ing fund of the proposed new university to be located three and a half miles from the center of the city.

THE department of sociology and anthropology at the University of Chicago has been dissolved and reconstituted as two separate departments. The department of sociology will be under the chairmanship of Dr. Ellsworth Faris, while the chairman for anthropology is Dr. Fay-Cooper Cole.

THE Grey University College at Bloemfontein, the chief town in the Orange Free State, has instituted a course leading to a degree in astronomy, the first in the Union. Professor Jan Paraskevopoulos, of the Harvard Observatory, and M. E. Jessup, of the University of Michigan, will conduct the course.

THE summer field course given at Grand Isle, Louisiana, under the auspices of the department of zoology of the Louisiana State University, will be repeated the coming summer from June 14 to July 24. The facilities of the laboratory are offered to research workers and others interested in marine biology during that season.

DR. RUSSELL M. WILDER, of the Mayo Clinic and Foundation, Rochester, Minnesota, has been appointed professor and chairman of the department of medicine at the University of Chicago. In the position of chairman of the department Dr. Wilder succeeds Dr. Franklin C. McLean, whose appointment as director of University Clinics was recently announced.

PROFESSOR KIRTLEY F. MATHER, of Harvard University, has been appointed exchange professor in geology at Tufts College.

DR. GEORGE T. HARGITT, of Syracuse University, and Dr. C. M. Child, of the University of Chicago, will serve next year as visiting professors at Duke University during the absence of Dr. A. S. Pearse, who has been granted a year and a half leave to aid in the establishment of the research work at Keio University, Tokyo, Japan.

PROFESSOR LINUS PAULING, at present at the California Institute of Technology, Pasadena, has been appointed lecturer in chemistry and physics in the University of California.

AT Harvard University, Sheldon fellowships enabling the recipient to travel for a year abroad have been awarded to Dr. Benjamin Kropp, instructor in zoology, and to Arthur Barton Brown, instructor in mathematics. Awards to students in physics have been made to James Holley Bartlett, Jr., and Clarence Melvin Zener; in botany to Walter Nicholas Bangham and Felipe Modesto Salvoza.

DR. ERIC D'ATH, pathologist at the Royal Prince Alfred Hospital, Sydney, has been appointed to the chair of pathology of the University of Otago, New Zealand.

DR. D. R. HARTREE has been appointed to the Beyer chair of applied mathematics in the University of Manchester. At present he holds a lectureship in mathematical physics at the Cavendish Laboratory, Cambridge.

DISCUSSION

THE INTERACTION OF MATTER AND RADIATION

NOT many years ago we pictured a beam of light as a procession of waves, possessing wave-lengths and amplitudes. The latter, however, became electric vectors always at right angles to the direction of propagation. Recently we have come to look upon light as a flight of bundles of energy, every bundle having an energy proportional to the frequency or *vice versa*. And in the *explanation* of any phenomena of light now we use the idea of waves or electric vectors or quanta as we wish, ignoring the characteristics unnecessary to the *explanation*. In accounting for the pressure of radiation we may use any of the three characteristics as Maxwell, Larmor and Einstein have, in turn, shown. Or we may arrive at the result by purely thermodynamic reasoning, as did Boltzmann. In this point we are much better off than the physicists of one hundred years ago who could not accept the possibility of radiation pressure, yet if we go back two hundred years we find that Newton required light to have a pressure on the basis of his quasi-quantum, *i.e.*, corpuscular, view of its nature.

Most of the progress of the past twenty years has been based on the idea of the quantum and its action upon or production by electrons capable of motion from one energy state to another. The ejection of photoelectrons by light of definite frequency, the emission of light of definite frequency by electrons of definite kinetic energy, all the phenomena of resonance and ionization potentials, of X-rays, the spectral series as visioned by Bohr, the new quantum mechanics which is replacing the Bohr picture, in all of these the compact bundle of energy—the quantum—is the essential quality of light. Occasionally the electric vector is brought into service, for example, in accounting for the prevailing direction of ejection of the photoelectrons. That direction is, on the whole, along the electric vector of the effective light beam.

A recent theoretical contribution, that of Smekal in 1923, although derived purely on the basis of quanta, may have an interpretation on the basis of

waves. Smekal came to the conclusion that light passing through matter might find the atoms in such a condition that there would be an interaction, a coupling, of the two energy conditions with the result that radiation would be scattered from the atom with frequencies $n-p$, n, and $n+p$, where n is the frequency of the radiation and p that of the energy quantum involved in the resulting change of state of the atom. Now so far as frequencies are concerned this is analogous to the broadcasting by an atom of a carrier wave of frequency n, modulated by a frequency p characteristic of the atom. It might be called the atomic voice frequency. His prediction was brilliantly confirmed by Raman and by numerous subsequent investigators. A variety of liquids and crystals show this effect; among the latter quartz is a conspicuous example. The outstanding fact in this phenomenon is the scattering of an increased as well as a decreased frequency, although it appears that the former may be filtered out or annulled in comparison with the latter. Or from another point of view it may be said that the probability of an atom taking up a quantum from the radiation is greater than the probability of the opposite transformation.

When we come to deal with the interaction of light on an isolated or nearly free electron no enhancing of the frequency can result. The phenomenon is relatively a simple one. We picture the radiation as a flight of bundles of energy, definitely related to the frequency, possessing momenta in keeping with their energy. When one of these quanta *strikes* an electron the latter acquires momentum and energy and the new (or old?) quantum rebounds or glances off always subject to the condition that the total momentum and energy remain constant. In every case in which there is a collision the rebounding or scattered quantum is decreased in energy and therefore in frequency. The greatest decrease is when the quantum rushes bull-headed at the electron and finds itself always thrown straight back, humbled, reduced in frequency, but perhaps consoling itself in the thought that it has sent the electron off at top speed. In this effect—the Compton effect—the lowering of frequency of the scattered radiation depends on the angle of scattering. It is the same for all free or nearly free electrons. In the Raman effect the change of frequency up or down does not depend on the angle of scattering but is dependent upon the energy states of the atoms.

Smekal does not tolerate the idea of waves in dealing with light. Quanta and frequencies are the only characteristics which he takes into account. And indeed in many of the new phenomena of light, waves with their electric and magnetic vectors are quite unnecessary. However, there is a predominant motion of the photoelectrons along the electric vector, and there is a corresponding preponderance of the recoil (free) electrons along the magnetic vector—though the latter observation has not as much evidence in its favor as one would wish.

A new phenomenon, however, comes to hand which will be *explained* by physicists of the older generation in terms of waves. Every amateur radio operator knows that if a continuous wave train of frequency n is modulated or interrupted by a periodic device of frequency p the frequencies resulting are $n+p$, n, and $n-p$. Now Rupp, of Göttingen, by means of a high frequency (10^8-10^9 per sec.) electrical oscillation and a Kerr cell has modulated the intensity of a *highly monochromatic* light beam and has found the frequencies indicated by theory. Here, however, on account of the square law of the Kerr cell the altered frequencies are $n+2p$ and $n-2p$. The new radiation is not scattered—it is direct.[1] Are there quantum interchanges as contemplated by Smekal? If so are they imposed on the atoms by the outside electrical frequency which is entirely under the control of the operator? No doubt this idea must be rejected. It seems clear that the ultimate reality in light is the energy quantum, frequency is merely a secondary, a derived property and wave-length is a convenient picture as it is now when we deal with the structure of the electron. I have in mind here the phase waves of the new electron which are regarded as waves in the q space and which have a velocity greater than the velocity of light; so related to the velocity of the electron that the slower it, the electron, moves the greater is the velocity of its phase waves—a rather difficult property to picture as a reality.

GORDON F. HULL

CAMBRIDGE, ENGLAND,
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[1] There has just appeared in *Nature*, December 1, a letter by Bramley, of the Bartol Institute, giving the results of some experiments he has performed similar to that by Rupp. Using an iron arc and a Kerr water cell he obtains, for an electrical frequency of about 3×10^8, an increase of wave-length of 0.1 Å for two of the iron lines and no variation whatever for eight others. But the shift to be *expected is only* 3×10^{-3} Å and can not possibly be detected except for extremely fine lines and can not be measured except by the use of the most precise methods. The half width of the green thallium line used by Rupp was 0.025 Å, and since the wave-length of the line was 5350.6 Å it would seem that he was working under very favorable conditions. However, Bramley's result might have been occasioned by high overtones in his electrical oscillations or, what amounts to the same thing, by Fourier components of his wave form. In any event, the result obtained is important and awaits interpretation.