On the Isomerism of Xe^{131}

INGMAR BERGSTRÖM
Nobel Institute of Physics, Stockholm, Sweden
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FOUR substantially different decay schemes of I^{131} have been reported.[1] Recently it was shown by absorption measurements[2] that the 163-kev γ-ray is due to an isomeric transition in Xe^{131}. It was thought that more detailed information on Xe^{131m} would be of help in deciding between the suggested decay schemes of I^{131}.

The electromagnetic isotope separator of this Institute was used to prepare an extremely thin β-spectrometer sample.[3] Xe^{131m} produced in the decay of 10 mC I^{131} (obtained from Harwell) was mixed with some stable Xe gas to make the Xe spectrum visible on a fluorescent screen. The activity of mass number 131 was collected on an Al foil (0.15 mg/cm), which was used as β-spectrometer sample.[3] The half-life of Xe^{131m} was found to be 12.0 ± 0.3 days. Figure 1 shows the β-spectrum measured with a resolving power of about one percent in the double focusing β-spectrometer and with a 3.9 mg/cm^2 mica G-M window. The energy of the conversion electrons obtained in this way corresponds to an energy of 162.9 ± 0.4 kev for the γ-ray emitted in the isomeric transition.

In order to search for the conversion lines of the γ-rays of energies 80, 284, and 364 kev as required by the decay scheme of Cork *et al.* a very strong sample was used in a high transmission lens spectrometer with a thin G-M window (cut off $\sim$8 kev). Except the Auger lines no conversion lines with an intensity >0.0005 of the K-line of Xe^{131m} are present. This fact seems to invalidate the decay scheme of Cork *et al.* The 177-kev line found by these authors may be due to a very weak Te^{131m} contamination.

From an analysis of the β-spectrum obtained in the double focusing β-spectrometer, $N_L/N_M=3.4\pm0.4$ was obtained. This value was used to obtain a correct value for the intensity ratio of the K and L conversion electrons obtained from measurements in the lens spectrometer (no window absorption for the K electrons). Thus $N_K/N_L=2.34\pm0.20$. The half-life relation[4] corrected for internal conversion[5] makes $l=5$ most probable. This assignment is also in good agreement with the isomer classification curves of Axel and Dancoff.[6] For $l=5$, $N_K/N_L\approx0.8$ according to the curves of Hebb and Nelson. This would indicate a mixture of 2^5 pole electric and 2^4 magnetic radiation corresponding to a spin difference of 4 and parity change in accordance with nuclear shell theory.[7] The high spin difference associated with the 163-kev γ-ray transition and the spin terms from the coupling theory[7] makes the decay scheme of Owen *et al.* unlikely. Lind *et al.* have also shown[8] by means of precision γ-measurements that this decay scheme is improbable.

The fact that the 163-kev γ-ray seems to decay directly to the ground state of Xe does not fit either the decay scheme of Metzger and Deutsch or that of Kern *et al.* It may therefore be possible that I^{131} decays to Xe^{131m} with a β-ray of about 800 kev to such a small amount that it hardly can be detected because of the strong overlapping 600-kev β-spectrum. This suggestion is also in agreement with the requirements of the nuclear shell theory.[7] Since the spin of Xe^{131} is $\frac{3}{2}$, the ground state of Xe would be a $d_{3/2}$ level and the isomeric state corresponds to the level $h_{11/2}$. The ground state of I^{131} would be $g_{7/2}$. The hypothetical β-transition $g_{7/2}\rightarrow h_{11/2}$ would then be associated with $\Delta L=1$ and $\Delta I=2$. According to Shull and Feenberg[9] the approximate formula $(W_0^2-1)f\cdot t=10^{10}$ is valid in this case. Feister *et al.*[2] showed that about one percent of the I^{131} disintegrations will lead to the metastable state of Xe^{131}. Using this fact and the predicted β-energy 800 kev $(W_0^2-1)f\cdot t=0.6\cdot10^{10}$ is obtained. Even if the ground state of I^{131} is $d_{5/2}$, the transition probability for the 800-kev β^- would be very small, showing that the suggested decay is also plausible from the point of view of the nuclear shell model.

All β-spectrometer investigations of electromagnetically separated rare gases recently performed at this Institute will later appear in detail in Arkiv för Fysik.

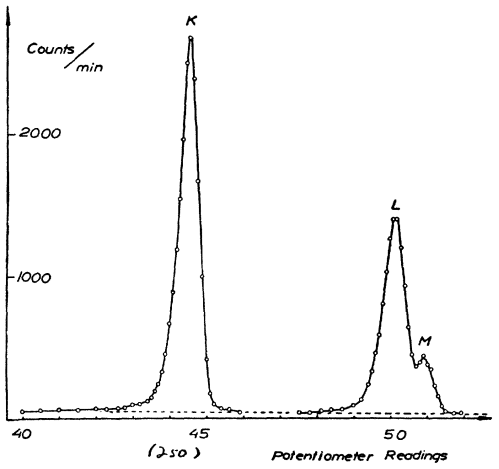

FIG. 1. β-spectrum of Xe^{131m} measured in the double focusing spectrometer with a resolving power of $\sim$one percent.

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[2] Brosi, De Witt, and Zeldes, Phys. Rev. **75**, 1615 (1949).
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[8] Lind, Brown, Klein, Muller, and Du Mond, Phys. Rev. **75**, 1544 (1949).
[9] F. B. Shull and E. Feenberg, Phys. Rev. **75**, 1768 (1949).

Microwave Magnetic Resonance Absorption in Nitrogen Dioxide*

J. G. CASTLE, JR.† AND ROBERT BERINGER
Sloane Physics Laboratory, Yale University,‡ New Haven, Connecticut
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WE have observed the absorption arising from magnetic dipole transitions between magnetic sublevels of rotational states of NO_2. The apparatus is similar to that described previously.[1]

The ground state of nitrogen dioxide has been extensively studied.[2] The state is analogous to a $^2\Sigma$-type with an almost free magnetic moment arising from the spin of the odd electron. There are two magnetic interactions present which give a field-free structure to each rotational level. According to McAfee's observation,[3] the energy of coupling of the electron spin with the spin of the N^{14} nucleus ($I=1$) is of the order of 100 Mc/sec., and is about twice the coupling of the rotational moment (per unit J) to the electronic moment. Therefore, observations at 9360 Mc/sec. would show a rather complete uncoupling of these three magnetic moments.

The observed spectrum at room temperature and a gas pressure of 5 to 15 mm Hg consists of three overlapping lines located at 3303, 3351, and 3398 oersteds. The "free spin" transition[4] with no diamagnetic correction would be located at 3339 oersteds. Outside the triplet there are broad tails which represent the sum of overlapping lines. At lower pressure the spectrum is partially resolved into a large number of lines.

The gas was made by the reaction of oxygen with nitric oxide and separated by condensation. The pressure in the microwave cavity was determined by the temperature of solid NO_2 in a side tube and was read from an extrapolation of Giaque's measurements.

The spectrum is interpreted in terms of a Paschen-Back effect on the three magnetic moments in the molecule. For a particular rotational level, J, K, the energy is approximately

$$W=M_S g_S \mu_0 H+A\ M_S M_I+B\ M_S M_J,$$

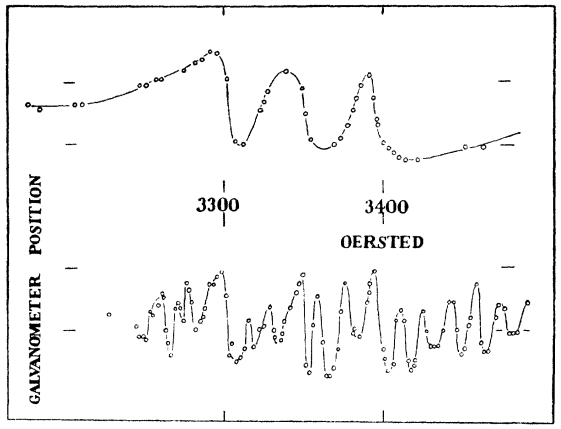

FIG. 1. Magnetic resonance absorption spectra of NO_2 at 9360 Mc/sec. The circles are output galvanometer readings; galvanometer deflections are proportional to the first derivative of the absorption contour. The upper figure shows the three-peaked band at 5.0 mm Hg and 290°K with a modulation amplitude of 8.4 oersteds. The lower figure is for 1.3 mm Hg, 290°K, and 2.1 oersteds.

where the coupling energies A and B may depend on J and K. The magnetic moment generated by the molecular rotation is assumed to be proportional to J, the total rotational angular momentum quantum number. Using the approximation that the rotational energies are given by the symmetric top expression,[3,5,6]

$$F=0.417J(J+1)+5.87K^2 \text{ cm}^{-1},$$

the partition function is 2700 at room temperature. It is evident that several hundred rotational levels contribute lines of low intensity, and that an observed resonance is the sum of a number of such.

Selecting the transition $\Delta J=0$, $\Delta M_s=1$, $\Delta M_I=\Delta M_J=0$, and summing over J, K, M_I, and M_J (with A independent of J and K), one predicts a three-peaked band of absorption lines with the spacings between the peaks equal to A. The envelope of line intensity retains this shape at low pressure.

The general features of the partially resolved spectrum are predicted by this model with B approximately equal to $A/2$. The sharpness of the lines indicates that the spin-rotation term is almost independent of J and K. The coupling of the spin of the odd electron to the spin of the N^{14} nucleus is $A=132$ Mc/sec.

* This study, together with that of reference 1, was part of a dissertation by one of us (JGC) presented for the degree of Doctor of Philosophy in Yale University.

† Du Pont Company Fellow in Physics (1949–50); present address: University of Buffalo, Buffalo, New York.

‡ Assisted by the ONR.

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Angular Correlation of the Gamma-Rays Emitted from the Excited States of A^{38}

ROLF M. STEFFEN
Department of Physics, Purdue University, Lafayette, Indiana*
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FROM a study of the beta-spectra[1] and the gamma-radiation[2] of the 38-min. Cl^{38} it can be concluded that the two excited states of A^{38} at 2.15 Mev and 3.75 Mev have angular momenta of $J_1=1$, 2, or 3 and $J_2=3$ respectively, the latter having a different parity than the lower excited and the ground state.

In order to obtain more information about the excited levels in A^{38} the angular correlation of the gamma-rays successively emitted from those levels has been measured. The apparatus consisted of two sintillation counters using anthracene crystals as phosphors and RCA 5189 photo-multiplier tubes. To avoid disturbing coincidence counts due to Compton scattering from one counter to the other the crystals were shielded by two lead cones and in addition covered with $\frac{1}{16}$-in. lead foils. The angular resolution of the instrument as determined by observations on annihilation radiation was 10°30′. The resolving time of the coincidence amplifier used was 5.8×10^{-8} sec. The arrangement was tested by a careful measurement of the angular correlation of the gamma-radiation emitted from the excited states of Ni^{60} (decay[2a] of Co^{60+}) and Pd^{106} (decay[2a] of Rh^{106}) (Fig. 1) and was found to be in perfect agreement with the results reported by Brady and Deutsch.[3] The solid line represent the correlation functions

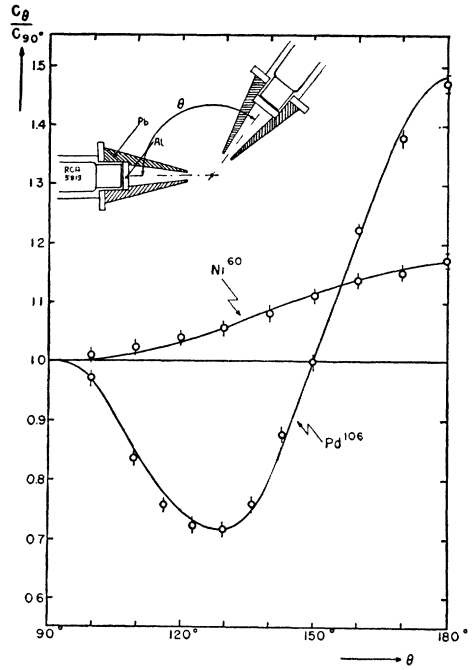

FIG. 1. Angular correlation of Ni^{60} and Pd^{106} gamma-rays.

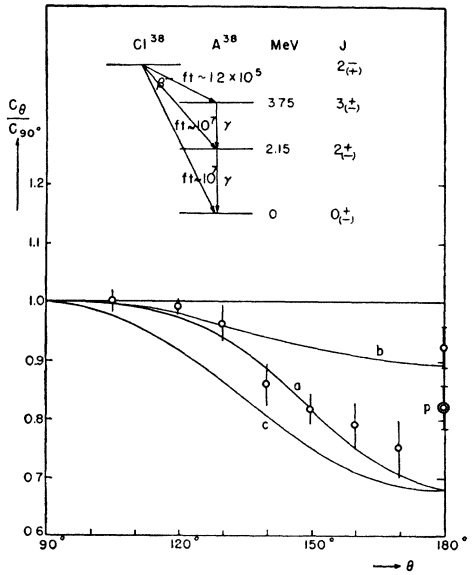

FIG. 2. Angular correlation of gamma-rays emitted from the A^{38} nucleus. Curve *a*: Correlation function for quadrupole-quadrupole transition between states of $J=3$, 2, and 0. Curve *b*: Correlation function for quadrupole-dipole transition and $J=3$, 1, 0 and dipole-quadrupole $J=3$, 2, 0. Curve *c*: Correlation function $Q-D$, $J=1$, 1, 0; $D-Q$, $J=1$, 2, 0; and $D-D$, $J=1$, 1, 0.