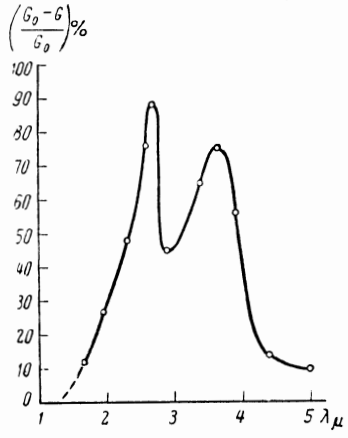

FIG. 1. G_0 is the intensity of the recombination radiation in the absence of infrared illumination; G is the intensity of this radiation for illumination with infrared light.

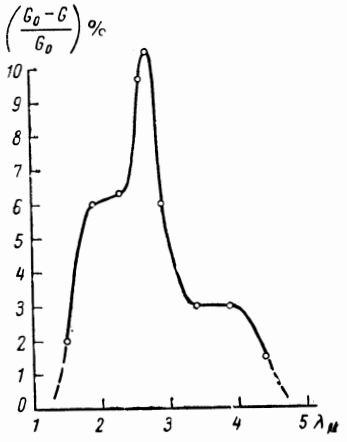

FIG. 2

To allow for this, we developed a special measurement method which will be described in detail in a later communication.

We investigated p- and n-type samples, both of high and low resistivity. It was found that for p-type samples of 50 ohm. cm resistivity and n-type samples of 40, 20, and 11 ohm. cm resistivity, the quenching effect had maxima at the infrared wavelengths $\lambda_1 \approx 2.7\ \mu$ and $\lambda_2 \approx 3.6\ \mu$ (Fig. 1) (the quenching effect was defined as the relative change in the integral intensity of the recombination radiation under the action of the infrared illumination).

For p-type samples of 0.7 and 3 ohm. cm resistivity, we found only one quenching-effect maximum at the wavelength $\lambda_1 \approx 2.7\ \mu$ (Fig. 2) and the amplitude of this maximum was smaller than that for high-resistivity samples.

For p- and n-type Ge of resistivity of the order of 0.01 ohm. cm, no quenching was observed at all. On reduction of the sample thickness, the spectral width of the maxima decreased.

It is very likely that there is some analogy between the investigated effect and the photoconductivity quenching.[2] As is known, [2] the photoconductivity quenching is usually ascribed to the presence of impurities which give rise to deep levels in a semiconductor. In our case, such an impurity is, obviously, copper which forms three acceptor levels in germanium.[2] The recombination radiation quenching is likely to be associated with the 0.33 eV level whose energy separations from the conduction and valence bands correspond exactly to the frequencies at which the quenching maxima were observed. The absence of quenching in samples with the lowest resistivity can be accounted for by the predominance of the "band-band" recombination process,[3] over the recombination process through impurity levels.

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CONCERNING THE SINGLE-ELECTRON APPROXIMATION IN COLLISION THEORY

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VEKLENKO and Novobrantsev[1] (VN) proposed a variant of the one-electron approximation for the case when one of the particles is in a continuous spectrum state. Specific calculations were made for the scattering of electrons by hydrogen atoms at zero energy. Unexpectedly good agreement was obtained with the results of the thorough but much more laborious calculations of Temkin [2] and Schwartz [3].

Temkin solved the electron scattering problem

by successive approximation. In the zeroth approximation, complete account was taken of the s-states of both electrons. The results of Temkin for the triplet case were then refined in the paper of Temkin and Sullivan [4]. In the zeroth approximation, the scattering lengths turned out to be $A_0^+ = 7.8$, and in the singlet state $A_0^- = 2.35$. The most accurate values for the scattering were obtained by taking higher moments into account, and according to [2,4] they are $A^+ = 5.6$ and $A^- = 1.767$.

According to the variational calculations of Schwartz, $A^+ = 5.965$ and $A^- = 1.7686$. Schwartz's results give an upper limit for the scattering lengths [5].

The difference between $A_0^\pm$ and $A_0^\pm$ is due essentially to the long-range polarization forces, which cannot be taken into account with the aid of the s-states only. In the VN paper the total wave function takes into account only the s-states of both electrons. Therefore they could obtain at best A_0^+ and A_0^-. However, the obtained scattering lengths $-\alpha^+ = 5.87$ and $-\alpha^- = 1.77$ turned out to be close to A^+ and A^-.

Such an agreement is very difficult to understand, and we consequently repeated the VN calculations with the BÉSM-2 computer. We found that their algebraic system of equations has solutions $A^+ = 8.17$ and $A^- = 2.36$. These solutions are close to the exchange-static solutions ($A^+ = 8.095$, $A^- = 2.35$ [6]), and at the same time they are close to Temkin's zeroth approximation, indicating that the s-correlation plays a small role. There are no other solutions in a reasonable range of variational parameters.

Thus, the agreement between the accurate results and those of VN is due to errors in numerical calculations. This pertains also to the results obtained by Veklenko and Starostin [7], where the calculations were made at energies different from zero, since the VN data were used in the latter paper as the zeroth approximation. Consequently the conclusion drawn by the authors that it is possible to take correct account of the polarization of the atom by the scattered electron within the framework of the single-electron approximation is based on a numerical calculation and is in error.

The main difficulty in applying the single-electron approximation to continuous-spectrum problems lies in the fact that it is not clear which stationary potential can be produced by the particle which is not bound. The variational principle proposed by VN corresponds to a definite choice of such a potential. For $e^- - H^-$ scattering at zero energy, the non-exchange potential $V(r)$, according to VN, is

$$V(r) = \frac{\int_0^r (1/r_1 - 1/r) g^2(r_1)\, dr_1}{\int_0^\infty [g^2(r_1) - q^2(r_1)]\, dr_1}, \qquad (1)$$

where $g(r)$ describes the scattered electron:

$$g(r) \underset{r\to\infty}{\sim} q(r) \equiv r - A. \qquad (2)$$

Taking (2) into account, we see that as $r \to \infty$ we get $V(r) \sim \text{const.}r^2$. Such a potential seems to us debatable.

We note that (1) vanishes if an actual account of polarization is made, for in that case the denominator, which is proportional to the effective radius, diverges [8].

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