with a repetition rate of only 10 per second would yield an average power of 20 milliwatts—a power somewhat above that presently available (considerably less than 1 μw). If multiple pumping could be employed, pulsed fields of the order of a kilo-oersted would be sufficient.

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SMEKAL-RAMAN TYPE MODIFIED X-RAY SCATTERING

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The spectroscopic analysis of x-ray beams, scattered from some low atomic number elements, viz., carbon, beryllium, and aluminium, made with the help of the two-crystal spectrometer, multicrystal spectrograph, and focusing spectrograph by DuMond,[1] Bearden,[2] Gingrich,[3] Ehrenberg,[4] and a few others, verified the existence of Rayleigh (unchanged frequency) and Compton scattering but could not detect the existence of the phenomenon of the partial absorption of photons of Smekal-Raman type.

With scatterer carbon and a monochromatic incident x-ray beam of energy $h\nu$, the frequency ν' of the modified line of Smekal-Raman type can be calculated from the equation $h\nu' = h\nu - \delta E$, where δE in a typical process will correspond to the energy difference between the initial ($1s^2 2s^2 2p^2$) and the final ($1s^1 2s^2 2p^3$) state of the carbon atom. The value of δE for the element carbon as obtained from the x-ray K-absorption data is 282.2 ev and the wavelengths of the Smekal-Raman type modified lines due to incident copper and molybdenum radiations, viz. (1) Cu $K\alpha_1 = 1537.4$, (2) Cu $K\alpha_2 = 1541.2$, (3) Cu $K\beta_1 = 1389.4$, (4) Mo $K\alpha_1 = 707.8$, (5) Mo $K\alpha_2 = 712.1$, and (6) Mo $K\beta_1 = 630.98$ xu (Siegbahn x units), will be (1) 1593.3, (2) 1597.4, (3) 1434.9, (4) 719.5, (5) 723.9, and (6) 640.2 xu, respectively.

With the help of a bent mica ($d = 2.554$ A) Cauchois spectrograph (diameter of the focal circle = 9 inches) and also a bent quartz ($d = 1.178$ A) spectrograph (diameter of the focal circle = 5.5 inches) and using $K\alpha$ and $K\beta$ radiations of copper and molybdenum from the sealed-off x-ray tubes, with graphite (reactor quality), polystyrene (for carbon), and beryllium as scattering specimens, the modified lines of Smekal-Raman type have been observed in calculated positions using both the spectrographs for each of the scattering specimens. Figures 1 and 2 are the tracings of the original microphotometer records, clearly showing (1) Rayleigh lines, (2) Compton bands, and (3) Smekal-Raman type of modified lines in x-ray scattering.

The sealed-off x-ray tubes (Matchlett) were run at 12 to 15 ma at 40 kv and the period of exposure

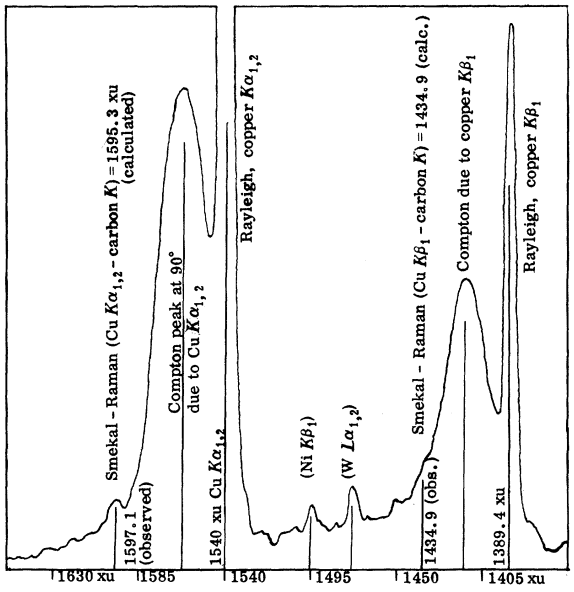

FIG. 1. Spectroscopic analysis of Cu target radiation scattered at ~90° by polystyrene with the help of the bent mica Cauchois spectrograph. The photometer record clearly shows (1) Rayleigh lines, viz., Cu $K\alpha_{1,2}$ and $K\beta_1$; (2) Compton bands due to $K\alpha_{1,2}$ and $K\beta_1$; (3) modified Smekal-Raman lines due to Cu $K\alpha_{1,2}$ and $K\beta_1$. Dispersion on the film = 21.6 xu/mm. The $K\alpha_{1,2}$ lines are not resolved.

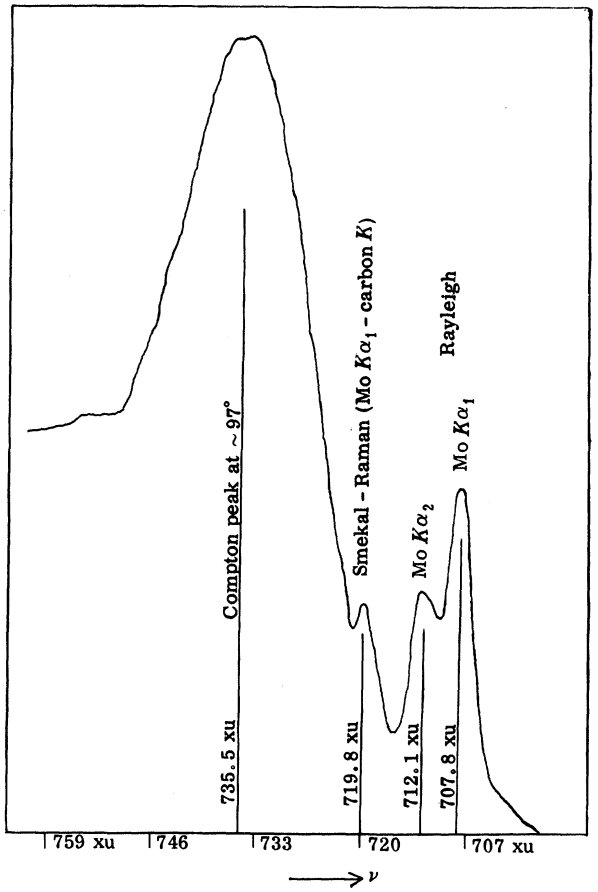

FIG. 2. Spectroscopic analysis of Mo target radiation scattered at ~97° by graphite, with the bent quartz Cauchois spectrograph. The photometer record shows clearly (1) Rayleigh lines, viz., Mo $K\alpha_1$ and $K\alpha_2$, (2) strong Compton band, and (3) the modified Smekal-Raman line due to Mo $K\alpha_1$; that due to $K\alpha_2$ overlaps with the short-wavelength end of the Compton band and is just visible in the original negative. The dispersion as measured in the original negative = 16.1 xu/mm.

varied between 100 and 150 hours. The target radiations from both copper and molybdenum were spectroscopically analyzed by giving prolonged exposures, and, only in the case of the copper target tube, $K\alpha$ lines of nickel and $L\alpha$ of tungsten appeared in the spectrum. The molybdenum target was, however, free from any such surface contamination of nickel and tungsten. The scattered radiation from graphite and polystyrene has been studied at scattering angles of approximately 90° (Fig. 1) and 97° (Fig. 2). The effective width of the bent crystal was about 6 mm and the slit in between the scatterer and the bent crystal is made of pure copper which allowed a beam of 6 mm×4 mm. The approximate distance between the scatterer and the focal spot of the target is about 1.5 inches. The effective irradiated area of the piece of graphite of 5 mm thickness is 1 cm×6 mm. The piece of graphite was kept at 45° to the direction of the incident beam. The scattering experiments with carbon and with beryllium have been done by keeping the spectrograph setting exactly the same, only the piece of graphite is replaced by a similar piece of beryllium. The observed modified lines due to carbon appeared at 282-ev gap and that due to beryllium at 116-ev gap on the low-energy side of the primary $K\alpha$ of copper or of molybdenum. The preliminary experiments made with the samples of extra pure magnesium and aluminium as scatterers, at different setting angles of the spectrograph, confirmed beyond doubt that the modified lines due to graphite, polystyrene, and beryllium appearing at the calculated positions cannot be due to any impurities either in the target or in the sample.

Although modified lines have been obtained with

different scatterers, viz., Be, C (graphite, polystyrene, apiezon oil), Mg, Al, Cu, and Fe at calculated positions, most of them are, however, extremely weak in intensity and it has not been possible to take their microphotometer records. It is hoped that by using the high light gathering power spectrograph, high contrast films, strong x-ray sources, and selecting suitable angles of scattering so as to have the minimum background due to the tail of the Compton band or the higher order Bragg reflections due to the white part of the target radiation, it will be possible to study, from this newly observed modified scattering, the term values of the elements and also the energy levels of the solid state.

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GROUND STATE Λ-DOUBLING TRANSITIONS OF OH RADICAL*

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One of the molecules whose presence in interstellar space may be detectable by means of its radio-frequency spectrum is the OH radical.[1] Attempts at observing it with radio telescopes have been unsuccessful thus far.[2] To make future searches more fruitful, frequencies of the appropriate absorption lines were measured in the laboratory with a Zeeman-modulated spectrometer.

For OH, at temperatures prevailing in interstellar space, only the lowest rotational state ($J=\frac{3}{2}$) of the $^2\Pi_{3/2}$ electronic state will be appreciably populated. This lowest energy level is split by Λ doubling into two levels 1666.4 Mc/sec apart. Each of the two Λ-doublet levels is split further by hyperfine interactions with the hydrogen nucleus, so that the spectrum consists of four absorption lines. The two stronger transitions, having no change in the total angular momentum $F(\Delta F=0)$, were measured and their frequencies are given in Table I together with frequencies calculated from expressions given by Dousmanis, Sanders, and Townes.[3] According to theory, the intensity ratio between the $F=2\leftarrow F=2$ and $F=1\leftarrow F=1$ transitions should be 9:5, and this was verified experimentally. Substantially the same ratio should prevail in interstellar space. The transitions with $\Delta F=\pm 1$ are expected to be about ten times weaker and have not been observed as yet.

Table I. Observed and calculated frequencies for Λ-doubling transitions in $J=\frac{3}{2}$ rotational state of $^2\Pi_{3/2}$ electronic state of OH radical.

Hyperfine transition	Experimental frequency (Mc/sec)	Calculated frequency (Mc/sec)
$F=2\leftarrow F=2$	1667.34 ± 0.03	1666.5
$F=1\leftarrow F=1$	1665.46 ± 0.10	1664.6

OH radicals were produced outside the absorption cell by an electrodeless radio-frequency discharge.[3] The microwave spectrometer was conventional in design except for the Zeeman-modulation technique. The absorption cell was a glass-lined, coaxial waveguide about $2\frac{1}{2}$ feet long and $1\frac{1}{4}$ inches in diameter. This coaxial cell was used both to propagate low-frequency microwave power and to provide Zeeman modulation. The modulating magnetic field was obtained by passing a large current through the center rod and back along the outer conductor. This produces a magnetic field between the two conductors which ideally does not extend outside the waveguide. The very small leakage fields which were obtained produced only very low pickup in the detecting circuits, whereas the pickup was quite troublesome when a conventional solenoid was wound around the