Meetings

Auroral Physics

International Conference Held in Canada

Under the joint sponsorship of the Geophysics Research Division, U.S.A.F. Cambridge Research Center, and the University of Western Ontario, a Conference on Auroral Physics was held at London, Ontario during the period 23–26 July 1951, inclusive. The attendees numbered over 120 and representation was had from England, France, Norway, Sweden, South Africa, Alaska, Canada, and the United States. In addition to considerations of the aurora, the meetings dealt with the properties and physics of the ionosphere (80–400km) and the mesosphere (400–1000km).

The conference was opened by N. C. Gerson of the Geophysics Research Division, U.S.A.F. Cambridge Research Center who outlined the four main phases of the auroral problem. These consist of: (1) the astrophysical problem involving the ejection of material from the sun; (2) the transit of the ejecta—a neutral plasma of charged particles—from the sun to the earth, the interaction of this plasma with the geomagnetic field and the subsequent concentration of the particles around the geomagnetic poles; (3) the excitation and ionization of the atmospheric constituents by the charged bombarding particles; (4) the secondary plasma problem (in the terrestrial atmosphere) which includes the macroscopic aspects of ionization and the generation of radio noise, both produced by the bombarding particles, observable by means of radio probing techniques.

The first paper of the conference, "Excitation of the Spectrum of Molecular Nitrogen in the Laboratory and the High Atmosphere," was presented by R. Bernard, Laboratoire d'Optique Electronique, Lyon, France, who gave an excellent survey of this complex and difficult subject. Although the energy levels of both the neutral and ionized nitrogen molecules have been studied by many leading scientists, they are so complex in nature that many details of the molecular structure are still not settled. Professor Bernard reviewed this problem and presented a new corrected scheme which takes into account the results which recently have been obtained. Also discussed were the spectral observations concerning N_2 and N_2^+ obtained both in the night airglow and polar aurorae, the statistical results obtained by Cabannes, Déjardin, and Dufay on the systems present in the night airglow, the systems found in the polar aurorae and their tentative interpretation. From the spectroscopic data it was possible to estimate the magnitude of the energy of the exciting electrons as about 30 electron volts.

In a paper entitled "Intensity Distribution in the OH Rotation-Vibration Spectrum," G. Herzberg, of the National Research Council, Ottawa, reported on the results of calculations carried out on the relative intensities of the OH bands on the basis of standard theory. Under the assumption of a Morse potential function for OH in its ground state and a dipole moment which is a linear function of the displacement, calculations have been made for the transition probabilities for all transitions up to $v = 12$. From these probabilities, the relative intensities of the various OH bands have been calculated on the further assumptions that all OH molecules are first formed in the $v = 9$ level and that no deactivating collisions take place. Although these calculations were intended to serve only as a model, the results are in fair agreement with the experimental measurements of Meinel. A few calculations have been made taking into account the quadratic term of the dipole moment.

D. R. Bates, The Queen's University, Belfast, Ireland, presented a theoretical paper on "Atomic and Molecular Processes in the Aurora". Professor Bates pointed out the difficulties inherent in this problem due to the very large number of competitive processes occurring at the same time. The various spectral intensities obtained from different aurorae give an estimate of the order of magnitude of the cross sections for the several reactions involved and give some indication of the change in importance of various reactions from one display to the next. Types of reactions which might occur in the ionosphere and mesosphere were listed and the likelihood of their occurrence discussed. The velocity distribution of the bombarding electrons in the auroral region was considered, and Professor Bates concluded that very few electrons have sufficiently high energy to instigate the processes needed to excite the observed spectral lines. Explanations were offered for the variance of intensity of the nitrogen band systems in different aurorae. A brief discussion of the temperature at high altitudes and its gradient with altitude was given. The photochemistry of certain polyatomic atmospheric constituents was also discussed.

R. W. Nicholls, University of Western Ontario, described some recent work carried out at that university in a paper entitled "Kinetics of Excitation Mechanisms in Nitrogen and Other Molecules". Collisional mechanisms, i.e., collisions between energetic electrons and molecules, giving rise to the auroral luminosities were outlined. A main desideratum is the prediction of the radiation arising from a given volume of space, provided one knows the particles existing therein and their distribution in momentum space. If this problem were solved, one might inversely be able to predict with a fair degree of certainty the reactions occurring in a certain volume from a knowledge of the observed radiations emanating from this volume. Although the experimental approach to this problem was mentioned, the major portion of the paper was devoted to a discussion of a theoretical method of attack. This may conveniently be divided into three steps: (1) the postulation of some excitation mechanism by which energy levels become populated, (2) the setting up and solution of the equations expressing the population of the excited levels when the excitation and deexcitation influences are in balance, and (3) the ultimate qualitative and quantitative prediction of the radiation arising from the downward radiative transitions from the excited level by the presupposed mechanisms. The theoretical method was directly applied to N_2 and N_2^+ for two excitation processes.

A number of excellent papers which emphasized the importance of both theoretical and experimental investigation to clarify the atomic and molecular reaction occurring in the ionosphere and mesosphere were also given. In his talk, "Laboratory Methods of Investigating Processes Important in the High Atmosphere," H. S. W. Massey discussed the experimental researches now being carried out at University College, London, England. The laboratory studies include: (1) an analysis of electric discharges in electromagnetic fields, to obtain more precise information regarding the rates of reactions involving negative ions; (2) examination of reaction rates in atomic hydrogen and oxygen; (3) measurements of the cross sections for collisional detachment of electrons from negative ions; (4) measurement of the cross sections for the transfer of excitation. Theoretical studies now in progress are associated with the experimental program. Some preliminary calculations are being made on the cross sections for excitation in atomic oxygen by electron impact. These studies are being made for the low energy adiabatic region as well as for higher energies. R. W. B. Pearse, Imperial College of Science and Technology, London, England, considered the problem of the "Identification of Night Airglow and Auroral Lines and Bands" from the point of view of laboratory research. This is an extremely important subject since the successful identification of lines and bands in spectra of the airglow and aurora depends as much on laboratory data as on direct observations. Professor Pearse pointed out the need for adequate laboratory measurements concerning the wavelengths and analysis of spectra obtained under a great variety of conditions of excitation. In addition, he emphasized the need for much more work on the experimental determination of intensities within molecular spectra. Recent work at Imperial College was briefly described to show how the results obtained for a few molecules can be used to give a more quantitative interpretation to the usual "visual estimates." A discussion was given of some of the present identifications, as well as certain other radiations which might be expected in the ionosphere and mesosphere. Lists of the more probable atomic lines were presented. The possibility of explaining certain intensity variations and anomalies through absorption by the lower atmospheric strata was also discussed. L. Herman, Astrophysical Observatory, University of Paris, presented a very interesting paper on "Laboratory Studies of Auroral Afterglows." Auroral spectra obtained at College, Alaska were compared with laboratory spectra. New bands found in the laboratory in the near infrared in nitrogen were reported. Some of these new bands are present in the spectrum of the aurora, but the rotational temperatures as calculated from laboratory spectra and auroral spectra are different. The observed bands do not appear to belong to a single electronic transition. A discussion of possible origins of these bands and a tentative classification in a single vibrational scheme were given. Higher dispersion spectra are needed to ascertain the correctness of these classifications, and Professor Herman is presently engaged in such experimentation. A study of the decay constant of the green auroral line OI 5577Å and the associated quasi-continuous band showed that the experimentally obtained value for this decay constant was only about ⅓ of the value predicted by theory. A tentative explanation based on the "imprisoned radiation" was given. A study of the afterglow relatively near and far from the electrode seems to indicate that the green emission is not excited by electron impact, but is probably due to an indirect collision process.

P. A. Forsyth, McGill University, Montreal, described experiments on "Radio Reflections from the Aurora" which have been carried out at Saskatoon for the past two years. Using 100 mc/sec equipment, no auroral "noise" has been detected, but many echoes have been received. Because of the nature of the apparatus used, the radio wave reflections have been restricted to auroral forms close to the horizon at a distance of from 600 to 1000 km. In general, the reflections occur from the ends of auroral arcs, i.e., where the radio waves are propagated along the arcs rather than normal to them. In most cases the arcs show a ray structure in the regions causing reflections. The echoes are strong and are usually spread out over a range of 200 to 300 km. They show at least two, and probably three, distinctive patterns. From the experimental data, it was concluded that the reflections do not occur at single extended surfaces, but rather at many small surfaces, each of which scatters the energy through large angles. The reflecting centers are believed to be small volumes of ionized material in which the free electron density is of the order of $10^8/cm^3$.

A paper on "Intensities of U-V Features of the Auroral Spectrum" was delivered by W. Petrie of the University of Saskatchewan. Comparing the work of Vegard in Norway and Barbier (at a lower latitude) in France, significant differences are found in the measured intensities of auroral features. For the N_2^+ negative group, it is found that with increasing vibrational quantum number of the upper vibrational state the results of Barbier fall off much more slowly than do those of Vegard. Recent measurements made at Saskatoon by Professor Petrie have been compared with the earlier results. Although these measurements agree more closely with those of Vegard, on close analysis important differences are found. In general, Petrie's intensities fall off more rapidly along v′ and v″ progressions. The measured intensities of both Vegard and Petrie have been used to compute fractional transitional probabilities.

The values computed from Petrie's measurements are in better agreement with the theoretical results of Nicholls, especially at the end of a v″ progression. The difference in the measurements is most evident in the vibrational temperatures they would require. Vegard's measurements require a vibrational temperature of at least 8000°K, whereas Petrie's results require less than 500°K. It was pointed out that the temperatures are extremely sensitive to the measurements of the band intensities. Since the intensity measurements depend on the atmospheric extinction, part of the present difficulty may be due to improper correction for this important effect. However, if the recent measurements are correct, then some of the present ideas about the excitation of the bands must be radically changed.

D. Barbier, Institut d'Astrophysique, Paris, summarized some of his recent researches in a paper entitled "Some Problems of the Night Airglow." Results were given on the identification of absorption lines in the spectrum of the night airglow. Dr. Barbier finds that the absorption spectrum is the most important source of systematic errors in altitude measurements. It is found that the continuous spectrum of the night airglow is quite intense, and that it correlates very well with the 5577Å line of oxygen. This correlation reduces to a proportionality over a period of a single night or even for the nights of the same month, although the coefficient of proportionality changes from month to month. The structure of the green line emission layer has been studied by observing the changes in isophote maps. It has been found that the lines of equal intensity are generally oriented east-west, although elliptical spots of higher intensity sometimes move from east to west. General changes of intensity without displacement of the lines of equal intensity may also occur. In a paper closely related to Barbier's, F. E. Roach, NOTS, Inyokern, California, discussed the "Diurnal Variation of OI, 5577Å, in the Night Airglow." A study of observations made at Cactus Peak, California over a two-year interval shows that the maximum of intensity may occur as much as two and one-half hours before or after local midnight. Although the various parts of the sky which can be observed from a single station go through similar time variations, there are significant differences both in the time of maximum and the range of intensities. An attempt has been made to reduce all the observations for a given night to the local zenith intensity. This permits an interpretation in terms of geographical distribution of the excitation of the 5577Å line and the construction of isophote maps. The study is being extended to other lines; preliminary results indicate that the excitation pattern of the sodium D-radiation is less stable than that of 5577Å.

A. T. Vassy, Université de Paris, presented an interesting paper on the "Absorption of Solar Radiation by the Atmosphere." Two experimental methods of study were discussed: (1) measuring the intensity of the solar radiation at different solar zenith distances; (2) measuring absorption coefficients and calculating the absorption from existing data on the chemical composition of the atmosphere. Our present state of knowledge of absorption coefficients of the different atmospheric constituents was reviewed. The coefficients for ozone are fairly well known, and those for the nitrogen oxides have recently been studied. The absorption coefficient of molecular oxygen has been investigated, and pressure effects have been observed. Attention was also given to the absorption of x-rays and corpuscular radiation by the atmosphere. Our knowledge of the vertical distribution of atmospheric constituents was also reviewed. The need for a direct determination of this distribution through rocket measurements was emphasized, owing to the prominent part played by photo-dissociation in the ionosphere and mesosphere. From the known data, a curve giving the altitude at which solar radiation has suffered an attenuation of 90% can be computed. This curve shows a relatively transparent spectral range at about 1215Å. The data for this range are, however, very poor. The data obtained experimentally by using rockets was compared with this curve. The observations are in excellent agreement with the computations near 2000Å, in fair agreement near 1500Å, but in the neighborhood of 1200Å the radiative energy measured is greater than would be expected.

Two informative papers were given by A. B. Meinel of Yerkes Observatory. The first, entitled "Protons and the Aurora," presented evidence from the great aurorae of August 18 to 20, 1950 which showed that high velocity protons were entering the upper atmosphere and that they were being sharply decelerated by it. During the above-mentioned aurorae, spectra were obtained of the H_α region with a high resolution spectrograph pointed toward the magnetic zenith and toward the north magnetic horizon. Spectra of a quiet auroral arc at the magnetic horizon show a strong, undisplaced, but broadened H_α line. The line was completely symmetrical. Spectra of another quiet arc passing through the magnetic zenith, however, showed a very asymmetrical H_α profile. The maximum was displaced 10Å, while the violet wing was shifted 71Å, corresponding to a velocity of 3300 km/sec. This velocity is considerably in excess of velocities for auroral particles as estimated by indirect means. The entire sequence of spectra obtained seems to indicate that the entry of protons into the atmosphere represents the primary excitation source for the aurora, while the rays and flaming structures represent secondary effects. It is interesting to note that this important work was performed as a result of discussions at the Conference on Ionospheric Physics held last year. In a second paper, Dr. Meinel discussed "The Near Infrared Auroral Spectrum." The chief results of the study of this spectral region have been the conclusive identification of permitted atomic lines of OI and NI and the new identification of two band systems. Although one of these systems has not been reproduced in the laboratory, the evidence for its correct identification in the auroral spectrum seems quite convincing. Dr. Meinel has identified this system as being due to the $A^2\pi$—$X^2\Sigma$ transition of N_2^+. There are six independent observable quantities for the auroral bands that point to the N_2^+ identification. The other system appears to be due to three sources, the first positive (2, 1)N_2 band, the atmospheric (0, 1)O_2 band and the widespread 8680Å NI multiplet. However, the final analysis of this complex group of emissions will have to await higher dispersion studies.

Dr. Meinel also read a paper, "Emission of Auroral Corpuscles in the Vicinity of the Sun," by K. O. Kiepenheuer, who unfortunately was unable to attend the Conference. This paper on the emission of corpuscles in the vicinity of the sun reviewed the arguments in favor of the existence of solar corpuscles and their geomagnetic actions. The ability to trace the recurrence of small perturbations of the earth's magnetic field for longer than eight solar rotations implies sources of radiation on the sun with a lifetime in excess of ½ year. These regions on the sun have been named M-regions by Bartels. Considering modern flare data and our present knowledge of the chemical composition of the solar atmosphere, the emission of storm-producing corpuscles from these M-regions was discussed in terms of the well-known Milne mechanism acting on CaII ions. The long-lived streams of solar corpuscles producing moderate disturbances of the earth's magnetic field were identified with the invisible extensions of the coronal streamers, and can be quantitatively understood as a process of evaporation of coronal protons into space. The unobservable M-regions are probably to be associated with the coronal streamers.

A second paper dealing with solar phenomena, "Magneto-Hydrodynamic Waves in the Sun," was presented by H. Alfvén of the Royal Institute of Technology, Stockholm, Sweden. In the sun, the general magnetic field and the high degree of ionization make the conditions favorable for the transmission of magneto-hydrodynamic waves. Their velocity should be about 1 m/sec in the solar core out to about 0.9 of the solar radius; in the photosphere the velocity should increase rapidly to a value of some km/sec, and in the upper corona it should attain a value of the order of 1000 km/sec. Since the wavelength of magneto-hydrodynamic waves depends essentially upon the mechanism by which they are generated, it might be possible to have several different wavelengths produced in the sun. Three mechanisms which have been proposed are: (1) standing waves of the whole sun, (2) waves generated in the turbulent region in the solar core, and (3) waves generated in the photosphere and associated with the granulation. It was pointed out that there is no reason to assume that oscillations of the first type occur on the sun, where they should have a period of about 100 years. Oscillations of the second type are believed to be important in the production of sunspots. Waves of the third type represent in part a transition between magneto-hydrodynamic waves and sound waves, and the conversion of their energy into heat as they are transmitted upwards is a possible cause of the high temperature of the corona. The controversial subject of the general magnetic field of the sun was also discussed, and it was pointed out that the existence of granulation waves produces a systematic error in the Zeeman effect measurements of the general field which may explain why the results are so conflicting.

One of the important functions of scientific meetings was illustrated when S. Chapman of Queen's College, Oxford, England, and Professor Alfvén received the opportunity to openly discuss the areas of agreement and disagreement between their respective theories of the formation of the aurora. In his paper, "Theories of the Aurora Polaris," Professor Chapman outlined the main observed facts concerning magnetic storms and aurorae. Since the evidence appears to rule out all but the corpuscular theories, the discussion proceeded on the basis that the cause is the emission from the sun of a neutral but ionized gas. An outline was given of the difficulties of even formulating, in a manageable way, the problem of the motion of such gas during its interaction with the earth's magnetic field. An alternative attack is the formulation and solution of relevant idealized problems of the motion, in a magnetic field, of large neutral assemblies of oppositely charged particles. This is the approach adopted by Chapman and Ferraro. By relying on mathematics for the construction of their theory, and avoiding speculation not closely guided by mathematical solutions of relevant illustrative problems, they have made some real progress towards a theory of magnetic storms. The initial rise in the geomagnetic field strength (associated with a magnetic storm) is said to be due to the compression of the earth's field as the beam of particles ejected from the sun approaches the earth. The subsequent depression of the geomagnetic field is said to be due to the formation of a westward ring current around the earth, or possibly the reinforcement of an already existing ring current. Particles accelerated out of the ring current could penetrate to auroral levels. However, this part of the theory is much less certain, and much work remains to be done. In contrast to the method of approach of Chapman and Ferraro who have attempted to solve the theoretical problem of the interaction of solar plasma with the geomagnetic field, Professor Alfvén has started from the viewpoint of an observer who sees the aurora in the sky and interprets it as an electric discharge. He cited model laboratory experiments performed by his colleagues in support of his view. He has therefore tried to explain how an electric field might be formed which could cause a large-scale atmospheric discharge in the auroral region. For this purpose, he attaches fundamental importance to the polarization field due to the motion of a neutral plasma in the solar magnetic field. From the discussions, it appeared that Professor Alfvén would be willing to accept an analysis of the Chapman-Ferraro type, provided this induced electric field were taken into account. Professor Chapman seemed willing to accept the possibility that electric discharges could occur in the auroral zone, but he believes that the electric field due to the motion of the plasma in the solar magnetic field is inadequate to produce such a discharge, and further that the effects of such a field are small compared to the effects produced by the earth's magnetic field and the electrostatic forces between the ions and electrons.

Professor C. Störmer, Institutt for Teoretisk Astrofysikk, Oslo, Norway, presented a paper on "Sunlit Aurorae." The remarkable phenomenon of aurorae in the sunlit atmosphere has been observed in southern Norway on numerous occasions from 1911 to 1951. The heights of the lower border of the sunlit aurorae were found to lie between about 200 and 800 km above the earth, while summits have occasionally reached heights exceeding 1000 km. On a few occasions these aurorae have been divided with one part in sunlight and another in the earth's shadow, the two parts being separated by a dark space. The spectra of sunlit aurorae are observed to be different from those of common low lying aurorae. The intensities of the oxygen line of 6300Å and the nitrogen bands at 4278 and 3914Å are very much stronger than that of the line 5577Å. The spectral difference is usually observable visually. The color of sunlit rays is generally a feeble violet white, in contrast to the common yellow-green color of ordinary aurorae. Professor Störmer concluded by recommending the study of sunlit rays to all who are interested in the uppermost layers of the atmosphere. Professor Störmer is one of the real pioneers in the field of auroral physics, and many references were made to his invaluable contributions, both theoretical and observational. His presence at the Conference added measurably to its success.

A change from the technical meetings was provided by the dinner session on 24 July. The Conference was fortunate in having as its after-dinner speaker Professor B. W. Currie of the University of Saskatchewan, who portrayed in a very interesting and comprehensive fashion the development of "Geophysics in Canada". On the following evening, the delegates were honored at a civic banquet tendered by the Corporation of the City of London, Ontario, at which time they were given an opportunity to meet His Worship, Mayor Allan J. Rush.

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ICSU Executive Board

Third Annual Meeting Held in Washington

The governing body of the International Council of Scientific Unions held its third annual meeting in the rooms of the National Academy of Sciences in Washington on October 16th and 17th at the invitation of Detlev W. Bronk, president of the Academy. The meeting, which was presided over by ICSU president Alexander von Muralt, distinguished Swiss physiologist and a lifelong friend of Dr. Bronk, was held to carry out current business of the Board and to prepare the way for the next General Assembly of the ICSU, which will be held next September in Amsterdam. New statutes will be adopted at that time, and new ICSU officers will be elected.

Under the heading of current business, the Council's main actions had to do with the creation of an international abstracting service to facilitate the work of existing abstracting journals, the formation of a special committee to coordinate scientific research during the Polar Year 1957–58, and the agreement of the Council to participate with Unesco in deciding upon the annual award of the Kalinga Prize for contributions toward the popularization of science.

It was decided that an International Abstracting Service (to be known as IAS) should be established under ICSU, of which abstracting journals in any part of the world may become members. The service is designed to facilitate the exchange of page proofs, summaries, scarce or nonperiodical publications, etc. between established abstracting journals.

The year 1957–58 will be a period of minimal sun spot activity, and the Council's action in this regard had chiefly to do with the possibility of planning special observations on the ionosphere in the polar regions and with special observations in the equatorial belt. Purposes of the coordination program would be primarily to study the number and nature of electrified particles emitted by the sun and to observe the circulation of air in the earth's atmosphere.

As has been announced previously, the Kalinga Prize (valued at one thousand pounds sterling annually) was established by Sir B. Patnaik of Tulsipur, Cuttack, India, for work in disseminating knowledge of science, whether by books, newspaper articles, films, radio talks, or television. The first award, for 1951, is expected to be made in the spring of 1952, and will be presented to a candidate chosen by Unesco and ICSU. The successful candidate will be invited to visit India at the expense of the Kalinga Prize Fund.

Members of the ICSU Executive Board who attended the meeting in Washington included, in addition to Professor von Muralt: H. Solberg, vice president (Norway); John A. Fleming, the retiring president (United States); F. J. M. Stratton, ICSU general secretary (Great Britain); J. N. Mukherjee (India); B. Lindblad (Sweden); B. Stromgren (Denmark); S. Chapman, and H. Munro Fox (Great Britain); G. Laclavere, R. Delaby, and P. Fleury (France); H. A. Kramers (Netherlands); and J. Murray Luck, J. Dillinger, George B. Cressey, Stuart Mudd, P. P. Ewald, H. L. Dryden, and G. Sarton (United States). Ronald Fraser, liaison officer between the International Council of Scientific Unions and Unesco, who has his office at Unesco House in Paris, also attended the meeting.

AAAS in Philadelphia

118th Annual Meeting This Month

Philadelphia, the city in which the American Association for the Advancement of Science was founded in 1848, will again be the scene of the annual AAAS meeting this year from December 26th to 31st. The program will include more than two hundred separate sessions. All eighteen of the Association's sections and subsec-