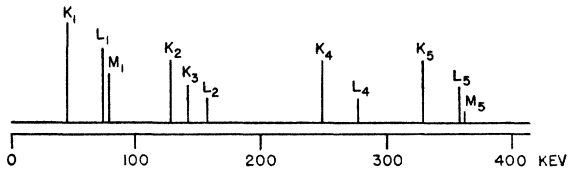

FIG. 1. Energy of the electron lines from iodine 131.

lens spectrometers with their accompanying low resolving power to evaluate the energy of the conversion electrons. J. DuMond and associates[4] have observed the unconverted gamma-rays in a crystal spectrometer and report energies of 80.13, 284.13, and 364.18 kev. We had, by means of photographic spectrometers, observed these and other gamma-rays with good relative precision but, due to the uncertainty in the absolute value of the magnetic field, entertained some doubt of the absolute accuracy. It is of interest to note that our previously published values for the strong higher energy lines were reported[3] as 284.8 and 365.0 kev, values consistently slightly greater than those of DuMond. It is now possible to calibrate the magnetic fields in an absolute manner in terms of DuMond's energies.

The complete electron spectrum as now obtained from carrier-free specimens procured from Oak Ridge is shown in Fig. 1, and the energies are collected in Table I. This shows

TABLE I. The electron spectrum of iodine 131.

Observed line	Identification	Gamma-energy
45.6 kev	K_1	80.1 kev
74.7	L_1	80.1
79.0	M_1	80.1
129.1	K_2	163.6
142.5	K_3	177.0
158.2	L_2	163.6
249.6	K_4	284.1
278.7	L_4	284.1
329.7	K_5	364.2
358.8	L_5	364.2
363.1	M_5	364.2

clearly four electron line sets with energy differences characteristic of xenon. A single additional electron line at 142.5 kev is interpreted as a K line. In all, there are five gamma-rays whose energies are 80.1, 163.6, 177.0, 284.1, and 364.2 kev.

A higher energy line was observed with less accuracy by absorption in lead. This had been reported by Deutsch as having an energy of 638 kev. It is now possible to propose a satisfactory level scheme incorporating the new lines, as shown in Fig. 2, provided both the lower energy beta-limit and the high energy gamma-ray are less energetic than reported by

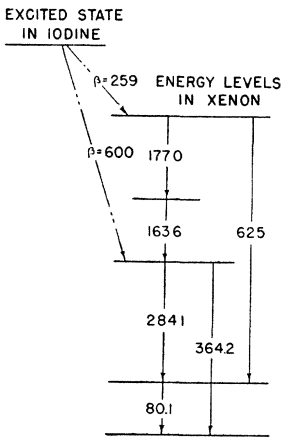

FIG. 2. A possible level scheme associated with iodine 131.

Deutsch. On observing the curves as presented this would seem to be not impossible.

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Microwave Absorption of Some Organic Vapors

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A MICROWAVE spectrograph for the 1.25-cm region has been built. The Hughes-Wilson technique[1] was applied. The klystron is a frequency-modulated 2K33 which radiates in the 22,600–25,700-mc region. Unfortunately, the coverage is not total, as the klystron is of a somewhat deteriorated war-surplus quality. The regions 24320–24270, 22860–22820 plus smaller, scattered regions are generally inaccessible. The gas cell is a 3-m K-band wave guide, vacuum-tight sealed by mica windows and placed with the broad side downwards. The modulation electrode is placed on the bottom of the cell, insulated from the guide by paper. It is kept straight by two weights placed outside the cell and connected with the electrode by violin strings, carried vacuum-tight through the mica windows. To ensure that the electrode follows the bottom of the guide, the latter is placed in a slightly curved position. The distance electrode-upper wave guide wall seems to be quite constant judging from the sharpness of e.g., the cos line at 24326 mc. This electrode has the advantage of being easy to place but the cell-electrode capacity is high, which gives rise to trouble in the construction of a stable square-wave generator, desirable as modulator element. So far, a d.c. voltage between 50 and 300 volts, superimposed by a sine wave with amplitude ±40 volts and frequency 0.22–0.24 mc, has been used. The narrow band communication receiver (~2 kc) following the 1N26 crystal is tuned to the frequency of the sine oscillator. The radio output, after passing an RC-filter, is displayed on an oscilloscope screen and simultaneously listened to via a loudspeaker. Signals, indicating absorption, are easily distinguished from the different types of noise in the way they look and sound, and in that they disappear when the sine oscillator is interrupted. Wave-lengths are measured by a wave meter of the absorption type calibrated against NH_3, all the lines of which were quoted in literature[2] in the 22600–25700-mc region were observed, as were the lines of BrCN,[3] and cos.[3] Our wave-length measuring technique seems good to ±5 mc, which is rather poor in these days. While a suitable frequency-measuring system is being constructed, we have investigated a number of organic gases to get an impression of the possibilities of the microwave technique.

Organic vapors hitherto investigated are CH_3OH,[4–6] CH_3NH_2,[5] CH_3Cl, CH_3Br, CH_3J,[7] CH_3CN,[8] CH_3NC,[8] CH_3NO_2,[6] and $(CH_2)_2O$.[9,10] More organic vapors were tried by us. In the case of acetaldehyde, acetic acid, dimethyl and diethyl-ether, nitrobenzene, pyridin, anilin, furan, and methyl-eneiodide, no absorption was found. Our positive results are:

C_6H_5Br (bromobenzene; gas pressure 0.3 mm, Stark d.c. voltage 100) 23742–23690–[22050] mc.

C_2H_5OH (ethyl alcohol; pressure 0.16 mm, d.c. voltage 120) 25069–24385–24369–24295–23605–23555–23148–23081–22820 mc.

$(CH_3)_2CO$ (acetone; pressure 0.19 mm, d.c. voltage 100) 24758–24691–24646–24102–23934–23839–23827–23793–23778–23749–23661–23603–23339–22940–[22560]–[22500]–[22410] mc.

CH_3NO_2 (nitromethane; pressure 0.07 mm, d.c. voltage 125) 25412–25391(25400)–24599(24603)–24448–(24320)–24428–24017(24047)–23706–23483–23467–23330–(23250)–23021–[22620]–[22580]–[21970] mc.

CH_3OH (methyl alcohol; pressure 0.1 mm, d.c. voltage 50) 25349–25332–25312–(25300)–25289–25151–25131(25132)–25110–25038(25050)–25021(25018)–24997–24977–24960 (24954)–24928(24929)–24913–24901–(24317–24081–24040)–23857(23861)–23457(23450)–(23415)–23122(23121) mc.

Numbers in square brackets are very roughly estimated values, numbers in parenthesis are from reference 6. The substances used were of high purity. Spectra of probable contaminations were investigated.

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On the External Polarization of the Vacuum

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WE consider here the motion of an electron (positron) in an arbitrary external electromagnetic field determined by the potentials $\phi(\mathbf{r}, t)$, $\mathbf{A}(\mathbf{r}, t)$. The equation of motion for the electron-positron field is

$$i\hbar(\partial\psi/\partial t) = \{-\boldsymbol{\alpha}\cdot[i\hbar\boldsymbol{\nabla} + (e/c)\mathbf{A}]c + mc^2\beta + e\phi\}\psi. \quad (1)$$

We denote by $U_k(\mathbf{r}, t, t_0)$ solutions of (1) which reduce to plane waves on the surface $t=t_0$. The solutions $U_k(\mathbf{r}, t, t_0)$ will then form a complete orthogonal set of function. For convenience in writing, we will also treat these solutions as if they could be normalized to unity. We now split the solutions $U_k(\mathbf{r}, t, t_0)$ into two sets $U_{k+}(\mathbf{r}, t, t_0)$ and $U_{k-}(\mathbf{r}, t, t_0)$, which are defined so that $H_0U_k(\mathbf{r}, t_0, t_0) = \epsilon_k U_k(\mathbf{r}, t_0, t_0)$ with $H_0 = -i\hbar c\boldsymbol{\alpha}\cdot\boldsymbol{\nabla} + mc^2\beta$ has $\epsilon_{k+} > 0$ and $\epsilon_{k-} < 0$. The general solution of (1) may now be written

$$\psi = \Sigma a_k U_k(\mathbf{r}, t, t_0), \quad (2)$$

in which the operators a_k are independent of time. If the field, ψ, is Fermi quantized, then the a_k and a_k^* satisfy the anti-commutation relations $[a_k, a_{k'}]_+ = 0$, $[a_k, a_{k'}^*]_+ = \delta_{kk'}$. We now define charge density and current density operators by

$$\begin{aligned}\rho(\mathbf{r}, t, t_0) = {} & \Sigma a_{k+}^* a_{k'+} U_{k+}^*(\mathbf{r}, t, t_0) U_{k'+}(\mathbf{r}, t, t_0) \\ & + \Sigma a_{k+}^* a_{k'-} U_{k+}^*(\mathbf{r}, t, t_0) U_{k'-}(\mathbf{r}, t, t_0) \\ & + \Sigma a_{k-}^* a_{k'+} U_{k-}^*(\mathbf{r}, t, t_0) U_{k'+}(\mathbf{r}, t, t_0) \\ & - \Sigma a_{k'-} a_{k-}^* U_{k-}^*(\mathbf{r}, t, t_0) U_{k'-}(\mathbf{r}, t, t_0). \\ \mathbf{S}(\mathbf{r}, t, t_0) = {} & \Sigma a_{k+}^* a_{k'+} U_{k+}^*(\mathbf{r}, t, t_0) \boldsymbol{\alpha} U_{k'+}(\mathbf{r}, t, t_0) \\ & + \Sigma a_{k+}^* a_{k'-} U_{k+}^*(\mathbf{r}, t, t_0) \boldsymbol{\alpha} U_{k'-}(\mathbf{r}, t, t_0) \\ & + \Sigma a_{k-}^* a_{k'+} U_{k-}^*(\mathbf{r}, t, t_0) \boldsymbol{\alpha} U_{k'+}(\mathbf{r}, t, t_0) \\ & - \Sigma a_{k'-} a_{k-}^* U_{k-}^*(\mathbf{r}, t, t_0) \boldsymbol{\alpha} U_{k'-}(\mathbf{r}, t, t_0).\end{aligned} \quad (3)$$

The charge and current density operators as defined by (3) are obviously gauge invariant. They, at least formally, transform covariantly under Lorentz transformations. If we define the vacuum, as was done by Schwinger,[1] by the condition that the states $U_{k+}(\mathbf{r}, t, t_0)$ are empty and the states $U_{k-}(\mathbf{r}, t, t_0)$ are full as $t_0 \to -\infty$, then the a_{k+} are annihilation operators for electrons and the a_{k-} are creation operators for positrons. If we take the state in which there are no positrons or electrons present at $t=t_0$, then the expectation values $\langle\rho(\mathbf{r}, t, t_0)\rangle = 0$ and $\langle\mathbf{S}(\mathbf{r}, t, t_0)\rangle = 0$. The above expectation values are independent of t and t_0. We have thus obtained a result which is in disagreement with the infinite results of Schwinger and others. The result we have here obtained is an exact consequence of the equations of motion (1) and of the initial conditions used. We thus see that the problem of positron-electron field in a given external field is not a dynamical problem, it is entirely the problem of the appropriate definition of which states are electron states and which states are positron states.

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