from the room temperature values of R. b_D is obtained from extrapolation of the resistivity at very low temperatures and with the help of Eq. (5). The calculated resistivity and Hall curves are shown in Figs. 1 and 2 together with the experimental curves for two of the samples. For the other samples, experiment and theory also agree. However, except when the Hall coefficients are measured to very low temperatures, it is not always possible to ascertain whether the carriers in the impurity bands behave as electrons or as holes. The mobility in the impurity bands varies between 10^{-4} and 100 cm²/volt-sec. for impurity concentration between approximately 10^{14} and 10^{17}/cc.

* Work assisted by Signal Corps contract.
[1] C. S. Hung and J. R. Gliessman, Phys. Rev. **79**, 726 (1950).
[2] Ginzbarg, Ph.D. Thesis, Purdue University, Department of Physics, (1949).

Infra-Red Spectra of Condensed Oxygen and Nitrogen*

A. Lee Smith, William E. Keller, and Herrick L. Johnston
Cryogenic Laboratory and Department of Chemistry, Ohio State University, Columbus, Ohio
June 19, 1950

INFRA-RED absorption spectra of condensed O_2 and N_2 have been obtained using a model 12-B Perkin-Elmer spectrometer. The chemically purified gases were purified further by distillation of the liquids, and were finally condensed in a variable thickness low temperature cell[1] fitted with silver chloride windows. Since induced infra-red absorption is weak, a sample thickness of about 7.5 mm was employed throughout the temperature range investigated, 35° to 85°K. A NaCl prism was used in the study of the O_2 fundamental, and a LiF prism for N_2. Careful corrections for water vapor and carbon dioxide absorption gave a reproducibility of ±2 percent transmission on different runs at the same temperature.

Figure 1 shows the absorption in the 1550 cm^{-1} region of the liquid, solid-γ-, and solid-β-O_2. The central frequency at 1559 cm^{-1} in the liquid is the same within experimental error as that given

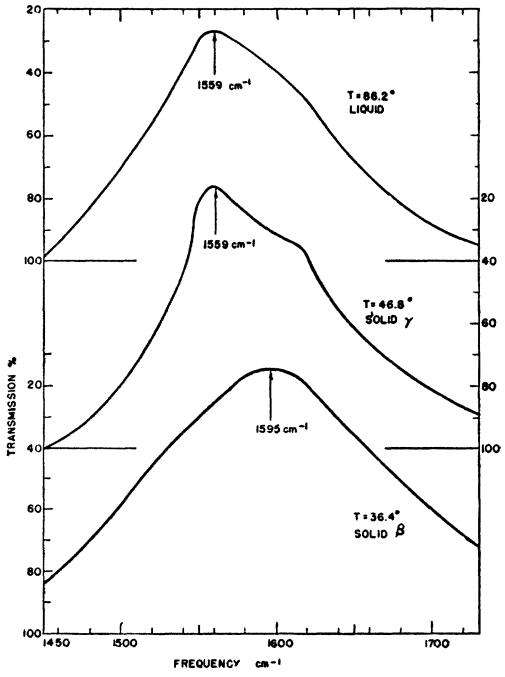

FIG. 1. Infra-red absorption spectra of condensed oxygen.

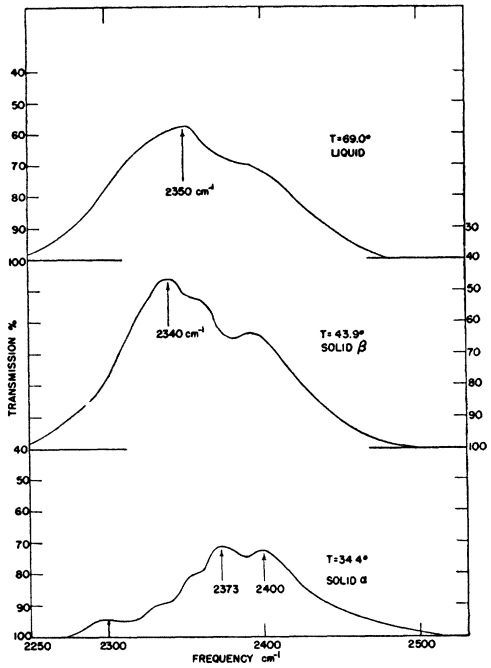

FIG. 2. Infra-red absorption spectra of condensed nitrogen.

for the gas by Crawford and his co-workers.[2] There is no detectable frequency shift as the liquid freezes to solid-γ at 55°K, nor is the transmission reduced. β-O_2, however, is highly scattering, and to register spectra of this phase a slit-width ten times greater than that used for the liquid was necessary.

The analogous results for the three condensed phases of N_2 are shown in Fig. 2. As the liquid freezes at 63°K the character of the absorption remains unchanged, but as the temperature is lowered further there is a gradual shift of the central peak from 2350 to 2336 cm^{-1} at 39°K. On going from solid-β to solid-γ at 36°K, transmission is somewhat reduced and the band center is replaced by two distinct peaks of equal intensity at 2373 and 2400 cm^{-1}.

The fact that the fundamental vibrational band appears in β-N_2 but only weakly in the α-form suggests that in the former phase the molecules are disordered, while in the latter they are ordered.[3] The two strong peaks in the α-N_2 spectrum are probably librational modes having frequencies[3,4] of 40 and 69 cm^{-1} in combination with the comparatively weak fundamental; a weaker subtractive combination is found at 2300 cm^{-1}. An interpretation of the spectrum of β-O_2 cannot be made at this time because of the unusually poor resolution encountered.

A more detailed account of this work and a possible interpretation of the observed envelopes will be presented later.

* This work was supported in part by the ONR under contract with The Ohio State University Research Foundation.
[1] Holden, Taylor, and Johnston (to be published).
[2] Crawford, Welch, and Locke, Phys. Rev. **75**, 1607 (1949).
[3] J. Deitz, Franklin Inst. **219**, 565 (1935).
[4] Vegard, Nature **124**, 267 (1929); **125**, 14 (1930).

Beta-Gamma-Angular Correlation Experiments*

J. R. Beyster and M. L. Wiedenbeck
Department of Physics, University of Michigan, Ann Arbor, Michigan
June 19, 1950

IN recent months several positive examples of beta-gamma-directional correlation have been found. Correlations have been reported for Rb^{86},[1,2] Tm^{170},[2] and Sb^{124}.[3] In many cases, however, no correlation seems to exist.[4]

For these experiments we have used the scintillation counter coincidence apparatus described previously.[3] The sources were mounted on thin zapon film and were at most 1 mg/cm² in thickness. In taking data, the beta-gamma-coincidence rate was observed as a function of angle between counter axes. Runs of 1000 sec. were taken alternately at two angles. The average coincidence rate was based on about 10 runs at each angle. These runs were always consistent statistically.

One of the first substances investigated was K^{42}. Both the individual beta- and gamma-counting rates followed the 12.4-hour half-life. The observed correlation function, listed in Table I, did not appear to depend on whether the experiment was performed in vacuum or at atmospheric pressure, and was not critically sensitive to source thickness. The correlation function was observed with all energies of beta-particles entering the counter. The function does not seem to change perceptibly when electrons with less than 600 kev are not counted. The asymmetry between the 90° and 180° positions has been observed on at least 10 separate occasions with different sources and various experimental arrangements. It might also be pointed out that the apparatus with slight modification was used in performing gamma-gamma-correlations experiments[5] on Co^{60}, Cs^{134}, Na^{24}, and Rh^{106}. The observed functions, in general, agreed with previous work.[6] In addition beta-gamma-correlation experiments have been run with this apparatus on the other activities listed in Table I. The negative results on Na^{24}, Co^{60}, Cs^{134}, and Cd^{115} are consistent with other published work on these activities.[4]

Sources for this work were obtained from the University of Michigan cyclotron and from Oak Ridge. It was necessary to separate sodium from potassium in both the cyclotron and pile produced sources.

The decay scheme of K^{42} has been discussed by Shull and Feenberg.[7] They suggest the angular momenta and parities given in Fig. 1 on the basis of the lifetime and E_{max} for each beta-transition, the shape of the higher energy beta-spectrum, and shell model considerations. Both beta-transitions are thus first forbidden with Gamow-Teller selection rules. According to these selection rules, the lower energy beta-transition may involve four matrix elements. The observed beta-gamma-angular correlation function seems to be compatible with the angular momenta suggested by Shull and Feenberg and with the selection of B_{ij} as a prominent matrix element in the lower energy beta-transition.

The absence of noticeable beta-gamma-angular correlation for Na^{24}, I^{131}, Cs^{134}, and Co^{60} is understandable, since one should not expect to find an asymmetry where the Fermi plot for the beta-spectrum is of the allowed type. Since Cd^{115} has a decay scheme similar to that of K^{42}, it is possible for Gamow-Teller selection rules to again have more than one matrix element present for the lower energy beta-transition. The over-all asymmetry may thus be small if matrix elements occur in the correct proportion. The angular correlation is also Z dependent which may explain in part the lack of a significant effect[8] for Cd^{115}.

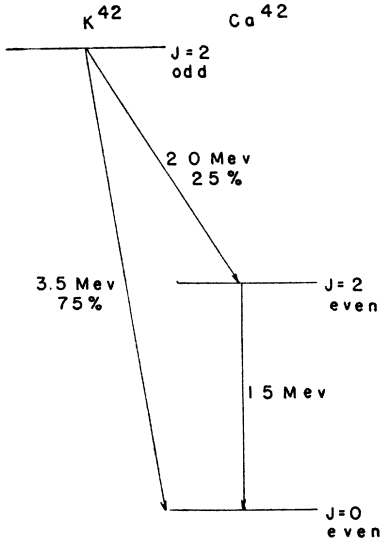

FIG. 1. Decay scheme of K^{42}.

TABLE I. Ratio of the observed beta-gamma-coincidence rate at 180° to that at 90° for various substances.

Isotope	$C(\pi)/C(\pi/2)$
K^{42}	0.938 ±0.015
Na^{24}	1.005 ±0.01
I^{131}	1.00 ±0.029
Cs^{134}	1.00 ±0.018
Co^{60}	0.98 ±0.03
Cd^{115}	0.99 ±0.027
Sb^{124}	0.73 ±0.035

The authors would like to thank Professor G. E. Uhlenbeck and Dr. E. S. Lennox for the many helpful discussions of this problem, and to express their gratitude to the cyclotron staff for sources prepared during the course of this investigation.

* This work was supported in part by AEC.

[1] D. T. Stevenson and M. Deutsch, Phys. Rev. **78**, 640 (1950); R. Stump and S. Frankel, Phys. Rev. **79**, 243 (1950).
[2] T. B. Novey, Phys. Rev. **78**, 66 (1950).
[3] J. R. Beyster and M. L. Wiedenbeck, Phys. Rev. **79**, 169 (1950).
[4] R. L. Garwin, Phys. Rev. **76**, 1876 (1949); Grace, Allen, and Halban, Nature **164**, 538 (1949); S. L. Ridgeway, Phys. Rev. **79**, 243 (1950).
[5] J. R. Beyster and M. L. Wiedenbeck, Phys. Rev. **79**, 411 (1950).
[6] E. L. Brady and M. Deutsch, Phys. Rev. **78**, 558 (1950).
[7] F. B. Shull and E. Feenberg, Phys. Rev. **75**, 1768 (1949).
[8] M. Fuchs and E. S. Lennox, Phys. Rev. **79**, 221 (1950).

Neutron-Deuteron Scattering at 4.5 and 5.5 Mev*

ERNEST WANTUCH**
Brookhaven National Laboratory, Upton, New York
June 16, 1950

THE angular distribution and differential cross section of 4.5- and 5.5-Mev neutrons scattered by deuterons were investigated. The source of neutrons for this investigation was the $D+D \rightarrow n+He^3+3.26$ Mev reaction. Incident deuterons were accelerated by the pressurized van de Graaff Generator at the Department of Terrestrial Magnetism. The target consisted of a thin volume of deuterium gas at atmospheric pressure, separated from the vacuum system by a 0.0001-in. nickel foil. Neutrons emitted in the forward direction within a cone of 3° half-angle, having a calculated energy spread of ±100 kev, were incident on the scatterer. The scattering materials were 7.5 cm³ of deuterium gas at atmospheric pressure or a 0.001-in. layer of heavy paraffin. Recoil deuterons ejected from the scatterer were detected by a twofold coincidence proportional counter telescope. These counters were filled with 25:1 argon-carbon dioxide mixture to a pressure of a few centimeters of mercury. They were operated at a gas amplification of approximately 100. Individual pulses were amplified with amplifiers having a pulse rise time of 0.2 μsec. They were shaped by a univibrator to a duration of approximately 1 μsec. Individual pulses were recorded on scales-of-64. A Rossi coincidence circuit using 6AU6 pentodes was used to determine coincident pulses.

The neutron source was monitored by the accompanying $D+D \rightarrow p+T+3.98$ Mev reaction, the protons being recorded by a small end-window proportional counter opposite a thin mica window in the side of the gas target.

All coincidence counting rates were normalized to a constant number of counts by the monitor. The deuteron current incident on the gas target was integrated as a check on the above-mentioned method of monitoring. The absolute yield of the neutron source was obtained from the results of Hunter and Richards.[1]