Proceedings of the American Physical Society

MEETING OF THE NEW ENGLAND SECTION AT NEW HAVEN, CONNECTICUT, OCTOBER 26, 1946

THE twenty-seventh meeting of the New England Section of the American Physical Society was held at the Sloane Physics Laboratory of Yale University in New Haven, Connecticut, on Saturday, October 26, 1946. At least one hundred and fifteen members were in attendance. The programme included a symposium of six invited papers on the subject of microwaves and twelve contributed ten-minute papers. There follow the titles of the invited papers and the abstracts of the ten-minute papers.

At the business meeting the following officers were elected for 1947:

Chairman, H. Margenau, *Yale University.*
Vice Chairman, K. T. Bainbridge, *Harvard University.*
Secretary-Treasurer, G. F. Hull, Jr., *Dartmouth College.*
Programme Committee, R. D. Rusk, *Mount Holyoke College*, C. W. Miller, *Brown University.*

Invited Papers

Microwave Circuits. C. G. MONTGOMERY, *Yale University.*

Microwave Studies of Electrical Discharges in Gases. S. C. BROWN, *Massachusetts Institute of Technology.*

Absorption of Microwaves by Liquids. D. H. WHIFFEN, *Oxford University.*

Absorption of Microwaves by Gases. W. D. HERSCHBERGER, *RCA Laboratories.*

Molecular Line Spectra in the Microwave Region. C. H. TOWNES, *Bell Telephone Laboratories.*

Experiments in Gaseous Absorption at Microwave Frequencies. R. BERINGER, *Yale University.*

Contributed Papers

1. The Metastable State $a^1\pi g$ of N_2 as a Factor in Active Nitrogen. ROLAND MEYEROTT, *Sloane Physics Laboratory, Yale University.* Herzberg* has suggested from spectroscopic evidence, that the $a^1\pi g$ state of N_2 (the lowest known excited singlet state) is metastable. Conclusive evidence for this is lacking, since the fine structure of bands originating or ending on this state has not been resolved. Additional support to Herzberg's conclusion can be found in the spectra of impurities in active nitrogen. Two types of transitions are possible for an N_2 molecule in the $a^1\pi g$ state on collision with an impurity molecule having the proper energy levels; either the transition $a^1\pi g \rightarrow X^1\Sigma g^+$, or $a^1\pi g \rightarrow A^3\Sigma u$. The first is forbidden (if Herzberg's conclusions are correct) since it is a g to g transition, while the second is a singlet to triplet transition. The spectra of the impurity, then, must originate in energy levels above the ground state, corresponding to the energy available in the particular N_2 transition. The CN red system and the lower vibrational levels of the CN violet systems excited in active nitrogen will be discussed as examples of enhancements due to the $a^1\pi g \rightarrow A^3\Sigma u$ transition, while the ultraviolet bands of N_2^+ will be used as an example of enhancement due to the $a^1\pi g \rightarrow X^1\Sigma g$ transition.

* G. Herzberg, Phys. Rev. **69**, 362 (1946).

2. Ultraviolet Bands of Nitrogen. R. B. SETLOW, ROLAND MEYEROTT, AND W. W. WATSON, *Sloane Physics Laboratory, Yale University.* Rotational constants for the upper $^2\Sigma$ state involved in the ultraviolet bands of N_2^+ have been measured for several vibrational levels. Thus vibrational constants are given in terms of band origins rather than band heads. The peculiar intensity distribution in these bands obtained using a discharge in nitrogen will be discussed and correlated with the previous paper by one of us. Gaydon and Penney,[1] in discussing the dissociation energy of CO^+, rest their argument, in part, on the break in the $\Delta G - v$ curve for the upper $^2\Sigma$ state of N_2^+.[2] The evidence for this break has been reexamined and is considered insufficient basis for postulating its existence. Two of the upper states of N_2 discovered by Watson and Koontz[2] have been assigned by Tschulanowsky[3] to vibrational levels 2 and 3 of Birge and Hopfield's b' state.[4] Plates taken of a discharge in nitrogen showed single headed bands at the same position as the double headed ones of Hopfield's c state. The observed frequencies of these bands correspond to those expected from transitions of the $v=1$ level of b' to the ground state.

[1] A. G. Gaydon and W. G. Penney, Proc. Roy. Soc. **A183**, 374 (1944).
[2] W. W. Watson and P. G. Koontz, Phys. Rev. **46**, 32 (1934).
[3] W. M. Tschulanowsky, Bull. Acad. Sci. U.S.S.R. 1313 (1935).
[4] R. T. Birge and J. J. Hopfield, Astrophys. J. **68**, 257 (1928).

3. Line Strengths in the FeI Spectrum in Intermediate Coupling, with Application to the Solar Curve of Growth. WINSTON M. GOTTSCHALK,* *Raytheon Manufacturing Company, Waltham, Massachusetts.* Menzel has given the theory of the curve of growth of a star, the curve of growth being essentially a plot of stellar intensity against theoretical intensity. Curves of growth for the sum have been derived by several authors. One objection to the validity

of values derived from the curve of growth has been the use of line strengths based on the Russell-Saunders approximation in atomic spectra. Wright, in particular, has avoided this difficulty by using measured values of intensities in the FeI and TiI spectra. The formalism for the computation of line strengths in intermediate coupling is given in Condon and Shortley *Theory of Atomic Spectra*. This was adapted to a transition array in the FeI spectrum with reasonable success. As a check on the transformation matrices used g values were computed and agree with experimental values. The curve of growth plotted from these computed line strengths is in substantial agreement with curves of other investigators. A long range program of computing line strengths in intermediate coupling should be undertaken in order to provide the astrophysicist with useful tables of line strengths.

* This work was done at Harvard University and is part of a thesis submitted to Harvard University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

4. Perot-Fabry Interferometers as Filters (with demonstrations). H. M. O'BRYAN, *Baird Associates, Cambridge, Massachusetts.*—The Perot-Fabry interferometer has been used for measurement of spectral lines for many years and recently filters have been obtained from Germany which are based on this principle. Filters of this type made by the Evaporated Metal Films Corporation will be shown and some of their unique properties described. The filters are made by evaporation of two metallic semi-reflecting layers with an evaporated dielectric layer several wave-lengths thick. The transmission bands are approximately 150A wide with a maximum of about 30 percent at normal incidence. The order of interference varies from 2 to 10 wave-lengths. At oblique incidence the transmission band shifts toward shorter wave-lengths and splits into two bands of different polarization. These filters make it possible to demonstrate before a large audience some aspects of interference and are also useful in many experiments in spectroscopy and optics.

5. Physical Interpretation of Electromagnetic Radiation from an Antenna. RONOLD W. P. KING, *Cruft Laboratory, Harvard University.* The physical interpretation of electromagnetic radiation from an antenna has been confused by two common errors. These are the assumptions (1) that the axial distribution of current in a cylindrical antenna is sinusoidal and (2) that the Poynting vector is a true measure of the direction and magnitude of "energy flow" at every point in space. Conclusions which follow the making of both errors, of each error separately, and of neither error are considered and discussed in terms of their physical and practical significance in the theory of antennas. The importance of careful presentation of electromagnetic principles in the classroom is pointed out.

6. Optical Theory of the Corner Reflector, ROY C. SPENCER,* *AAF, Air Materiel Command, Watson Laboratories, Cambridge Field Station, Cambridge, Massachusetts.* A corner made from three glass mirrors enables one to observe the regions of the incident plane wave which undergo single, double, or triple reflection. All three are analyzed. Only the triple reflection is at all times exactly reversed causing a maximum signal at the transmitter. The equivalent scattering cross section σ of the corner is $4\pi(A/\lambda)^2$ where A is the actual cross section of the triply reflected beam. A has a maximum value A_0 along the symmetric axis of $a^2/\sqrt{3}$ for triangular corners and $\sqrt{3}a^2$ for square corners where a is the edge. A chart gives σ for various values of a and λ. The variation of A with direction of the line of sight is illustrated by means of cardboard models. The equations for A are derived and the results shown in charts. For the triangular corner, A/A_0 approximates a paraboloid of revolution $(1-.00076\delta^2)$ for $\delta<26°$ where δ is the deviation in degrees from the symmetric axis. For the square corner A/A_0 approximates a cone $(1-.0274\delta)$ for $\delta<26°$ which makes it unsuitable as a standard target. The analysis of the effect of errors in perpendicularity of adjacent sides, as treated by G. A. Van Lear, Jr., has been extended and applied to both triangular and square corners.

* Formerly, Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts. This paper is based on work done for OSRD under Contract OEMse-262 with M.I.T.

7. Large Angle Scattering of Gamma-Radiation. E. C. POLLARD AND B. B. BENSON, *Yale University.* Observations of the scattering of gamma-radiation from Mg^{24} (from the beta-decay of Na^{24}) by lead, copper, aluminum, and magnesium at an average angle of 135° have been made. In order to determine the proportion of Compton scattering and annihilation radiation, absorbers up to 2.2 cm thickness have been placed around the counter used to detect the gamma-rays. In the case of copper and aluminum the results indicate that the great majority of scattered radiation is attributed to Compton recoil and annihilation. Some additional effect seems definitely to be present in the case of lead scattering. Comparison of the scattering from aluminum and magnesium should show the presence of resonant absorption and re-emission from Mg^{24}. There is some evidence that there is an excess of scattering by Mg^{24} at high counter absorption. An estimate of the cross section gives a probable value of 2×10^{-27} cm^2 with an upper limit of 5×10^{-27} cm^2. This corresponds to a line width of the order of 1/100 ev which would be a reasonable fit to a quadruple transition.

8. The Determination of Small Time Intervals between Related Nuclear Events. H. L. SCHULTZ, *Yale University.* The method to be described makes use of techniques for the accurate measurement of very short time intervals between electrical pulses. It can be applied in the determination of short lived activities where related nuclear events occur (e.g., the case of ThC′ or RaC′ where a β-particle leads to the formation of the element which subsequently emits an α-particle). The method is applicable also to the determination of time of flight of charged particles. The equipment consists of two proportional counters with independent wide band amplifiers each feeding into a coincidence circuit of high resolving power. The number of coincidences is measured as a function of time delay introduced electrically in one of the channels. Preliminary measurements show that for simultaneous excitation of

both amplifiers by a pulse signal generator a variation in electrical delay of approximately 10^{-9} sec. can be detected. However, in actual nuclear applications the precision is reduced because of the statistical nature of the ionization process and because of the fact that pulse shape will depend upon the direction of entry of the ionizing particle into the counter. For the case of α-particles traversing two counters placed in line under highly collimated conditions, a time of flight in the region of 10^{-8} sec. can be detected.

9. Reversible Binary Counter and Shaft Position Indicator.* H. P. STABLER, *Williams College.* A binary counter has been developed that responds to subtracting pulses as well as to adding pulses. The two types of pulses are distinguished by different input channels, by polarity, or by size, and the reversible action is accomplished by suitable carry-over provisions between the counter stages. Each stage employs four 6AK5's. Resolving times of 10^{-5} sec. and less are readily obtainable. In conjunction with a photoelectric actuated pulse generator and a reading circuit, the counter has been used to indicate the angular position of a rotating shaft. The pulse generator produces adding pulses for clockwise rotation of the shaft and subtracting pulses for counterclockwise rotation. The reading circuit "scans" the several counter stages and gives the counter reading in the form of a microsecond pulse binary wave form number. While the system has been designed to provide one of the input parameters to a digital electronic computer, the methods employed can be used for other situations involving two directional motion and differential counting.

* This paper is based on work done at the Radiation Laboratory, Massachusetts Institute of Technology, for the Office of Scientific Research and Development under contract OEMsr-262.

10. A Proposed Focusing Cosmic-Ray Telescope. W. T. HARRIS, *United States Time Corporation, Waterbury, Connecticut.* A magnetic lens which will focus charged particles entering its aperture parallel to the axis can be constructed in the form of a toroidal winding. For an air or iron core toroid, the cross section of the winding is parabolic. If partial iron filling is used, trapezoidal or rectangular cross sections may be employed to produce sharp focusing. The focal length is proportional to the particle momentum, and hence a telescope of this type is also a spectrograph. By using coincidence counters and anticoincidence guard counters for observations, a collimating tube effect can be obtained, permitting full use of the properties of the telescope lens without a background due to particles which do not pass through the lens. There are some advantages to an installation in a deep shaft in the earth having two lenses. With such a device charged and uncharged components can be studied separately.

11. Free Ring Discharge in a Metallic Torus. CHARLES G. SMITH, *Raytheon Manufacturing Company,** *Waltham, Massachusetts.* The limits of intensity of excitation of a gas at pressures below .001 mm can apparently be extended if a toroidal discharge is arranged so that unwanted magnetic fields are controlled. One field, that linking the torus supplying the current driving e.m.f., is confined in a closed iron core upon which the primary winding is uniformly distributed. This field links without invading the discharge region. The second field, that of the gaseous current, usually reacts upon the discharge forcing it against the outer walls of the torus. By employing a metallic torus (conducting except for a radial insulating cut to prevent short circuiting the driving e.m.f.) a new distribution of the second field results causing the current to be held away from the walls. The resulting discharge should be free of material bounds. Mercury vapor at about .0004 mm pressure within a cast aluminum torus was energized by 890-cycle e.m.f. at 8 volts. Current in the vapor (600 amperes) was more than that in a comparable glass torus. However, glass side arms glowed brilliantly indicating appreciable electron bombardment of the toroidal boundary after all. The observations nevertheless encourage further effort.

* Experiments were done at Harvard University.

12. Interpretation of the Microwave Absorption of HDO at 1.3 Centimeters. GILBERT W. KING AND R. M. HAINER, *Arthur D. Little, Inc., Cambridge, Massachusetts.* The pure rotational absorption spectrum of HDO differs from those of H_2O or D_2O because the permanent dipole moment has components along both the axes of intermediate and least moments of inertia. The selection rules for the latter component are quite different from those of the former, which obtain alone in H_2O and D_2O. They permit transitions between neighboring rotational levels which are split from the doubly degenerate levels of the prolate symmetric rotor. This splitting is a function of the K_{-1}-index of the level, and covers (for a rigid rotor) the whole range from a few to less than 10^{-5} cm^{-1}. Thus absorption lines of HDO will occur throughout the microwave and radio regions. HDO is of further interest in that its rotational term values are not known. A completely resolved vibrational band of HDO at 1.1μ has been analyzed by Herzberg[1] and effective moments of inertia of the ground state determined. With these, one can calculate the position of lines in the microwave region with sufficient accuracy to guide experimental investigation, from the theory of the rigid rotor, because, although deviations from this theory due to centrifugal distortion and the like are high, as in H_2O and D_2O, these corrections cancel to a large extent in the transitions considered since they are between neighboring levels of the same J and K_{-1} values. The absolute intensity of absorption can be calculated quite accurately because the dipole moment and line width will be the same as the known values of H_2O. At our suggestion Townes[2] has investigated the region of 0.7 to 0.8 cm^{-1}, and found a line at 0.7441 cm^{-1}, with absorption coefficient of $30\pm14\times10^{-6}$ cm^{-1}. The transition $5_{33}-5_{32}$ is predicted at 0.79 cm^{-1} with absorption coefficient of 26×10^{-6} cm^{-1}. There are other lines which would have more nearly the observed absorption, were they to appear at .74 cm^{-1}; but the required change in position we believe is outside the possible corrections that could be added in the calculations of the energy levels based on the rigid rotor.

[1] L. Herzberg, Zeits. f. Physik **107**, 549 (1937).
[2] C. H. Townes and F. R. Merritt, Phys. Rev. **70**, 558 (1946).