Letters to the Editor

ON THE POSSIBILITY OF STIMULATED EMISSION IN THE FAR ULTRAVIOLET

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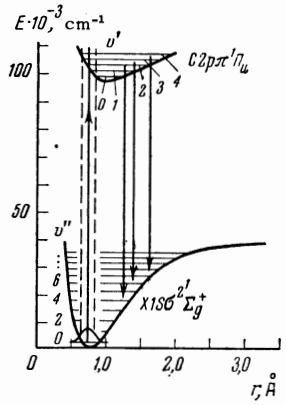
WE have previously observed [1] stimulated emission in the infrared using the H_2 molecule, and we have discussed the possible mechanisms responsible for the inversion, based on the Franck-Condon principle. The experimental results, as well as similar data on other molecules [2], in general bear out this mechanism very well. On this basis one may find many molecular transitions for which population inversion is possible under certain excitation conditions. In the present note we wish to deal only with the possibility of obtaining stimulated emission in transitions between resonance and ground electronic states of molecules. This possibility is of particular interest. The mechanism considered is similar to one described in [1] and is in principle applicable to many molecules having similar dispositions of their potential energy curves.

As an example we choose the simplest molecule, H_2. As upper and lower states of the active medium we consider the electronic state $2p\pi\,^1\Pi_u$ and the ground state $1s\sigma^{2\prime}\Sigma_g^+$, which will be designated in what follows by C and X respectively (one might equally well choose the $2p\sigma\,'\Sigma_u^+$ state as the upper level). The dipole transition $C \longleftrightarrow X$ corresponds to the Werner bands observed in the far ultraviolet [3]. The potential curve for the ground state is calculated in [4]. A Morse function gives a sufficiently good approximation to the lowest vibrational levels of the C state. Both of these curves are shown in the figure.

Because of the large magnitude of the vibrational quanta, only the lowest vibrational level $v'' = 0$ in the ground state is occupied at room temperature. During the initial moments of discharge, excitation of the vibrational levels of the states X and C occurs primarily via electron collisions with molecules in the ground state. Since the Franck-Condon principle applies to electron excitation [5], it is seen that, owing to the



displacement of the potential curves, the levels $v' = 1, 2, 3, 4$ of state C are most effectively populated. Transitions from these levels to ground state $v'' = 0$ have relatively large probability. From these levels there are, besides transitions to the ground state $v'' = 0$, rather large probabilities for making transitions to the upper vibrational levels of the ground state (the Werner bands seen in emission). Population of these latter vibrational levels by electron collisions from the ground state $v'' = 0$ is very unlikely, since no change in the electronic state is involved. Thus during the initial moments of the discharge one should observe inversion between the states $C(v' = 1\text{-}4)$ and $X(v'' > 1)$. For sufficiently intense excitation one should obtain stimulated emission on several bands of the Werner system in the wavelength region from 1100 Å (1-1) to 1250 Å (4-8). The corresponding transitions are shown by arrows in the figure. Owing to the symmetry of the H_2 molecule, radiative transitions between vibrational levels are forbidden and the lifetime of the upper vibrational levels of the ground state is determined by collisions with other molecules. In practical cases it will obviously be very long. This will make continuous operation of the laser impossible and will limit the obtainable pulse repetition rate.

This mechanism has two special features which make its implementation particularly attractive. In the first place it allows one to obtain laser action in the so far unattainable region of very short wavelengths. Secondly, such a procedure for obtaining stimulated emission should give a very large efficiency and very high peak powers. This is related to the fact that, in distinction to the known gaseous systems, we are here using transitions between the lowest resonance levels which, because of the large cross-section for the electron excitation, are populated much more strongly than the others. Moreover, the use of transitions terminating in the ground electronic

state is very efficient, since in this case a very large fraction of the energy given to the active medium by fast electrons is converted to quanta of stimulated emission.

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EXPERIMENTAL OBSERVATION OF THE TUNNEL EFFECT FOR COOPER PAIRS WITH THE EMISSION OF PHOTONS

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IT has been pointed out earlier[1] that the initial part of the volt-ampere characteristic for superconducting tunnel structures of the type Sn-SnO_2-Sn has steps characterized by a current increase at nearly constant potential. These steps occur for tunnel structures which have a sufficiently thin and uniform oxide layer between the films. For such structures a constant superconducting tunnel current is observed, the amplitude of which oscillates as the constant magnetic field is varied. The height of the step on the volt-ampere characteristic also depends on the constant magnetic field and oscillates as the latter is changed. The position of the step on the voltage axis, however, remains nearly constant, being probably determined by the dimensions of the transition layer, since structures with the same dimensions exhibit similar systems of steps, whereas altering the dimensions changed the system of steps. In[1] the statement was made that the system of steps on the volt-ampere characteristic of Sn—SnO_2—Sn superconducting tunnel structures owed its existence to the generation of

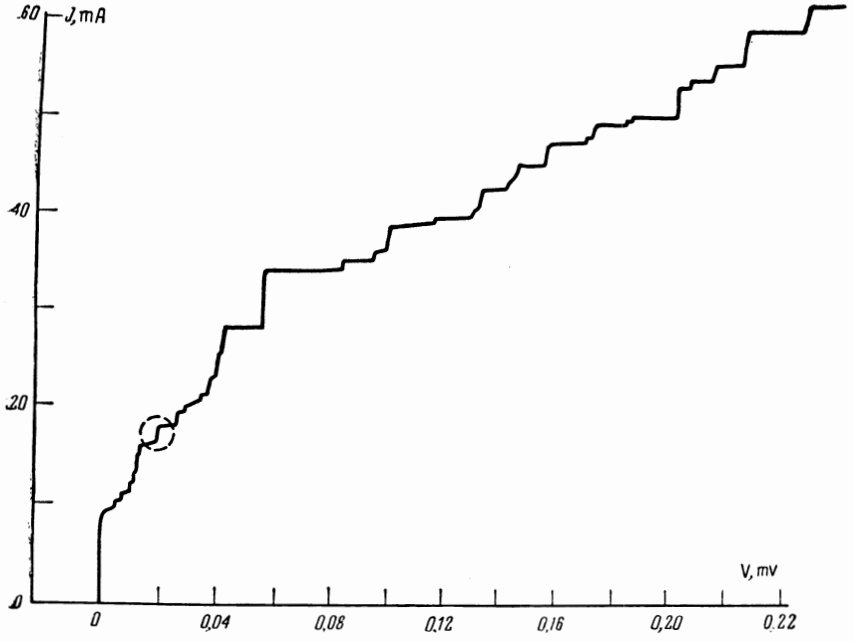

FIG. 1. Volt-ampere characteristic of the tunnel structure Sn—SnO_2—Sn at T = 1.57°K, H = 1.5 Oe. The step with frequency inside the transmission band of the detector is shown by the circle.