ionized impurities, and l_{NI}, due to non-ionized impurities. l_L is independent of electron or hole energy;[2] l_{II} depends on the square of the energy,[3] $l_{II}=a\epsilon^2$; l_{NI} depends on the square root of the energy,[4] $l_{NI}=b\sqrt{\epsilon}$. Then the total mean free path is

$$1/l_T=(1/l_L)+(1/l_{II})+1/l_{NI}. \tag{1}$$

One can obtain the energy distributions by considering Boltzmann's equations for electrons and holes. Using these and (1) in calculating the electric current flow, one may readily derive the resistivity and the Hall constant for weak magnetic fields.

$$\frac{1}{\rho}=\frac{4}{3}e^2\left[\frac{a_eK^2T^2}{(2\pi m_eKT)^{\frac{1}{2}}}\Phi_2(\gamma_e,\alpha_e)n_e+\frac{a_HK^2T^2}{(2\pi m_HKT)^{\frac{1}{2}}}\Phi_2(\gamma_H,\alpha_H)n_H\right], \tag{2}$$

$$R=-\frac{3\pi^{\frac{1}{2}}}{4ec}\frac{\left[n_e\frac{(a_eK^2T^2)^2}{2\pi m_eKT}\Phi_1(\gamma_e,\alpha_e)-n_H\frac{(a_HK^2T^2)^2}{2\pi m_HKT}\Phi_1(\gamma_H,\alpha_H)\right]}{\left[n_e\frac{a_eK^2T^2}{(2\pi m_eKT)^{\frac{1}{2}}}\Phi_2(\gamma_e,\alpha_e)+n_H\frac{a_HK^2T^2}{(2\pi m_HKT)^{\frac{1}{2}}}\Phi_2(\gamma_H,\alpha_H)\right]^2}, \tag{3}$$

where the subscripts e and H denote electrons and holes, respectively, and

$$\Phi_1(\gamma,\alpha)=\int_0^\infty\frac{e^{-x}x^{9/2}dx}{[1+\gamma x^{3/2}(1+\alpha x^{\frac{1}{2}})]^2}, \tag{4}$$

$$\Phi_2(\gamma,\alpha)=\int_0^\infty\frac{e^{-x}x^{3}dx}{[1+\gamma x^{3/2}(1+\alpha x^{\frac{1}{2}})]}, \tag{5}$$

$$\gamma=\frac{aK^2T^2}{b(KT)^{\frac{1}{2}}}=\frac{\text{average ionized impurity mean free path}}{\text{average non-ionized impurity mean free path}},$$

and

$$\alpha=\frac{b(KT)^{\frac{1}{2}}}{l_L}=\frac{\text{average non-ionized impurity mean free path}}{\text{lattice scattering mean free path}}.$$

γ varies as $(T^2/N_I)/(T^{\frac{1}{2}}/N_n)$, and α varies as $(T^{\frac{1}{2}}/N_n)/(1/T)$, where N_I and N_n are, respectively, the concentrations of ionized and non-ionized impurities. The product $\gamma\alpha$ will be called ϵ.

In the exhaustion range $\gamma\to0$ and $\alpha\to\infty$, while ϵ is finite. $\Phi_1(\gamma,\alpha)$ goes over into $F_1(\epsilon)$ and $\Phi_2(\gamma,\alpha)$ goes over into $F_2(\epsilon)$, where

$$F_1(\epsilon)=\int_0^\infty\frac{e^{-x}x^{9/2}dx}{(1+\epsilon x^2)^2}, \tag{6}$$

$$F_2(\epsilon)=\int_0^\infty\frac{e^{-x}x^{3}dx}{(1+\epsilon x^2)}. \tag{7}$$

In the low temperature range $\alpha\to0$, and $\Phi_1(\gamma,0)=f_1(\gamma)$ and $\Phi_2(\gamma,0)=f_2(\gamma)$ become the pertinent functions. Plots of $F_1(\epsilon)$, $F_2(\epsilon)$, $f_1(\gamma)$, and $f_2(\gamma)$ are shown in Fig. 1. The relation of γ to impurity concentration is discussed in a previous letter by the author.[5]

When $n_H=0$ the mobility μ_e becomes

$$\mu_e=-\frac{e}{c}\frac{a_eK^2T^2}{(2\pi m_eKT)^{\frac{1}{2}}}\frac{\Phi_1(\gamma_e,\alpha_e)}{\Phi_2(\gamma_e,\alpha_e)}, \tag{8}$$

and when $n_e=0$,

$$\mu_n=\frac{e}{c}\frac{a_HK^2T^2}{(2\pi m_HKT)^{\frac{1}{2}}}\frac{\Phi_1(\gamma_H,\alpha_H)}{\Phi_2(\gamma_H,\alpha_H)}. \tag{9}$$

Only in the approximation in which $\gamma_e=\gamma_H$ and $\alpha_e=\alpha_H$ can one substitute (8) and (9) into (3) to obtain

$$R=-\frac{3\pi}{8}\frac{1}{ec}\frac{n_e\mu_e^2-n_H\mu_H^2}{[n_e\mu_e+n_H\mu_H]^2}. \tag{10}$$

The familiar expressions for Hall constant and resistivity are obtained as limiting cases of (2) and (3). For instance, if one tabulates $-R\cdot n_ec$ for the case of electron conduction alone, one

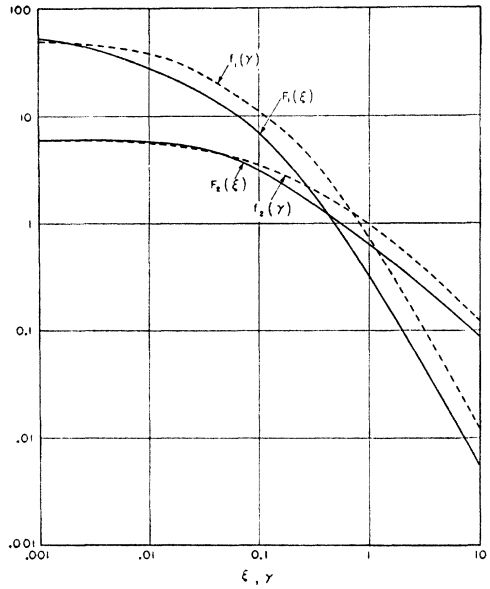

FIG. 1. Functions related to Hall constant.

obtains for $\epsilon=\infty$, $3\pi/8$; for $\epsilon=0$, 315/512; for $\gamma=0$, 315/512; for $\gamma=\infty$, $8/\sqrt{\pi}$. Limiting results for the exhaustion range when the Φ's are replaced by the $F(\epsilon)$'s are shown in the figure of reference 1. From Eqs. (2) and (3) it can be seen that the presence of holes and non-ionized impurities tend to lower the previously published values of $-R\cdot n_ec$.

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Fluctuations in the Refractive Index of the Atmosphere at Microwave Frequencies

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FLUCTUATIONS in atmospheric refractive index are being measured with a recording microwave refractometer, described in a previous paper.[1] The instrument employs a frequency modulation technique to measure small changes in frequency difference between two cavity resonators which, in the present work, are of the cylindrical TE_{011} type and made of Invar. About 30 percent of the area of each end plate was removed to permit the flow of atmosphere through the cavity. Because the openings were located at the center and along the circumference of the end plates, the reduction in cavity Q was not serious. Variations in the output current of the refractometer were amplified by a dc amplifier and measured by a recording milliammeter; the meter limited the response time of the equipment to about 0.5 sec.

Preliminary observations have been obtained with this apparatus installed on top of a building at the National Bureau of Standards. In view of the well-known turbulent aspect of the atmosphere, it was not surprising to find that the instantaneous

refractive index varies rapidly and in an irregular fashion about a mean value. A typical record of these fluctuations, obtained with one cavity open to the atmosphere and the other closed, is shown in Fig. 1b.[2] For comparison, Fig. 1a shows a record of the

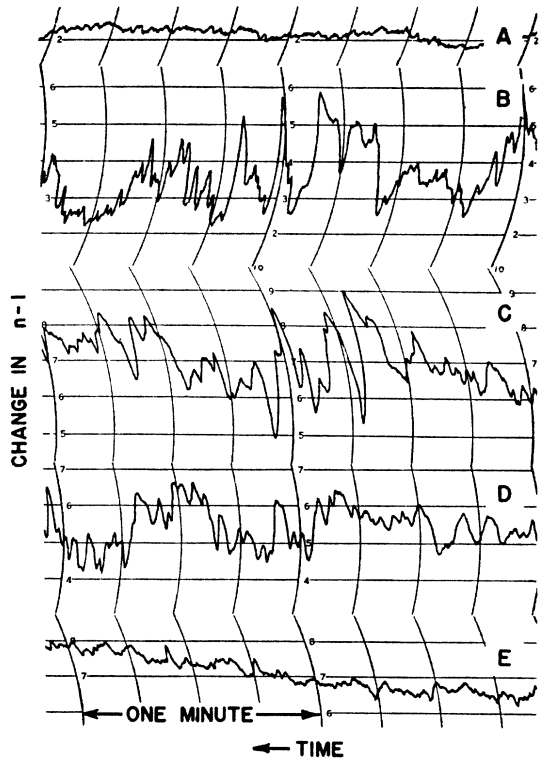

FIG. 1. The measurement of fluctuations in atmospheric refractive index with two cavity resonators: (a) both closed; (b) one open, the other closed; (c) both open, separated 1.8 m; (d) both open, separated 0.61 m; (e) both open, separated 7.6 cm. (Data taken on November 7, 1950; average wind speed was roughly 0.5 m/sec.)

stability of the instrument when both cavities were closed. In Fig. 1, ten small divisions are equal to nearly 0.8×10^{-6} in $n-1$.

Starting with an empirical expression for the radio (or microwave) refractive index of moist air,[3] and inserting mean values of temperature ($T=19.2°C$), water vapor pressure ($e=7.4$ millibars), and total pressure ($p=1011$ millibars) appropriate for the data of Fig. 1, the change in index Δn is found to be

$$10^6\Delta n=-1.1\Delta T+4.4\Delta e+0.27\Delta p. \quad (1)$$

The Δp term is unimportant, since fluctuations in pressure[4] are too small to have any significant effect on Δn. Thus, a simultaneous measurement of Δn and ΔT could determine Δe. It is sufficient to note here that an examination of a few records of simultaneous temperature and refractive index fluctuations did not reveal, in general, any marked correlation between these factors.

Some indication of a size for the random refractive index inhomogeneities[5] was obtained by observing the instantaneous difference in refractive index between two open cavities as their distance of separation was varied. Typical of several trials are the records shown in Fig. 1. When the cavity separation was less than 10 cm, fluctuations at one cavity were closely correlated with fluctuations at the other (Fig. 1e). For larger separations, the correlation began to disappear, as suggested by Figs. 1c and 1d.

To obtain a quantitative estimate of inhomogeneity size, a correlation coefficient ρ is defined as the correlation between simultaneous values of Δn and $\Delta n'$ distant x apart, thus

$$\rho=\langle(\Delta n)(\Delta n')\rangle_{Av}[\langle(\Delta n)^2\rangle_{Av}\langle(\Delta n')^2\rangle_{Av}]^{-\frac{1}{2}}. \quad (2)$$

If the inhomogeneities are isotropic, ρ may be regarded as independent of direction, and a measure of average size may be defined by[6]

$$L=\int_0^\infty \rho dx. \quad (3)$$

In the present instance, the quantities on the right side of Eq. (2) were determined from a periodic sampling of the recorded data, part of which are shown in Fig. 1. All the records were obtained within 50 minutes, during which time the weather remained practically unchanged. Figure 2 shows ρ fitted by the equation

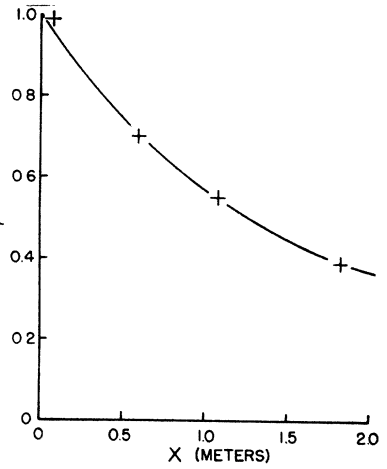

FIG. 2. Correlation coefficient, ρ, of refractive index fluctuation as a function of distance, x.

$\rho=\exp(-x/1.9)$; inserting this in Eq. (3) gives a size of 1.9 m. The root-mean-square deviation of refractive index $\langle(\Delta n)^2\rangle_{Av}^{\frac{1}{2}}$ was nearly 0.3×10^{-6}. These results apply, of course, for a particular site and state of the atmosphere. Further investigations along these lines are now in progress.

The author wishes to thank Mr. S. J. Kryder and Mr. R. R. Larson for assistance with the experiments.

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On the Decay of $Xe^{125}\rightarrow I^{125}\rightarrow Te^{125}$

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RECENTLY, Anderson and Pool[1] reported a new isotope, Xe^{125}, with the half-life of 20 hr, produced in a Te(α, n) reaction. K x-rays of I and a weak γ-ray of the energy ~0.6 Mev were reported.

We have produced Xe^{125} by neutron irradiation of Xe in the Harwell pile. After electromagnetic separation, a gas activity of the half-life 18 ± 0.5 hr appeared on the collector foil (0.15 mg Al/cm^2) at mass number 125, confirming the existence of Xe^{125}. All odd mass numbers between 135 and 125 showed activities strong enough for β-spectrometer investigations. The activities at the mass numbers 133, 131, 129 (a new 9-day isomer, $E_\gamma=195$