Journal notes

Theory of Superconductivity

In quantum mechanics an electric current is closely connected with translational degeneracy. This is the reason why the difference between metals, insulators, and semiconductors can be qualitatively obtained from symmetry considerations assuming appropriate gaps in the energy spectrum. A systematic investigation of symmetry has shown that there is one more coupling case not previously considered, which leads to a model with the essential properties of superconductor. This model is described in terms of many-electron wave functions which correspond intuitively to electron lattices resonating between several equivalent positions.

The method is not adequate to prove whether the theoretical conditions of superconductivity are satisfied in actual cases. However, the assumption that they are satisfied in the two regions of the periodic table where the hard and soft superconductors are located fits in well with independent quantum chemical evidence. The London relation is given a quantum mechanical derivation. In contrast to these qualitative results Fröhlich's recent theory of superconductivity is quantitative, but at the price of using free electron wave functions.

We are apparently confronted with another instance of a many-body problem where the free particle approximation provides better results than theoretically expected (as in the case of "magic numbers" in nuclei). It may well be that Fröhlich's narrow electron beams exhibiting distance correlations are convenient approximations to the resonating electron lattices of the present theory. Whereas the free electron functions provide obvious advantages for explicit calculations, the many-electron functions may be superior for the understanding of the distribution of superconductors in the periodic table. L.T.

Theory of Superconductivity. By Laszlo Tisza. *Phys. Rev. 80: 719, November 15, 1950.*

Wavelengths of Mercury 198

The international standard of length, a platinum-iridium bar located in a vault at the International Bureau of Weights and Measures near Paris, was measured relative to the wavelength of the red cadmium line by Michelson in 1892, and the value he derived for the wavelength of the red cadmium radiation has been provisionally adopted as the international standard of length.

The advantages of Michelson's new standard were obvious: it was indestructible, more precise than the meter bar, and could be reproduced in any laboratory.

The Michelson lamp, however, is quite cumbersome and must be operated at elevated temperatures. A superior lamp would be one containing a pure, even isotope of high mass and low vaporization temperature. Such an isotope has been found in mercury 198, artificially prepared by neutron bombardment of gold 197. Its advantages as a universal standard of length are legion, but to name a few, its spectrum lines are extremely sharp, a milligram drop placed in a small glass tube yields an easily excited and compact source that can be operated at low temperatures, it is a simple spectrum and the intense green light at 5460 A corresponds to the maximum sensitivity of the eye.

The wavelength of the green line in the spectrum of mercury 198 has been measured to eight figures relative to the red line of cadmium and 26 lines in the spectrum of mercury 198 ranging from 2536 A to 5790 A have now been measured relative to the green line. When this green line is adopted as a primary standard of length, these 26 lines will serve as excellent secondary standards of length covering a wide region of the spectrum, and will be very useful in spectroscopy, metrology, and many other fields.

In the course of this investigation it was also discovered that all existing formulae for the dispersion of air in the ultraviolet region are in error, and a proposed series of determinations of the wavelengths of the above lines in vacuo and in standard air will yield a new formula that fits the observations.

The precise term values derived from these latest determinations of the wavelengths of the mercury 198 lines have shown that the wave number difference between spectroscopic energy levels as calculated from different spectrum lines involving those levels is constant to eight figures. A redetermination of these same wavelengths in vacuo should yield a check on the combination principle to nine figures, thus testing the discreteness of atomic energy levels with greater precision than ever conceived possible.

W.F.M. AND K.G.K.

Wavelengths of Mercury 198. By William F. Meggers and Karl G. Kessler. *J. Opt. Soc. Am. 40: 737, November, 1950.*

Spin Echoes

An ensemble of nuclear magnetic moments which freely precesses in phase in a large magnetic field at a given Larmor frequency will provide a nuclear induction signal. If suitable pulses of radio-frequency power at the Larmor frequency are applied to an ensemble, the necessary in-phase conditions can be established which make possible the detection of spontaneous induction signals. If the ensemble is made up of spins spread over a range of Larmor frequencies, it is possible to obtain free induction or "spin echo" signals due to the constructive interference of the freely precessing spins. An echo is observed to occur at a time after a pulse which is equal to the time interval between that pulse and a previous pulse. On the basis of transient solutions to Bloch's macroscopic nuclear induction equations, echo measurements provide a means for the direct and simple determination of relaxation time. A new method is available for the measurement of the self-diffusion coefficient of liquid molecules which contain precessing spins. The echo technique can provide information which is also obtained from steady-state methods, but has some technical advantages for certain applications because the driving radio frequency field is absent during the observation of nuclear signals. E.L.H.

Spin Echoes. By Erwin L. Hahn. *Phys. Rev. 80: 582, November 15, 1950.*

Thyratron Thermostat

Systematic phase-equilibrium studies have been of great value in exploring new systems involving the components of glass, refractories, metallic alloys, portland cement, and other industrial products. In order properly to employ this method of investigation, it is necessary that the specimen under study reach a state of equilibrium at any given temperature. To accomplish this, constant temperature must be maintained until no further changes take place in the sample under study. Even small fluctuations in temperature may be responsible for erroneous data, especially in multicomponent systems. A thyratron thermostat based upon that of H. S. Roberts (*Temperature: Its Measurement and Control in Science and Industry*, by H. S. Roberts, American Institute of Physics and Reinhold Publishing Corporation, New York, 1941, pp. 604–610), in which the furnace winding forms one arm of a Wheatstone bridge, was constructed to supply proper temperature control for such studies.

In the method of control developed, an AC bridge and amplifier control firing of a thyratron. Both the phase angle and amplitude of the unbalanced bridge voltage influence the response of the thyratron. The plate impedance of the thyratron, reflected through a transformer whose primary is in series with the furnace, regulates the current to the furnace winding. The control response requires only one sixtieth of a second. This thyratron control is highly sensitive and essentially independent of normal fluctuations in line voltage. It allows furnace temperatures to be maintained constant within ± 0.1°C. for several hours, and within ± 1.0°C. for several days. This precision thermostat has been employed for the control of relatively high temperatures, i.e., in the range 1000°–1550°C. W.R.E.

Precision Thermostat for High Temperatures. By W. R. Eubank. *Rev. Sci. Inst. 21: 845, October, 1950.*

Ionic Mathematics

Ionic solutions differ from nonelectrolytic solutions of the same molecular weight in showing much greater deviations from the laws of perfect solutions. This is due to the comparatively long range of the forces between the solute particles. The Debye-Hückel theory has, for twenty-five years, given correctly the first approximation to these deviations. Unfortunately, even this approximation fails at fairly low concentrations.

In this paper a method not hitherto employed is used to obtain the theoretical equation for the deviations from perfect solution law to an approximation beyond that given by the Debye-Hückel theory. The method employed follows closely the pattern used to compute deviations of gases from the perfect gas law. It makes use of a simple mathematical trick to avoid a difficulty introduced by the long range of the forces between ions, which has previously hindered the use of this method.

In the Debye-Hückel theory the deviations are proportional to the square root of the concentration. In this paper those deviations which are proportional to powers up to the three-halves power of the concentration are computed. J.E.M.

The Theory of Ionic Solutions. By Joseph E. Mayer. *J. Chem. Phys. 18: 1426, November, 1950.*

Photometrics

Photometric devices, especially those intended for the measurement of color, must be highly sensitive to small differences if they are to give useful information. Some of the most successful instruments in current use employ a null principle in which a phototube is alternately shown the sample and a standard. The information obtained is generally integrated or fed into a ratio device and the results are frequently recorded as percent reflectance (or transmittance). Perhaps the best known illustration of this type of photometric instrument is the GE spectrophotometer.

The present device has some points of similarity with the GE spectrophotometer but new features make it less expensive and at the same time give it some unique and interesting operating characteristics.

Two tungsten filament lamps are operated from a combination of alternating and direct currents in such a way that the lamps themselves are modulated in opposite phases. Thus they can be used directly in a null type instrument to illuminate respectively a sample and a standard for photometric comparison in an integrating sphere.

By using the resulting phototube signal as the source of alternating current for the lamps, this device becomes a servomechanism with photoelectric coupling. In this form it can be adapted for the measurement of density. By introducing the proper filters, spectrophotometric or colorimetric data can be obtained. J.E.T.

A New Photometric Device. By John E. Tyler. *J. Opt. Soc. 40: 693, October, 1950.*

Airglow

The airglow is that part of the light from the night sky which originates in the upper atmosphere. It is bright line or band spectrum and consequently an analysis of the wavelengths and intensities is one method of understanding the physics and chemistry of the upper atmosphere. Since the light from the night sky is very faint, the instrumentation must be of high light gathering power and very sensitive. The spectrograph used in the investigation has a high speed camera with an aperture ratio of 0.7. The photometer uses the highly sensitive photomultiplier tube and a specially designed amplifier which will give both the sensitivity and the time resolution required. The photometer automatically sweeps the sky recording the intensity from horizon to horizon.

The airglow spectrum shows the presence of atomic sodium and oxygen high in the atmosphere. The oxygen lines are "forbidden" ones and are the same as the green and red auroral lines; however, they are not excited by the bombardment of the atmosphere with ionized particles as in the case or auroral displays. The blue, violet, and ultraviolet parts of the spectrum are dominated by numerous faint bands which have been identified with forbidden bands from the nitrogen and oxygen molecules. Spectrophotometric observations of the sodium D-lines during twilight give the distribution of sodium atoms in the atmosphere. The distribution in the region from 60 to 120 km is that which would be expected if the sodium atoms were a component of the atmosphere, but for the region from 200 to 600 km the concentration is much greater.

Any reasonable theory indicates that the emissions must come from relatively thin layers, hence, an analysis of the variation of intensity with zenith distance will give a measure of the height to the layer. Observations show that the emission layer for the green auroral line is about 100 km and for the sodium D-lines is between 250 and 300 km. The heights of the emissive layers are important data required for the understanding of the physico-chemical processes in the upper atmosphere. In general the processes are the dissociations of molecules by ultraviolet sunlight during the day and recombinations at night. Owing to the low densities the recombinations continue throughout the night and the energies of dissociations released by this process furnish the energy for the excitation of the airglow spectrum. C.T.E.

Progress in Studies of the Airglow in Upper Air Research. By C. T. Elvey. *Am. J. Phys. 18: 431, October, 1950.*