molecule itself. When $K \neq 0$, and is a multiple of 3, the two originally superimposed levels belong to two symmetry classes[2,3] α and β. The first of these is symmetric for an interchange of two of the hydrogen nuclei, and the other is antisymmetric for such an interchange. The degeneracy of these levels may be removed by a perturbation which is threefold degenerate. Since the total wave function must be antisymmetric, and since the proton spin functions for three protons possesses no antisymmetric functions, of the two component rotation levels only one can actually occur. The order of the levels is inverted for the excited vibration level giving rise to the microwave spectrum. Thus, the line for $K=3$ will be displaced from its expected position. The direction in which the displacement takes place may be shown to depend upon the oddness or evenness of J.

We have examined the quantum-mechanical Hamiltonian for the ammonia molecule expanded in orders of magnitude and find that a splitting of the levels where $K=3$ occurs in the fourth order of approximation because of an interaction between the first-order Coriolis terms and first-order correction terms to the moments of inertia of the molecule. The constants which are involved are therefore only the usual potential constants together with the dimensions of the molecule and curiously enough do not depend to this approximation upon any anharmonicity in the motion. The displacements may be shown to be of the form

$$\Delta\nu = A F(J), \tag{1}$$

where A is a function of the molecular constants only, and $F(J)$ takes the values -1, 7, -28, 84, -210 for values of J from 3 to 7 inclusive. The numerical values may therefore be evaluated with an accuracy which we estimate to be of the order of 10 percent.

In Table I below are given, for various values of J, the

TABLE I. Measured and predicted values of the shifts of $K=3$ lines in the ammonia microwave spectrum.

J	K	Shifts as observed by Good and Coles (megacycles/second)	Predicted shifts (megacycles/second)
3	3	−0.30	−0.26
4	3	1.76	1.82
5	3	−7.17	−7.28
6	3	22.3	21.85
7	3	—	−54.62

shifts measured by Good and Coles of lines arising from transitions between levels where $K=3$ together with the values of these shifts predicted by the relation (1).

The displacements where $K=6$ or higher are found to be exceedingly small. A full account of these calculations will appear in the near future.

[1] W. E. Good and D. K. Coles, Phys. Rev. **71**, 383 (1947); M. W. P. Strandberg, R. Kyhl, T. Wentink, Jr., and R. E. Hilliger, Phys. Rev. **71**, 639 (1947). We are also indebted to Dr. Good and Dr. Coles for a private communication giving numerical results which we shall quote in this letter.

[2] D. M. Dennison, Rev. Mod. Phys. **3**, 280 (1931); see especially p. 341. These levels are also said to belong to the symmetry species E. See, for example, G. Herzberg, *Infrared and Raman Spectra* (D. Van Nostand Company, New York, 1945), p. 27.

[3] These levels are also said to belong to the symmetry species A_1 and A_2, respectively.

Propagation of U. H. F. Sound in Mercury

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MEASUREMENTS have been made of the velocity and attenuation of sound in Hg in the frequency range 100 to 1000 Mc/sec. The electroacoustic transducers used were two identical x-cut quartz crystal disks 0.038 cm thick and 2 cm in diameter. These crystal disks were each cemented on one face across the end of a 50-ohm coaxial line. They were then mounted facing each other in an Hg bath which served simultaneously as: (a) one electrode of each crystal, (b) an acoustic transmission medium, and (c) an electrical shield between the transmitting and receiving crystals.

By means of a micrometer adjustment the separation of the crystals could be varied. In order to obtain separations of the crystals as small as 0.05 cm, which was necessary at the two highest frequencies used, a grid of 0.025-cm diameter silver wires was placed between the crystals to prevent the Hg film from breaking and withdrawing from between the crystals. In addition, in order to insure that the Hg would wet the quartz crystals, the face of each crystal to be immersed in the Hg was coated with an evaporated film of silver before being placed in the bath. These precautions, of course, caused some contamination of the Hg, but the amount (less than 0.1 percent) probably did not affect the measurements.

Conventional transmitters of 50–100 watts power output were used to excite the transmitting crystal through its 50-ohm line, and conventional receivers were used to amplify the output of the receiving crystal. By use of modulated continuous-wave excitation, the band width of the receiving system was held to about 200 cycles/sec. The sound wave was detected by the familiar method of combining the output of the receiving crystal with a direct signal from the transmitter and then changing the separation of the crystals. This change in the separation changed the phase of the acoustic wave incident on the receiving crystal and gave rise to variations in the output of the receiver which approximately repeated as the separation of the crystals was changed by multiples of the acoustic wave-length in Hg. In order to detect sound at the highest frequency used, it was necessary to record the output of the receiver on a recorder driven synchronously with the micrometer controlling the crystal separation.

The attenuation was measured by noting the change in the amplitude of the variations of the receiver output as

TABLE I. Data on propagation of sound in Hg.

Frequency in Mc/sec.	Velocity $\times 10^{-5}$ in cm/sec.	Frequency-free pressure absorption coefficient $\times 10^{17}$ in sec.^{2}/cm	Temperature °C
0.50[1]	1.451		20
21.5[2]		6.3	24.3
54.0[2]		6.4	24.3
152	1.449 ±0.002	5.8 ±0.5	23.8
291	1.451 ±0.002	5.5 ±0.5	24.0
390	1.450 ±0.002	5.7 ±0.5	28.2
774	1.47 ±0.02	4.7 ±1.0	27.2
996	1.44 ±0.05	6.0 ±1.0	26.9

the separation of the crystals was changed by many acoustic wave-lengths. In these attenuation measurements the direct signal from the transmitter was kept constant at a level above that of the highest output of the receiving crystal. Standing wave effects were not important in these measurements because the sound absorption was so high at the frequencies used.

The results of these measurements are summarized in Table I, which also shows some of the results obtained by earlier workers. Attenuation is ascribed entirely to absorption, largely on the grounds that the frequency-free attenuation coefficient (i.e., the attenuation coefficient divided by the square of the frequency) is very near the value of the frequency-free absorption coefficient given by the Stokes–Kirchoff formula, which is 5.1 for Hg. The data show no significant change in velocity or frequency-free absorption coefficient with frequency.

It is planned to extend this work to higher frequencies and to fluids other than Hg.

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[1] J. C. Hubbard and A. L. Loomis, Phil. Mag. **5**, 1177 (1928).
[2] P. Rieckmann, Physik. Zeits. **40**, 582 (1939).

The Fission Cross Section of Np^{237}*

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THE fission cross section of Np^{237} has been measured for neutrons of energies from near thermal to 3 Mev by counting simultaneously the fissions from known foils of Np^{237} and U^{235}, placed back to back in a parallel-plate comparison chamber filled with pure argon.[2]

The source of monoenergetic neutrons in the energy range from near thermal to 1.67 Mev was the Wisconsin electrostatic generator, using the $Li^7(p, n)Be^7$ reaction with a Li target 60 kev thick. The 2.5-Mev and 3.0-Mev points were taken with the Illinois Cockcroft-Walton set, using the $D-D$ reaction with a thick heavy-ice target and an accelerating voltage of 200 kev.

The Np^{237} foil was prepared from material purified and analyzed by the Chicago Metallurgical Laboratory groups.

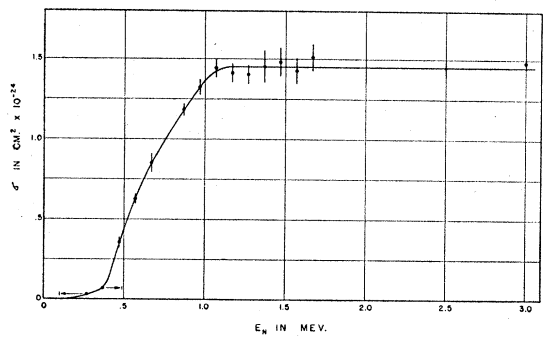

FIG. 1. The fission cross section of Np^{237} as a function of the incident neutron energy. The errors given are the statistical errors of counting. Because the errors of the two lowest energy points are so small, they have been drawn to the side and are the vertical lines at the heads of the horizontal arrows.

According to the analysis furnished us, the $1N$ sulfuric acid solution contained 100 micrograms of Np^{237} metal, about 0.05 microgram of Pu^{239} metal, and 50 micrograms of potassium as bisulfate. The solution was deposited in drops on a platinum foil by means of a micropipette and evaporated. Care was taken to transfer all the material in the solution to the foil, and the Np^{237} mass was taken as 100 micrograms.

Figure 1 gives the fission cross section of Np^{237} as a function of the incident neutron energy. For each point the statistical error of counting is given. For the points obtained with the electrostatic generator, the cross sections are given for the average neutron energy in each case. A correction was made for the Pu^{239} in the Np^{237} foil for the 270- and 370-kev points.

A point was taken with the electrostatic generator with a maximum primary neutron energy of 150 kev and a block of paraffin about $1\frac{7}{8}$ inch thick between the target and the comparison chamber. Using the ratio of cross sections of U^{235} and Pu^{239} at near thermal energy, and assuming the Np^{237} foil to contain 0.05 percent Pu^{239} by weight, the fissions from the Np^{237} foil obtained by this means can be more than accounted for by the fission of Pu^{239} in this foil. Thus no thermal fission was observed in Np^{237} within the accuracy of this experiment.

The cross sections given here for Np^{237} are based on the fission cross sections of U^{235}, U^{238}, and Pu^{239} as measured at Los Alamos.

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[1] Now at the University of Illinois.
[2] Work on the relative cross section as a function of energy was carried out at Los Alamos by D. H. Frisch and K. Greisen prior to the measurements reported here.

Solar Magnetic Field and Diurnal Variation of Cosmic Radiation

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THE effect of the solar magnetic field on the cosmic radiation, according to the Störmer theory, is that particles below a certain momentum $P_1=(a/r^2)(3-2\sqrt{2})$ (a = sun's moment, r = distance sun-earth) cannot reach the earth at all, whereas particles above a certain momentum $P_2=a/r^2$ can reach it from any direction. For momenta between P_1 and P_2 some orbits intersecting the earth's surface come from infinity, whereas others are periodic (or quasi-periodic) in the solar magnetic field. In the theory of the influence of the solar magnetic field on cosmic radiation proposed by Jánossy[1] and further developed by Vallarta,[2] Epstein,[3] and Rossi,[4] it is tacitly assumed that the asymptotic orbits possess full intensity whereas no particles move in periodic orbits.

This is not certain, however, because particles may be *scattered* from the asymptotic into the periodic orbits. Interplanetary dust, and also the electric fields associated with magnetic disturbances,[5] may produce scattering, but