where $\bar{I}=\langle I(t)\rangle_{Av}$= average electron current, $\omega=2\pi f$= angular frequency of observation, $G(\omega)$= a.c. conduction of gas discharge plasma, N= total number of electrons in the plasma.

The available noise power P_ω from a gas discharge plasma placed in the transverse plane of a rectangular wave guide propagating only in its lowest mode is

$$P_\omega=|I_E|^2/4G(\omega). \quad (6)$$

Here I_E= a.c. electron current in the direction of the E vector of the wave guide. Hence in this case,

$$P_\omega=\left\{kT_e+\frac{P_0}{NZ}\cos^2\theta\left[2+\frac{Z^2-\omega^2}{Z^2+\omega^2}\right]\right\}df, \quad (7)$$

where θ= angle between E vector and axis of gas tube, and P_0= d.c. power dissipated in tube. For ordinary gas tubes that are used as microwave noise standards, the contribution of the frequency sensitive term is of the order of a few percent of the total noise power output. This calculation does not account for noise power due to other fluctuations.

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Nuclear Magnetic Resonance of Sb^{121} and Sb^{123}*

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WE have made attempts to find the nuclear resonance of Sb in Sb_2O_3 and $SbCl_3$ without success. On the supposition that this failure was due to a large interaction between the electric quadrupole moment of the Sb nucleus and the non-uniform electric field of the above molecules a search was made in an ion in which the electric field would be symmetrical. This requirement is fulfilled in the $SbCl_6^-$ ion in which the Cl atoms are believed to be arranged in a regular octahedral configuration about the Sb.

A search was made in a solution of $HSbCl_6$ in HCl guided roughly by the spectroscopic values of the magnetic moments as given by Crawford and Bateson[1] using a radiofrequency magnetic resonance spectrometer.[2] Distinct resonances were observed in the vicinity of 9800 kc and 5300 kc which from the spectroscopic information would presumably be associated with Sb^{121} and Sb^{123} respectively. Repeated series of readings were taken comparing the Sb^{121} resonance to that of Na in solid NaCl, and the Sb^{123} resonance to that of D in D_2O. The frequencies of resonance were measured by means of a U. S. Signal Corps frequency meter type EC 221−Q, calibrated at 100 kc intervals against harmonics generated by a General Radio crystal controlled oscillator operating at 100 kc and in turn standardized against Station WWV. The magnetic field was electronically controlled to a constancy of about one part in 50,000.

The average values of the ratios of the observed frequencies are:

$$[\nu(Sb^{121})/\nu(Na^{23})]=0.90469\pm0.00004$$

and

$$[\nu(Sb^{123})/\nu(D^2)]=0.8442\pm0.0001.$$

If we take Bitter's[3] value of the observed ratio of $\nu Na/\nu H = 0.26450\pm0.01$ percent, and used a first-order atomic diamagnetic correction for Sb of 1.00517 as calculated from the Hartree-Fock functions[4] and the value[5] for H^2 of 1.000027, we get for the ratio $g(Sb^{121})/g(H^1)=0.24052\pm0.00003$. Taking the spectroscopic value of 5/2 for the spin of Sb^{121} and the value for μ_H as measured by Taub and Kusch,[6] we get

$$\mu(Sb^{121})=3.3595\pm0.0004.$$

One must note that this value of the magnetic moment may possibly be in error as a result of second-order molecular effects which we are unable to evaluate at this time.

Similarly, taking Bloch's[7] value of

$$\mu(P)/\mu(D)=3.257195\pm0.00002,$$

we get $[g(Sb^{123})/g(H)]=0.13025\pm0.00002$, and taking the value 7/2 for the spin, we get for the magnetic moment

$$\mu=2.5470\pm0.0003 \text{ nuclear magnetons.}$$

It is of interest to compare the ratio of the g-values of the two Sb isotopes as obtained spectroscopically by Crawford and Bateson,

$$[g(Sb^{121})/g(Sb^{123})]=1.82\pm0.02 \text{ to our } 1.8466.$$

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Effect of Magnetic Fields on Conduction—"Tube Integrals"

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THE effect of a magnetic field **H** on electrical conduction can be reduced to integrals by using "tubes." Choose parallel to **H** an axis $\mathbf{P}_H$ in the $\mathbf{P}=\hbar\mathbf{k}$ space of the Brillouin zone. Then the region lying between planes $\mathbf{P}_H$ and $\mathbf{P}_H+d\mathbf{P}_H$ and energy surfaces $E(\mathbf{P})=E$ and $E+dE$ is a "tube." For spherical energy surfaces the tube is a torus with a parallelogram cross section. For more complex surfaces and for energies for which the surfaces reach the boundary of the Brillouin zone the tube may possibly take a helical path and eventually fill most of the space between E and $E+dE$. We shall discuss only simple closed tubes of interest for semiconductors.

For any tube α an angle variable θ and a tube mass m_α are defined by equations

$$m_\alpha\theta=\int_0^{P_t}dP_t/v_t, \quad 2\pi m_\alpha=\oint dP_t/v_\alpha, \quad (1)$$

where P_t is the distance in the **P**-space along the tube from an arbitrarily selected fixed point and v_α is the scalar magnitude of the component perpendicular to **H** of the group velocity $\mathbf{v}=\nabla E(\mathbf{P})$. **H** produces incompressible flow along the tube α with

$$d\mathbf{P}/dt=(-e/c)\mathbf{v}\times\mathbf{H}, \quad \dot{P}_t=(-e/c)v_\alpha H$$
$$\dot{\theta}=\dot{P}_t/v_\alpha m_\alpha=-eH/m_\alpha c=\omega_\alpha, \quad (2)$$

so that $\dot{\theta}$ is constant and the period is given by the classical formula with a mass m_t.

If we assume that after one transition, due to thermal vibration for example, an electron will have average velocity zero, then the current produced by a given tube can be reduced to closed form as follows. When an electric field **E** is applied each element dV_P of volume in **P**-space becomes a source of electrons of strength

$$(-eV/kTh^3)f(1-f)\mathbf{E}\cdot\mathbf{v}dV_P, \quad (3)$$

where V is the volume of the crystal, f the Fermi-Dirac distribution function and e, k, T, h are as usual. If $\nu(\varphi)=1/\tau(\varphi)$ is the probability of being scattered per unit time at tube position φ, the total current density $d\mathbf{I}_\alpha(=(-e/V)\epsilon\mathbf{v}(\varphi))$ due to electrons brought into tube α by **E** is

$$d\mathbf{I}_\alpha=(e^2/kTh^3)f(1-f)dEdP_H(m_\alpha/\omega_\alpha).$$
$$\int_\theta^{2\pi}d\theta\int_0^\infty d\varphi\mathbf{E}\cdot\mathbf{v}(\theta)\mathbf{v}(\varphi)\exp\left[-\int_\theta^\varphi\nu(\varphi')d\varphi'/\omega_\alpha\right]. \quad (4)$$