TRANSMISSION STUDIES WITH THE NEW PSYLLID-YELLOWS DISEASE OF SOLANACEOUS PLANTS

DURING the years of 1926, 1927 and 1928 a peculiarly destructive disease of potatoes was found on the western slope of Colorado in the potato fields, and it was thought to be associated with the common tomato psyllid (*Paratrioza Cockerelli Sulc.*). The exact nature of the injury is not well understood, and it was thought either to be caused by a toxic material secreted by the nymph while feeding on the leaves of the plants or that the insect transmitted a so-called virus. The disease is apparently different from any of the so far described diseases of either the potato or the tomato. The outstanding characteristic symptom is the upward cupping of the leaves and a marked dwarfing of the plant. The disease was most severe during the 1927 growing season, when the early potato crop was reduced from a six hundred to a two carload crop. Since 1927 it has been found on other solanaceous plants and the most damage has been observed on the potato and tomato crops.

The investigations carried on to date indicate that the injury is not produced by the feeding of the psyllid nymph alone.[1] Eggs laid by viruliferous tomato psyllids on diseased plants, grown under caged conditions, were hatched artificially under sterile conditions. The nymphs so secured were placed on healthy tomato plants and permitted to feed for the first time on the growing portions of the plants. The nymphs were permitted to feed until reaching the adult stage and in each case no injury was observed on the plants. Duplicate checks produced the same effect. The results indicate that the so-called virus is not transmitted through the egg and then to the nymph stage, and further that the feeding of the nymphs alone does not severely injure the growth of the tomato plants.

In the observations made, with viruliferous nymphs under caged conditions, the disease was transmitted from affected to healthy plants in a short time. Viruliferous nymphs were transferred from diseased to healthy potato plants and the characteristic symptoms produced within seven to ten days. The insects apparently bear an important relationship to the disease, and are important in spreading and transmitting the disease. The disease has been transmitted from diseased tomato to healthy potato plants and also from potato to tomato plants. It has also been transmitted to the common garden pepper, to eggplant and to the ornamental Jerusalem cherry. The evidence to date indicates that the disease is of a virus nature.

Artificial inoculation, of extracted and filtered juice secured from a diseased plant, by means of a needle injection, did not prove to be a satisfactory method of transmission.

The scale-like nature of the nymph, its habit of feeding on the under-side of the leaves, and the further protection afforded by the cupping or upward rolling of the leaves make control by spraying and dusting a very difficult problem. The strong spray mixtures necessary to kill the insect injure the foliage of tender solanaceous plants. The destructive nature of the disease and the difficulties encountered in control indicate that it may become one of the most serious diseases affecting solanaceous plants in the inter-mountain region.

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Polarized fluorescence in liquids: ERNEST MERRITT and DONALD ROGER MOREY. While the light emitted by fluorescent liquids ordinarily shows no polarization, it has been found that solutions of fluorescent materials in highly viscous solvents emit light which is partially polarized. In its dependence on the direction of emission and on the state of polarization of the exciting light the fluorescence of such solutions is qualitatively similar to the light scattered by small suspended particles in the Tyndall effect. The polarization is, however, never complete. The polarized fluorescence of viscous solutions, first noticed by Weigert, has been studied by numerous observers, and has been satisfactorily explained as the result of the relatively slow Brownian rotations of the active molecules, for if the viscosity is sufficiently great the excited molecules will return to the normal state before the random distribution has been reached which is necessary for unpolarized emission. The percentage of polarization will therefore depend upon two factors: *viz.*, (1) the extent to which viscosity slows up the Brownian movements of rotation, and (2) the duration of the excited state. Since the fluorescence spectrum consists of a band extending over a range of several hundred Ångström units, it seems not unlikely that the duration of the excited state is different for the excited molecules corresponding to different parts of the band. And in this case we should expect the amount of polarization to vary, probably progressively, throughout the spectrum. Unfortunately, the only two attempts that have previously been made to determine a possible variation of polarization with wave-length have led to contradictory results. The question seems therefore to call for further experiment. Using glycerin solutions of rhodamin B and of uranin we have compared the intensity of the fluorescent light

[1] The psyllids used in the cage experiments were kindly identified by E. O. Essig, entomologist of the University of California.

for the directions of maximum and minimum polarization by a photographic method. A rectangular cell containing the fluorescent solution was placed in front of each of the two slits of a Lummer-Brodhun spectrophotometer and the two solutions were simultaneously excited by light from a mercury arc. With nicol prisms to secure proper conditions of polarization and color filters to prevent errors due to stray light the two spectra formed were photographed one above the other on the same plate and the intensities were adjusted by trial until the two were as nearly as possible alike. The density of the image on the plate was measured by a microphotometer. The measurements made thus far indicate that the polarization of the fluorescent light for the two substances tested is constant throughout the fluorescence band. In the case of uranin, however, the spectrum appears to consist of two overlapping bands, and in one of these the polarization is considerably greater than in the other. The results thus add support to the view that the processes involved in the emission of the different parts of a fluorescence band are so closely connected that each band is to be regarded as a unit.

The relative intensity of X-ray satellites: F. K. RICHTMYER and L. S. TAYLOR. Close to and on the short wavelength side of many of the more prominent X-ray spectrum lines are faint lines called satellites. Two theories of their origin have been proposed: (1) A single-electron jump between doubly ionized states of the atom; and (2) a simultaneous two-electron jump between doubly ionized states, the resulting energy thus freed being emitted as a single quantum of slightly higher frequency than that of the parent line. The first theory requires double ionization of inner electron shells. The second requires single ionization of one inner and one outer shell. Data concerning the relative intensities of satellites compared to parent lines should be of value in deciding between these two theories. No quantitative measurements of such intensities have been previously made. Using the double X-ray spectrometer and accessory equipment of Professor Bergen Davis at Columbia University, the authors have measured the intensity of the satellite $Ka_{3,4}$ of the "parent" line $Ka_{1,2}$ of Cu (29), and of Ni (28). The following are the important results: (1) The wavelengths of the satellites determined by this ionization method agree well with other determinations by the photographic method. (2) In the photographic method the satellites were unresolved. They are clearly resolved by the double X-ray spectrometer into two, or possibly three, components. (3) The intensity of $Ka_{3,4}$ for Cu is about 0.00400 of the intensity of $Ka_{1,2}$. From (3) one concludes that the number of atoms, doubly ionized in such a manner as to produce $Ka_{3,4}$, is about 1/250 of the number of singly ionized atoms under the conditions of the experiment. It is hoped to continue this investigation to ascertain how this ratio varies with applied voltage and with atomic number of the target.

The Waidner-Burgess standard of light: H. T. WENSEL, M. F. ROESER, L. E. BARBROW and F. R. CALDWELL (introduced by G. K. Burgess). Following out the suggestion made in 1908 by Waidner and Burgess, the luminous intensity of the primary photometric standards of the Bureau of Standards has been compared with the brightness of a black body at the freezing-point of platinum. The black body standard was realized experimentally by immersing a tube of fused thoria in a bath of purest platinum (purity higher than .999996) contained in a crucible of fused thoria. The platinum was melted in a high frequency induction furnace and observations of brightness were taken during the period of freezing. The brightness of the Waidner-Burgess Standard was found to be 58.9 International Candles per sq. cm.

Preparation and resolution of 2,2′ difluors. 6,6′ dicarboxyl diphenyl: ROGER ADAMS.

On the technique of measuring the magnetic susceptibility of gases: FRANCIS BITTER (introduced by R. A. Millikan). At the present time accurate methods for measuring the magnetic susceptibility of gases are of considerable importance for the solution of two problems: the origin of the anomaly in the pressure dependence observed by A. Glaser (*Ann. der Physik,* 2: 233, 1929); and the establishment of an upper limit for, and perhaps the measurement of, nuclear magnetic moments by accurate measurements of the temperature dependence of the magnetic susceptibilities of gases like hydrogen, nitrogen, xenon, etc. A new type of suspension for a Glaser-type apparatus consisting essentially of a closed glass cylinder divided radially into four equal chambers is discussed. The zero reading is practically independent of the field strength and the temperature, and in consequence two of the most important possible sources of error in previous measurements are removed. The method is discussed as to the limits of its sensitivity and applicability.

On the magnetic properties of electrons in metals: FRANCIS BITTER (introduced by R. A. Millikan). In order to calculate the diamagnetic contribution of free electrons to the magnetic susceptibility of a metal, two expressions are necessary: firstly the magnetic moment of a free electron as a function of its energy, and secondly the distribution of the energy among all the electrons. The application of the Fermi statistics to a gas of free electrons performing elastic collisions with the atoms of the lattice leads to an expression for the susceptibility which can not be reconciled with the facts. It is shown that the discrepancy is due to improper assumptions concerning the interaction of the electrons with the lattice in the metal. The magnetic perturbation of a free electron in a lattice is discussed according to wave-mechanical methods. This gives for elements in the first column of the periodic table a diamagnetism less than the paramagnetism due to free electrons as calculated by Pauli.

The magnetic properties and microstructure of some high platinum alloys: F. WOODBRIDGE CONSTANT (introduced by R. A. Millikan). In view of the present unsatisfactory state of our knowledge concerning the mechanism of ferromagnetism, a study of the Pt-Co series of alloys is interesting. These alloys are ferromagnetic even

for high platinum concentrations, as recently reported by the author (*Phys. Rev.*, October 15, 1929); the magnetic moment per cobalt atom actually increased with platinum concentration. The phase diagram for these alloys not being known, an investigation of the microstructure was made microscopically which showed them to be solid solutions. Under high magnifications, the individual crystals showed the mosaic structure predicted by Zwicky. Since the cobalt atoms may be regarded as further isolated from one another by the presence of the platinum, their magnetic properties are discussed with reference to the recent theories of ferromagnetism.

Theory of deflection of neutral molecules in non-homogeneous electric fields, with and without a crossed uniform magnetic field: H. P. ROBERTSON and E. A. MACMILLAN (introduced by K. T. Compton).

The quantum mechanical theory of electron scattering from crystals: PHILIP M. MORSE (introduced by K. T. Compton). A detailed analysis of the behavior of an electron stream impinging on a crystal lattice shows that the rules for the scattered beams, obtained by considering the electron as completely analogous to a beam of X-rays, are only approximately correct. For instance, for normal incidence, it is shown that the electronic energy E for intense specular reflection would be $(n^2h^2/8md_x^2) - V_o + G_n$, where n is an integer, m the mass of the electron, d_x the separation between the atom planes parallel to the surface, V_o the work function of the crystal and G_n a small correction which varies with changed surface conditions and with change of n. The result obtained by analogy with X-rays would not include G_n. The known experimental evidence confirms the necessity of including G_n. The "index of refraction" of the electron beam is shown to be $\sqrt{(E+V_o+f)/E}$, whereas the analogy with X-rays would make it $\sqrt{(E+V_o)/E}$. The function f is very small except when $E \sin^2\theta = n^2h^2/8md_y^2$, where θ is the angle of incidence and d_y is the separation between the atom planes perpendicular to the plane of incidence. At these particular values of $E \sin^2\theta$, the rapid variation of f produces a change in the index of refraction similar to anomalous dispersion. Experiments have found such cases of "anomalous dispersion" at values of $E \sin^2\theta$ which check with the theory. Thus the quantum mechanical theory of the electron explains not only the general effect of scattering from crystals, but also the small peculiarities in the experimental results. This work was done at the Bell Telephone Laboratories under the supervision of Dr. C. J. Davisson, to whom the writer is greatly indebted.

Series in the copper arc spectrum: A. G. SHENSTONE (introduced by K. T. Compton).

Comparison of protons and electrons in the excitation of X-rays by impact: HENRY A. BARTON (introduced by Ernest Merritt). The fundamental charged particles in nature are the electron and the proton. The great difference in behavior of the two in collisions with atoms probably arises chiefly from the fact that the proton is 1,846 times as massive as the electron. The new wave mechanics presents the possibility, not yet quite realized, of quantitatively comparing the effectiveness of the two particles in collision processes. An example is the efficiency in the production of X-radiation by bombardment of a target. So far, the wave mechanics only states that the critical energy for the production of the characteristic radiation (*e.g.*, Cu-K) shall be the same whether protons or electrons are used as the striking particles. No formula for the intensity has yet been derived. The work to be described aims to furnish a basis of experimental fact with which eventually to check the theory. An arrangement resembling a mass spectrograph was used to bring either a beam of electrons or of protons onto a copper target. The design of the apparatus was such that several possible sources of erroneous conclusions were eliminated. The comparison between radiation produced by proton, as opposed to electron, impact could be made with identical energies, target, detecting device and geometrical arrangement. It was found that with the proton currents that could be produced, the X-radiation excited was too weak to detect, the experiment thus yielding a negative result. However, a calibration of the overall sensitivity of the apparatus for an electron beam enabled the setting of a certain upper limit to the effectiveness of protons. The direct experimental conclusion reached is that ρ, the ratio of the excitation efficiency of electrons to that of protons, is of the order of 10^5 or greater. This number is well above the ratio (M/m), about the same as $(M/m)^{3/2} = 79{,}310$ and considerably smaller than $(M/m)^2$.

Positive ion emission from tungsten and molybdenum: L. P. SMITH (introduced by Ernest Merritt). An examination of the positive ion emission from tungsten and molybdenum has been made in which it was sought to determine the following points: (1) The nature of the ions emitted at various temperatures; (2) the temperature variation of the positive ion current; (3) the theory of positive ion emission with regard to where and how the ions are formed; (4) the positive ion work function for these metals; (5) to determine whether the work function, determined by experiment, checks with that calculated by a simple cyclic process involving the thermionic work function, the ionizing potential and the latent heat of evaporization of the metal. The mass spectrum for tungsten and molybdenum filaments taken at moderate temperatures (1700° to 2000°) has shown that the emitted ions consist of sodium, the two isotopes of potassium and aluminum. At high temperatures these impurities disappear and finally both tungsten and molybdenum filaments yield positive ions of their own metal. The latter confirm a report by Wahlin (*Phys. Rev.*, 34: 164, 1929). The temperature variation of the positive ion current at high temperature yields a value of 6.55 volts for the positive ion work function of tungsten and 6.09 volts for that of molybdenum. These values disagree widely from the values 10.88 volts and 9.26 volts calculated from the simple cyclic process mentioned above. This suggests that the ions are formed as a by-product of

an irreversible recrystallization of the metal. Theoretical considerations show that the ions are emitted from the metal and are not formed after a neutral atom evaporates.

On shatter-oscillations in liquid columns: E. H. KENNARD (introduced by Ernest Merritt). In some experiments recently witnessed by the writer in an industrial plant an extraordinary and apparently little-known type of fluid oscillation was observed. A pipe thirty-one meters long, filled with water, was connected to a tank containing some water and above it air under a pressure of three to four atmospheres; to the other end of the pipe was attached a pump. A recording gauge attached to the pipe near the pump showed at regular intervals narrow peaks of pressure, ranging as high as seventy atmospheres, separated by calm intervals four to eleven times as long as the duration of the peaks, during which the pressure appeared to be slightly below atmospheric. The interval between the peaks was several times longer than the period of oscillation of the water column regarded as a closed organ pipe. The proposed explanation is that when the water column expands and its pressure sinks to zero, the column "shatters." Theory indicates that, as soon as the pressure reaches zero at one point, a shatter-front will sweep from that point in both directions along the column with a speed above that of sound, leaving the water in an expanding condition behind it; no large breaks in the column can occur, but it will become full of little cracks or holes. During the subsequent reconsolidation of the column the water may acquire high velocities toward the pump, and when the reconsolidation-front reaches the pump an impulsive "water-hammer" pressure will result. A detailed study of such oscillations in the laboratory would be of interest.

On the existence of integrals of Einstein's gravitational equations for free space and their extension to a variable: T. Y. THOMAS (introduced by O. Veblen).

Memoir of John Trowbridge: E. H. HALL.

Biographical memoir of John Merle Coulter: WILLIAM TRELEASE.

Two contradictions in current physical theory and their resolution: F. S. C. NORTHROP. Our purpose is to show that two contradictions exist in current physical theory which can be met only by a certain amendment to our traditional atomic theory. The first contradiction will be demonstrated by establishing three propositions. (1) Atomicity is an inescapable fact. (2) Atomicity necessitates the existence of a referent other than the microscopic particles. (3) According to current scientific theory no such referent exists. It appears that the facts permit no conclusion but that a new referent must be introdueed into our traditional atomic theory to replace the discarded absolute space. The second contradiction also rests on three propositions. (1) The metric of space is conditioned by matter. (2) This metrical structure exhibits uniformity over macroscopic distances. (3) Matter, as currently conceived, is incapable of producing such uniformity. Since neither of the first two premises can be escaped it follows that our traditional theory of matter must be amended to provide a basis for the metrical uniformity which was previously assigned to absolute space. A consideration of what is required to produce the type of metric, which Einstein suggests and the facts reveal, indicates what the required amendment must be. In a relativity theory, space is a relation between objects. Hence metrical variability means that the relations between the ultimate atomic entities change; and metrical uniformity means that they do not. It becomes evident, therefore, that the kinetic and contingent properties of the microscopic elements of the traditional atomic theory insure their adequacy as the source of local metrical variability, but eliminate them as the source of macroscopic metrical uniformity. In short, the general macroscopic uniformity must be regarded as imposed upon their contingent relatedness from without. This calls for an entity which is atomic and physical in character, and so large in size and fixed in form as to surround and congest all the microscopic atomic entities of the traditional atomic theory.

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