pulses: a) 100 nsec fwhm and with 1.5 μsec tail, and 
b) 60 nsec fwhm without tail. The results show that there 
are three characteristic times: \( \tau_{\text{dis}} \) - dissociation into frag-
ments in the ground state, \( \tau_{\text{lum}} \) - dissociation into frag-
ments in the excited states, and \( \tau_{\text{isom}} \) - isomerization, with 
\[ \tau_{\text{dis}} < \tau_{\text{lum}} < \tau_{\text{isom}} \]

The isomerization requires the longest time of preserving 
of vibrational excitation and is easily quenched by buffer 
gases.

The measurements of energy absorbed in trans-C₂H₂Cl₂ 
at high intensities of laser field show that the heating effects 
can be neglected completely. The isomerization also goes 
with the same efficiency when composite vibrational bands 
are pumped, as in the case of pumping the \( \nu_6 \) vibrational 
mode of C₂H₂Cl₂. The experiments show that the threshold 
of isomerization and both kinds of dissociation are approxi-
mately the same, but they are sensitive to the full energy of 
the pulse. Thus by changing the pulse length and its energy 
it will be possible to shift the processes in the desired way.

Some theoretical considerations are presented of these 
processes which are common to all processes with multiple 
photon absorption involved.

Reference
[1] R.V. Ambartzumian, N.V. Chekalin, V.S. Dolijkov, 
V.S. Letokhov and V.N. Lokhman, Optics Commun. 
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**T12 PROSPECTIVES OF FREE ELECTRON LASERS**

A. GOVER, A. YARIV, P. YEH,
California Institute of Technology, Pasadena, Cal., USA

Free electron lasers are light amplifiers and oscillators based 
on stimulated radiative transitions of accelerated free 
electrons. Such radiative transitions which are forbidden in free 
space, are possible in periodic structures and other structures. 
In this sense the TWT amplifier may be regarded as an exam-
ple of a free electron maser; the Smith–Purcell effect, 
Cerenkov radiation and bremsstrahlung are examples of free 
electron spontaneous emission radiators. Recently stimulated 
emission of radiation by free electron spontaneous emission 
radiators. Recently stimulated emission of radiation by free 
electrons in periodic magnetic field was demonstrated in the 
optical frequency regime [1].

We are carrying out a research program to identify pros-
pective free electron lasers, to understand the various modes 
of operation, and to estimate their gain and other character-
istics. We distinguished between free electron lasers of the 
bremsstrahlung type [1] (schemes b, c in Figs. 3, 4) and ones 
of the Cerenkov (or Smith–Purcell) type (scheme a in Figs. 3, 
4). We also distinguished between devices in which collective 
interaction with the electron plasma takes place (like the 
TWT), and other in which the interaction is essentially a single 
electron interaction (like the Smith–Purcell effect).

A generalized one-dimensional coupled mode model was 
developed in the classical, quantum-mechanical and relativi-
tic regimes to describe a large class of "Cerenkov–Smith– 
Purcell type" free electron lasers. The model reduces to the 
conventional TWT equation in the regime of collective inter-
action. In the single electron interaction regime the exponential 
gain is found to be

\[
a = \left( K_m \sqrt{\frac{\rho_0}{\epsilon}} \right) \frac{2 \pi}{\lambda} \frac{k_D^2}{2} \text{Im} G' \left( \frac{\omega - \sqrt{\epsilon} \nu_0}{v_{\text{th}}} \right) \]

\[
\begin{align*}
    k_{m0} & \rightarrow k_{b0} \\
    \beta_m & \rightarrow \beta_b \\
    \frac{\beta_0}{L} & \rightarrow \frac{\beta_b}{L} \\
    \frac{m_2 \pi}{L} & \rightarrow \frac{m_2 \pi}{L} \\
    \frac{m_2 \pi}{L} & \rightarrow \frac{m_2 \pi}{L} \\
    \frac{\beta_0}{L} & \rightarrow \frac{\beta_b}{L}
\end{align*}
\]
A home-made atmospheric pressure CO$_2$TEA laser was used. Commercial paraformaldehyde powder was evaporated under vacuum and transferred to a glass cylindrical absorption cell (4 cm in diameter and 10 cm long) with NaCl windows. To avoid polymerization on the walls, the cell was heated to 100-120°C. The gas was kept at 20 torr, the pressure at which experiments were performed. The laser beam transmitted through the cell was strongly focused back into the cell by an $f = 4$ cm concave mirror which was attached to the cell's second window. In a typical experiment the cell was irradiated by 300 laser pulses, with a repetition rate of 0.5 Hz.

The main photodissociation reaction is [1]

$$\text{HDCO} + n h\nu \rightarrow \text{HD} + \text{CO},$$

where $n$ is the number of photons whose energy is $h\nu$ and which participate in the photodissociation of one molecule. Photodissociation of this type is unlikely to occur for H$_2$CO at the radiation wavelength of the laser (10.59 μ) unless power broadening reaches 100 cm$^{-1}$ or more, but this does not seem to occur at the intensities used. Immediately after irradiation the non-dissociated formaldehyde was frozen out of the cell with the aid of a liquid nitrogen trap. The residual gases whose pressure was usually less than 0.2 torr were then analyzed in a mass spectrometer. This analysis yielded the enrichment factor, defined as the ratio of (HD:HD$_2$) in the residual gases after irradiation by the CO$_2$ laser to (HD:HD$_2$) in the original formaldehyde.

Our present preliminary results show that for 300 CO$_2$ laser shots focused strongly into the sample, the deuteration enrichment factor is approximately 4.0. No enrichment was found for 300 laser shots with an unfocused laser beam. These results clearly show that the selective photodissociation process is very efficient and strongly power dependent. It follows from our experiment that the power broadening with the focused beam is of the order of 10 cm$^{-1}$, since selective photodissociation of HDCO occurs, while the distance between the 10.59 μ line of the CO$_2$ laser and the nearest HDCO absorption line is $\sim 8$ cm$^{-1}$. This power broadening implies that the intensity reaches $\sim 20$ GW/cm$^2$ in the focal zone. This result is also attained using purely optical considerations.

Reference


T13 SEPARATION OF DEUTERIUM IN FORMALDEHYDE
BY A CO$_2$-LASER
G. KOREN and U. OPPENHEIM
Solid State Institute and Department of Physics,
Technion-Israel Institute of Technology, Haifa, Israel

Following the efficient isotope separation process in molecules such as SF$_6$, BCl$_3$, etc., with CO$_2$ laser radiation, it was attempted to attain laser enrichment of deuterium by this method. The formaldehyde molecule is a perfect candidate for this method, since for one-photon processes its absorption lines overlap the emission bands of the CO$_2$ laser radiation mainly in the deuterated molecules (HDCO and D$_2$CO), while almost no such overlap occurs for the non-deuterated molecule (H$_2$CO).

T14 CHEMICAL DF-CO$_2$ AMPLIFIER WITH HIGH-POWER PHOTONIZATION
N.G. BASOV, A.S. BASIKIN, P.G. GRIGORIEV, A.N. ORAEVSKY and O.E. FORODINNOV
P.N. Lebedev Institute, Moscow, USSR

Not received,