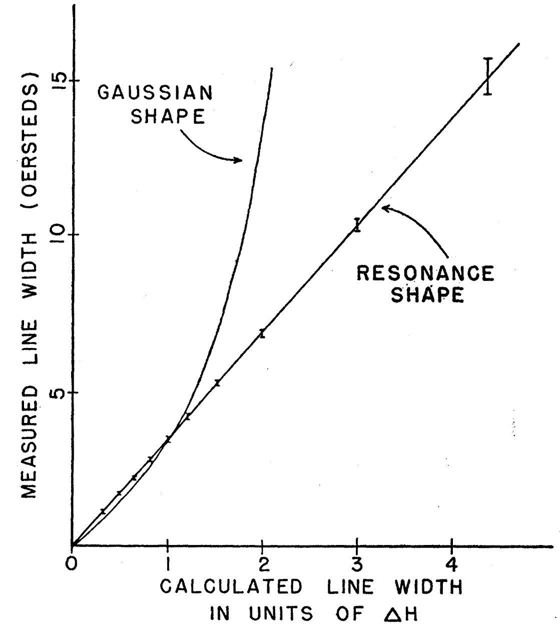

FIG. 1. Shape analysis of diphenyl picryl hydrazyl resonance at 4.2°K and 3.2-cm wavelength.