96 (1962)].

[12]This beat effect has been observed in a different way (F. T. Arecchi, E. Gatti, and A. Sona, to be published) using a 2-m cavity going on two adjacent axial modes and with observation times of the order of the beat period, i.e., 13 nsec.

ESR MEASUREMENTS OF METASTABLE ATOMIC NITROGEN IN HELIUM-NITROGEN AFTERGLOWS

K. M. Evenson and H. E. Radford

National Bureau of Standards, Boulder, Colorado
(Received 15 November 1965)

The electron spin resonance (ESR) spectra of the $^2D_{3/2}$ and $^2D_{5/2}$ metastable levels of atomic nitrogen were observed in the afterglow of a helium-nitrogen microwave discharge. Appreciable amounts of metastable nitrogen were previously measured by mass spectrographic means by Foner and Hudson[1] in such afterglows. The spectra, which are the first spectra of a gaseous metastable atom to be observed with an ESR spectrometer, are shown in Fig. 1. A 100-kHz and 100-Hz double-modulation ESR spectrometer was used with an output time constant of 10 sec. This spectrometer records the second derivative of the absorption curve. The lower curve is a superposition of three tracings taken at twice the gain and twice the modulation amplitude of those of the upper curve.

The gas-flow system is shown in Fig. 2. It is a moderately high-speed system, pumped by a 7-liter/sec mechanical vacuum pump. A faster pump was tried, but it gave no increase in signal. The capillary nozzle increases the flow velocity and forms a beam of gas which reduces wall de-excitation of the metastable atoms. The position of the discharge cavity relative to the end of the nozzle is critical, best results being obtained when the visible discharge region extends just to the end of the nozzle. Correct operating conditions are indicated by the presence of a bright orange beam, which emanates from the nozzle and passes completely through the ESR cavity. Maximum

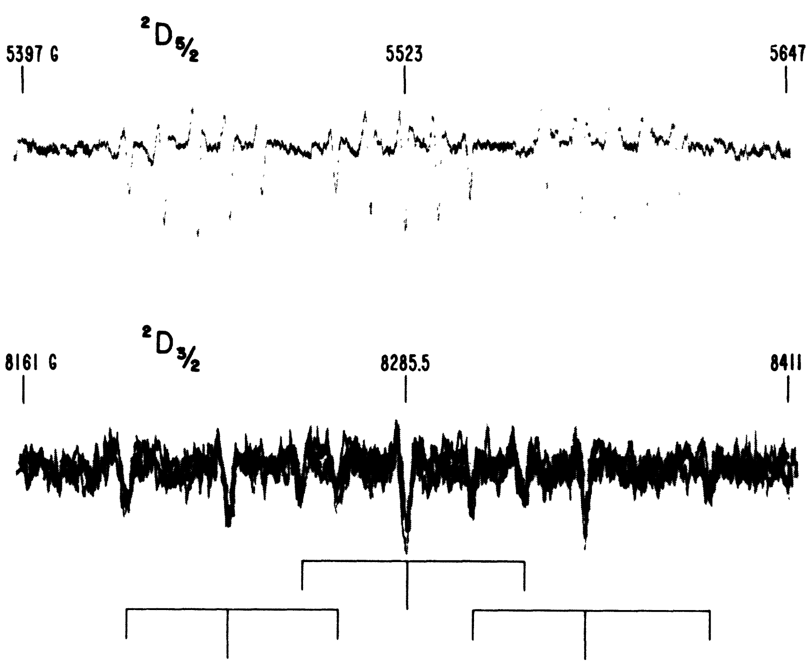

FIG. 1. Tracings of the ESR spectra of the metastable ^2D levels of atomic nitrogen, as observed, taken in a helium-nitrogen afterglow. The upper trace shows the $^2D_{5/2}$ spectrum and the lower trace, the $^2D_{3/2}$ spectrum. The microwave frequency was 9.280 GHz. The 250-G scans were made in 50 minutes with a 10-sec time constant.

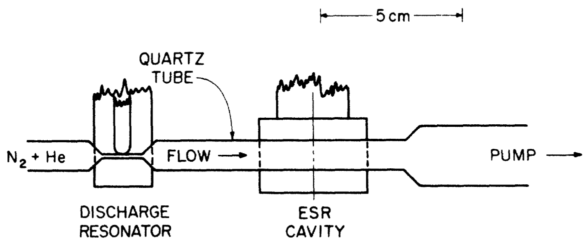

FIG. 2. Diagram of gas-flow system.

signals were obtained when the partial pressures measured 25 cm downstream from the ESR cavity were 0.13 Torr of nitrogen and 3.2 Torr of helium. No signals could be observed in pure nitrogen afterglows.

The g factors were determined from the central line of each of the spectra to be 0.8002 ± 0.0004 for the $^2D_{3/2}$ level and 1.2005 ± 0.006 for the $^2D_{5/2}$ level, in agreement with the theoretical Landé g factors $\frac{4}{5}$ and 6/5. Each of the spectra exhibits three groups of lines, due to the magnetic hyperfine splitting caused by nitrogen's nuclear spin of one. The measured separations of the three groups are 58.5 G for the $^2D_{3/2}$ spectrum and 68 G for the $^2D_{5/2}$ spectrum. Theoretical separations, based on the central-field approximation[2] and accurate analytical wave functions,[3] are calculated to be 69 G for both spectra, in fair agreement with the measured values. The splittings within the three hyperfine-structure groups of each spectrum result from the second-order Zeeman interactions between the two fine-structure levels. The measured splittings agree within 10% with those calculated from second-order perturbation theory,[2] using the known level separation of 8 cm^{-1}. A more detailed analysis of the spectra, including the effects of electric-quadrupole hyperfine structure, deviations from LS coupling, configuration interaction, and relativistic corrections, will be published elsewhere.

Measurements of the ^4S ground state concentration showed that approximately 5% of the nitrogen atoms were in the ^2D levels. The relative intensities of the $^2D_{3/2}$ and $^2D_{5/2}$ spectra showed these levels to be approximately in thermal equilibrium.

Further experiments are under way to measure the spectra more accurately, to measure the linewidth as a function of pressure, and to look for other metastable levels (a preliminary scan did not reveal the presence of the ^2P levels of nitrogen).

[1]S. N. Foner and R. L. Hudson, J. Chem. Phys. 37, 1662 (1962).

[2]E. U. Condon and G. H. Shortley, The Theory of Atomic Spectra (University Press, Cambridge, England, 1935).

[3]E. Clementi, C. C. J. Roothaan, and M. Yoshimine, Phys. Rev. 127, 1618 (1962).

ELECTRON-H-ATOM ELASTIC-SCATTERING RESONANCES*

J. William McGowan, E. M. Clarke,* and E. K. Curley

General Atomic Division of General Dynamics Corporation,
John Jay Hopkins Laboratory for Pure and Applied Science, San Diego, California

(Received 8 November 1965)

The competition between compound nucleus formation and Rutherford scattering is reflected in the characteristic resonance shape of the cross section for nucleon-nucleus scattering. Such interaction has received considerable experimental and theoretical study, and as a result is well understood. Although the possibility of atomic analogs has long been recognized, it is only within the past few years that much attention has been given to them. The one analog thus far studied extensively is that involving the temporary formation of an excited atomic or molecular negative ion which is observed through resonance structure in the cross-section curves for elastic and inelastic scattering of electrons.

In this Letter we report resonances in the e-H scattering signal observed essentially at 90 deg to the plane of intersection between a modulated beam of H atoms and a beam of energy-analyzed electrons. The experimental configuration[1] is shown in Fig. 1. As can be seen in Fig. 2, there are two resonances defined below 10 eV. If we define the center of a resonance as half-way between the maximum and minimum, the first is centered near 9.45

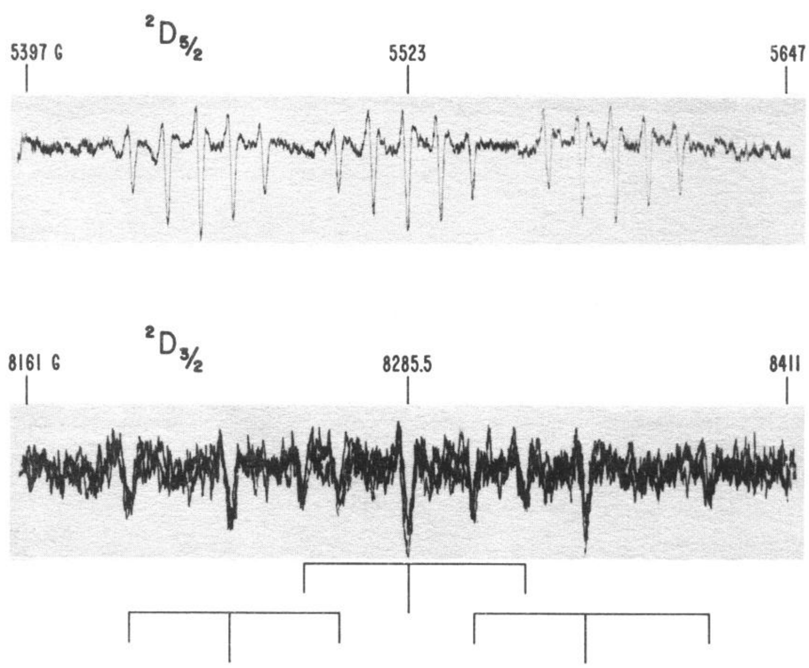

FIG. 1. Tracings of the ESR spectra of the metastable ^2D levels of atomic nitrogen, as observed, taken in a helium-nitrogen afterglow. The upper trace shows the $^2D_{5/2}$ spectrum and the lower trace, the $^2D_{3/2}$ spectrum. The microwave frequency was 9.280 GHz. The 250-G scans were made in 50 minutes with a 10-sec time constant.