Band Spectra of the Selenium Isotopes

SUMNER P. DAVIS AND F. A. JENKINS
Department of Physics, University of California, Berkeley, California
(Received July 30, 1951)

AN investigation of the rotation structure of the ${}^1\Sigma_u{}^+ \rightarrow {}^1\Sigma_g{}^+$ band system of Se_2 in the region 3700–3815A has been undertaken in an attempt to resolve the discrepancy[1] that exists between the value of the nuclear spin of ${}_{34}Se^{77}$ indicated by optical hyperfine structure[2] and by microwave spectra.[3] The former method indicates $I=7/2\pm1$ and the latter $I=\frac{1}{2}$, although with certain reinterpretations[2,4] either value may be reconciled with the other. Under these circumstances it seemed logical to apply the method originally used[5] to establish the value $I=0$ for Se^{80}, namely observation of the alternating intensities in the rotational lines of the electronic band spectrum. For this purpose spectrograms have been obtained of the separated isotopes[6] in which the major components were Se^{77}, Se^{78}, and Se^{80}, respectively. They were taken in the second order of the 21-foot grating, which gives a dispersion of 0.67 A/mm. The source was a small quartz tube containing about 10 mg of selenium and 1–5 mm of argon excited by a 60-Mc oscillator. This source may be scaled down in size to yield band spectra of the nonmetallic elements with much smaller samples. Preliminary studies of the possibility of measuring the spin of P^{32} in this way show that the $P_2{}^{31}$ spectrum may be obtained with as little as 2 μg of phosphorus.

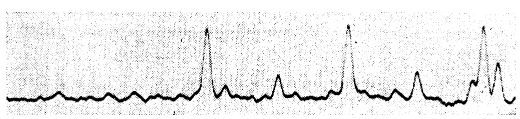

FIG. 1. Tracing of last five lines of 10,5 band of $Se_2{}^{77}$, enlarged 40 times from the original plate. The abrupt ending of the P branch due to predissociation is apparent.

$P(45)(44)(43)(42)(41)$

Even though the bands of Se_2 become much simpler when produced by the separated isotopes, only a few at the ultraviolet end are sufficiently free from overlapping to permit an analysis of the rotational structure. Measurements of the 10,4 and 10,5 bands confirm the analysis given by Olsson,[5] who reported on bands due to $Se_2{}^{80}$ and $Se^{78}\,Se^{80}$. The state $v'=10$ shows strong perturbations, while the predissociation occurring in this state at $K'=49$ in $Se_2{}^{80}$ comes at $K'=44$ in $Se_2{}^{77}$. The 9,4 and 9,5 bands appear to be free from such irregularities, and are most suitable for observing the intensity alternation. Our plates of $Se_2{}^{78}$, from a sample containing 82.6 percent of Se^{78}, show a very simple structure consisting of singlet P and R branches with alternate lines missing. Hence, as expected, the spin of this isotope is zero.

The first plates with enriched Se^{77} gave evidence of a pronounced alternation,[7] with the lines of odd K stronger since the nucleus obeys Fermi statistics. This sample had a concentration of 58.4 percent Se^{77}, but overlapping by lines due to the next most abundant molecule, $Se^{77}\,Se^{80}$, prevented an accurate measurement of the alternation ratio. Hence a special separation was made by the Stable Isotopes Division[6] yielding 50 mg of 91.7 percent Se^{77}. Using 9.5 mg of this material, successful spectrograms were obtained on which the alternation of intensities was essentially free from disturbances. Photographic photometry on the last five lines of the P branch in the 10,5 band, a microphotometer trace of which is shown in Fig. 1, was done by the method previously used by one of the authors[8] in determining the spin of P^{31}. The average ratio obtained was 3.0:1, showing definitely that the nuclear spin of Se^{77} is $\frac{1}{2}$. The band spectrum method, it should be emphasized, is the only way of determining nuclear spins which gives a positive result in cases where $I=0$ or $\frac{1}{2}$. Our value agrees with the conclusion of Canada and Mitchell,[9] based on measurements of the beta-ray spectrum of As^{77}. It also confirms the presumption of Mayer[10] that the odd neutron in Se^{77} is in the $p_{1/2}$ state, rather than in $g_{9/2}$.

In the course of this work, an accidental contamination of air in one tube yielded a well-resolved band system which is evidently that now attributed[11] to SeO, but not as yet studied in detail. By using the separated isotopes, a complete analysis of the rotational structure of these bands will be possible.

[1] J. E. Mack, Revs. Modern Phys. **22**, 64 (1950).
[2] J. E. Mack and O. H. Arroe, Phys. Rev. **76**, 173 (1949).
[3] Strandberg, Wentink, and Hill, Phys. Rev. **75**, 827 (1949); Geschwind, Minden, and Townes, Phys. Rev. **78**, 174 (1950).
[4] Townes, Foley, and Low, Phys. Rev. **76**, 1415 (1949).
[5] E. Olsson, Z. Physik **90**, 138 (1934). A more complete account is given in E. Olsson, Dissertation, Stockholm (1938).
[6] All enriched isotopes were supplied by the Stable Isotopes Research and Production Division, Y-12 Area, Oak Ridge National Laboratory.
[7] S. P. Davis and F. A. Jenkins, Phys. Rev. **83**, 891 (1951). The final result, as reported in the present letter, was given in this paper at the Vancouver meeting.
[8] F. A. Jenkins, Phys. Rev. **47**, 783 (1935).
[9] R. Canada and A. C. G. Mitchell, Phys. Rev. **81**, 485 (1951).
[10] M. G. Mayer, Phys. Rev. **78**, 16 (1950).
[11] Asundi, Jan-Khan, and Samuel, Proc. Roy. Soc. (London) **157**, 28 (1936).

Photodisintegration of He^4

T. S. BENEDICT AND W. M. WOODWARD
*Cornell University, Ithaca, New York**
(Received July 27, 1951)

CROSS sections for the production of protons from He^4 using the 300-Mev bremsstrahlung beam of the Cornell synchrotron have been measured for proton energies ranging from 45 to 120 Mev. The apparatus consists of a pressure vessel (Fig. 1)

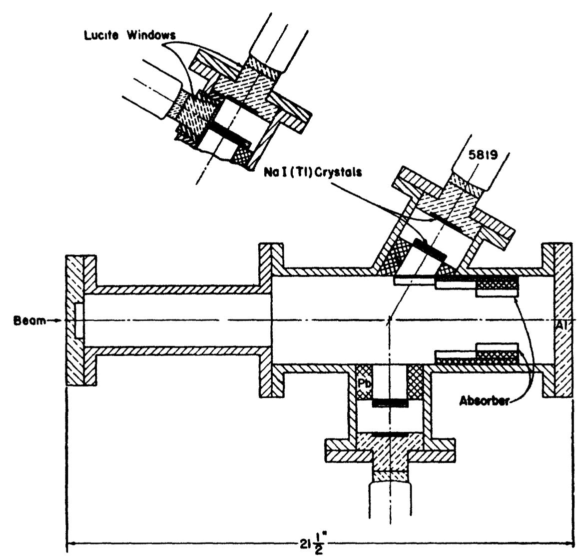

FIG. 1. Schematic diagram of the apparatus.

capable of withstanding pressures up to 2000 lb/in.^{2}, with counting arms mounted at 60° and 90° with respect to the γ-ray beam. Two NaI(Tl) crystals are mounted inside each arm in such a way as to form a proton counter telescope. The light from the crystals is piped out of the vessel through Lucite windows which are about 4 cm thick. The scintillations are detected by RCA 5819 photomultiplier tubes. The front counter, in conjunction with a multi-channel pulse-height discriminator, was used to measure the ionization of those particles which pass through the front crystal and subsequently lose $>$15 Mev in the back crystal.

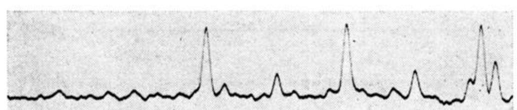

FIG. 1. Tracing of last five lines of 10,5 band of Se_2^{77}, enlarged 40 times from the original plate. The abrupt ending of the *P* branch due to predissociation is apparent.

P(45) (44) (43) (42) (41)