The ionization trace rises sharply in less than 20 nsec, then decays in several hundred nanoseconds.

The minima in the breakdown curves are predicted by the familiar theory of electron impact ionization. The change in energy of the electrons is given by $d\epsilon/dt = e^2E_0{}^2\nu_m/2m \times(\nu_m{}^2+\omega^2)$, where E_0 and ω are the amplitude and frequency of the light wave, ν_m is the electron momentum-transfer collision frequency with neutrals, and e and m are the charge and mass of the electron. This energy change has a maximum when $\nu_m = \omega$. The collision frequency ν_m is related to pressure p (mm Hg) by

$$\nu_m = p_0 P_c v = (5.4\times10^7)P_c U^{1/2} p, \qquad (1)$$

where $p_0 = (273/T)p$ is the reduced pressure, P_c is the collision probability, v is the velocity, and U is the mean energy in electron volts. The approximate range of energy U is from the thermal energy, 0.04 eV, to the ionization potential, 24.5 eV for He, 15.7 eV for Ar, and 15.5 eV for N_2. Data are readily available from the literature giving P_c in terms of $U^{1/2}$ for most gases. For He the product $U^{1/2}P_c$ changes very little for U between 4 and 25 eV. Using a value in this range and setting $\nu_m = \omega = 2.72 \times 10^{15}$ $\sec^{-1}$ in Eq. (1) gives $p = 21\,400$ psi for the pressure at which the minimum in the breakdown curve should occur. The same procedure for Ar predicts the minimum to be at $p = 3300$ psi. These results are in agreement with the experimental data presented, being quite close for Ar and within a factor of 2 for He. In N_2 interpretation of the results must take into account the low-level inelastic collisional processes prevailing as well as the elastic.

It should be noted that the curve of P_c vs $U^{1/2}$ for He has a very broad maximum. The minimum in the curve of threshold E versus pressure is correspondingly broad. For Ar and N_2 the P_c maxima are much sharper, and correspondingly so are the threshold minima.

In conclusion, minimum breakdown fields have been observed for laser-induced discharges. These minima are characteristic of electron-impact ionization where electron heating occurs through energy transfer from the light wave to the electrons undergoing collisions with neutrals. The presence, pressure, and sharpness of these minima are predicted by a simple electron-impact ionization theory, and these predictions agree with the experimental data presented here.

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FREQUENCY DEPENDENCE OF OPTICALLY INDUCED GAS BREAKDOWN*

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The frequency dependence of the threshold intensities for the breakdown of gases by optical maser radiation has been of interest in attempting to determine the fundamental energy coupling mechanisms responsible for the breakdown phenomenon. Investigations by the authors[1] using 1.06μ radiation from a Nd-in-glass and 0.69μ radiation from a ruby optical maser led to the conclusion that the threshold intensity for breakdown increases with decreasing wavelength. A similar observation was made by Haught, Meyerand, and Smith in He, Ar, and air[2] at the same maser frequencies, and by Akhmanov et al.[3] using the Nd radiation and its second harmonic in air. We have made further studies of breakdown thresholds in research grade Xe and Ar at four optical wavelengths and have concluded that the thresholds do not increase monotonically as the wavelength is decreased.