LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. Because of the late closing dates for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

Electrical Conductivity as a Function of Temperature of Some Manganous Compounds

Recently the author[1] has studied the magnetic susceptibility of MnO, MnS, MnSe, and MnTe as a function of temperature. The anomalies observed has led to a study of the conductivity of these salts. The compounds were powders pressed firmly between two copper disks with electrical leads. For low resistance values a Wheatstone bridge was used; for high resistance values, the feeble current driven through the specimen was amplified by a Vance meter.

Plotting the log of the resistance against temperature for MnSe, MnS, and MnO one gets a series of straight lines one above the other. They behave like nonconductors in that the greater the temperature the lower the resistance (order of 10^5 ohms at 298°K). The greater the molecular weight of the Mn^{++} compound, the greater the specific conductivity. The resistance value of MnTe in Fig. 1 is very much smaller and the change in conductivity is unique.

The hysteresis effect which has been detected in the magnetic studies presents itself again as an abnormally long relaxation time for the conductivity to return to its characteristic value after the crystals had been transferred from one temperature bath to another. Thus in the case of MnSe, if one approached 200°K (solid CO_2 bath temperature) from the high temperature side (ice bath) it required approximately an hour before the resistance reached its final higher value. A similar long relaxation time was observed for MnTe around its λ-point.

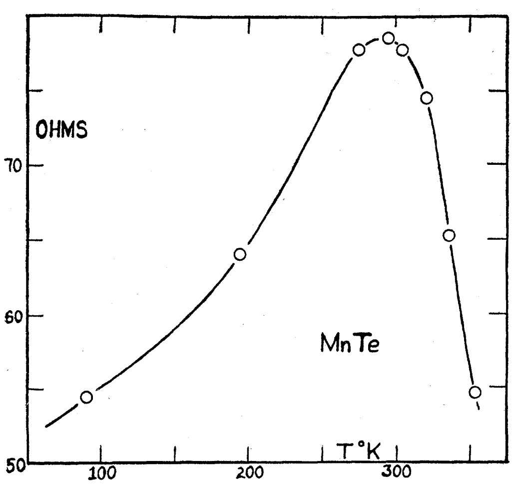

FIG. 1. Variation with temperature of the resistance of MnTe.

The fact that MnTe has a relatively high conductivity would lead one to classify it as a semi-conductor. The fact that the exchange force at the λ-point draws the crystal together, leads one to suppose that the electronic energy bands approach one another in going from high to lower temperature at the λ-point. One can reason from this, though it is by no means conclusive, that the conductivity anomaly of MnTe is associated with the change in the value of the excitation energy needed for an electron to enter the conducting energy band.

The theoretical problem which these experiments present is one which has already received some attention by L. Landau.[2] Hysteresis effects in third-order transitions have been measured in completely different phenomena than mentioned here.[3] The author is indebted to Professor Edward Teller for discussions of this research.

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August 22, 1939.

[1] *Physical Review*, this issue.
[2] L. Landau, Sow. Phys. Zeits. **4**, 675 (1933).
[3] A. Smits, Physik. Zeits. **36**, 367 (1935).

Suggested Observation of the Zodiacal Light During a Total Solar Eclipse

Various features of the zodiacal light, such as the width and brightness of the zodiacal band, are known to within about 30° from the sun.[1] Because of the obscuration by sunlight scattered by the atmosphere no observations have been made closer than about 30°. It appears that observations might be extended to perhaps 5° from the sun during a total solar eclipse by an observer on the night side of the earth and within a few degrees of the sunset or sunrise horizon. In such a situation he would be shielded from the direct rays of the sun by both the earth and the moon, and his twilight sky toward the sun being shielded by the moon would be unusually dark although illuminated by the solar corona. Thus he would be in a position to examine with the unaided eye the width and brightness of the zodiacal band as near to the sun as possible and perhaps to see how the band merges into the corona. Since the brightness of the zodiacal light increases rapidly with decreasing angular distance from the sun plans might be made to photograph the light and to obtain its spectrum.

A total solar eclipse occurs on October 1, 1940, the path of totality extending across the northern part of South America and the southern part of South Africa.[2] The twilight regions most favorable to the foregoing zodiacal observations are strips about 2° wide, one strip in about 3° north latitude and 80° to 100° west longitude in the Pacific Ocean off the coast of Colombia, and one strip in about 33° south latitude and 53° to 73° east longitude in the Indian Ocean about a thousand miles east of the Cape of Good Hope. The regions are entirely at sea and embrace no islands or land areas. This is an important advantage and in agreement with the view of Conrad who referred to the surface of the earth as "seven-eighths water, a fit abode for sailors."

E. O. HULBURT

Naval Research Laboratory,
Washington, D. C.,
October 3, 1939.

[1] E. O. Hulburt, Phys. Rev. 35, 1098 (1930).
[2] *American Ephemeris and Nautical Almanac for 1940*, p. 586.

Mass and Energy Levels of S^{33}

Among the lighter stable nuclei the mass of S^{33} has not yet been determined. It was found that on bombarding a sulphur target with 3.1-Mev deuterons from a cyclotron a considerable yield of protons was observed corresponding to the absorption of a neutron by the sulphur nucleus and emission of a proton. An absorption curve was plotted for these protons which showed the presence of three very well-marked groups with energy change values +6.60, +3.70 and +1.02 Mev. The third group may perhaps be due to carbon contamination but the first two are definitely due to sulphur. If it is assumed that the observed protons are from the S^{32} isotope which comprises 96 percent of the target, then the reaction occurring is

$$S^{32}+H^2 \rightarrow S^{33}+H^1$$

and since the mass of S^{32} has been found by Aston we may deduce the mass of S^{33}. The value found is 32.9818±0.0030. This agrees nicely with the value 32.9816 calculated by Barkas.[1] It is not likely that the isotope S^{34} which is present to 3 percent is responsible for the observed protons, for this would require a mass of 34.978 which is stable with respect to beta-decay to Cl^{35}, contrary to experience. The S^{33} isotope can virtually be eliminated on account of its very low abundance of 1 percent only.

The group at an energy-change value of 3.70 Mev indicates an excited state 2.9 Mev above the ground state and, if the third group is due to sulphur as its abundance indicates, a second excited state 5.58 Mev above the ground state. The probability of transition to the first excited state is three times that to the ground state. It is interesting to compare the above levels with the values 1.3, 2.8, 4.8 Mev above ground found for S^{34} from the reaction

$$P^{31}+He^4 \rightarrow S^{34}+H^1.$$

I wish to thank Mr. W. L. Davidson, Jr., for his assistance in operating the cyclotron and preparing the target, and Professor E. O. Lawrence for the gift of the 27″ acceleration chamber formerly used at Berkeley.

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October 16, 1939.

[1] W. H. Barkas, Phys. Rev. 55, 691 (1939).

Deviation from the Coulomb Law for a Proton

In a recent letter to the Editor of this Journal W. E. Lamb[1] has criticized our paper on the deviation from the Coulomb law.[2] In this paper we have discussed the possibility of short range forces between a proton and a point charge on grounds of the meson theory.

The total interaction energy between the proton and the point charge at a distance R was shown to be of the following form:

$$V(R)=-\frac{e^2}{R}+\frac{e^2}{R}\int \rho d\tau - e^2\int \frac{\rho(\mathbf{r})}{|\mathbf{R}-\mathbf{r}|}d\tau. \qquad (1)$$

Here $\rho(\mathbf{r})$ is the charge density of the meson field surrounding the proton according to the first approximation of the meson theory and is given in F.H.K. The third term (denoted in F.H.K. by $W_{\mathrm{I}}(R)+W_{\mathrm{II}}(R)+W_{\mathrm{III}}(R)$) arises from the third-order perturbation theory (corresponding to the three stages: emission of meson by proton, deflection of meson by point charge, reabsorption of meson by neutron). The second term of (1) represents the change of the second-order self-energy in the presence of the point charge as discussed in F.H.K., footnote on p. 274. It is due to the fact that the resonance denominators in this expression contain an additional term e^2/R. If one expands the expression for the second-order self-energy in powers of e^2 the term proportional to e^2 is exactly given by the second term of (1).

Both the second and the third terms of (1) diverge separately. The sum of the two terms, however, converges and was denoted in F.H.K. by $W'(R)$. A consistent application of the perturbation theory up to the third order gives therefore a converging result. At small distances, $W(R)$ was found to be larger than the Coulomb attraction e^2/R and $V(R)$ is therefore repulsive at small distances.

Because of its proportionality to $1/R$ we have interpreted the second term of (1) as due to the absence of the Coulomb attraction of the proton during the "time of dissociation" the fraction of which would be equal to $\alpha=\int\rho d\tau$. This concept was used in our paper merely as an abbreviation for a term occurring in the perturbation theory.

Lamb's criticism is now based on the fact that according to (1) *a repulsive effect can only be obtained if* $\alpha>1$. *This would seem unreasonable in view of the physical meaning of* α.

In view of this result it is necessary to investigate the question as to what extent such a dissociation time has any physical meaning. In fact it seems that the only meaning one can attach to it is in the sense of a probability of finding the meson at a distance larger than r, say, from the nucleus. In its physical essence this is equivalent with the question of whether there is a "probability of finding the meson at a certain point or in a small volume v." As will be seen below this is not the case if the linear dimensions of v are smaller than $h/\mu c$ (μ=rest mass of meson).

The physical quantity which always has a physical meaning is the *charge density*. In our problem the charge density from which (1) is derived consists of two terms:

$$\rho'=-\delta(r)\int\rho d\tau+\rho, \qquad (2)$$

where the first term represents an infinite negative point