For larger current densities the intensity of the line continued to grow but its width increased somewhat. For small current densities the emission intensity, after the excitation was switched off, fell exponentially with a time constant of about 2 μsec. At higher beam currents the time of the afterglow decreased and the light pulse coincided exactly with the current flux.

In order to estimate the relative intensity of the line, the pulse amplitude was measured with an FÉU-19 photomultiplier, first using an interference filter (4960 ± 35 Å) and then without the filter. The amplitude of the pulse without the filter increased linearly with increasing current. For small currents the emission was totally absorbed by the filter. It was estimated that the intensity of the stimulated emission at the maximum current density was comparable with the total spontaneous emission intensity.

In conclusion the authors consider it a pleasant duty to express their thanks to V. S. Vavilov for a number of useful suggestions and for constant interest in this work, and to Yu.M. Popov and O. M. Krokhin for constant and fruitful discussions concerning the preparation and execution of these experiments and also to A. N. Mestvirishvili and N. P. Lantsov for competent help with the accelerator.

[1] N. G. Basov, Advances in Quantum Electronics, Columbia University Press, 1961, p. 506.

[2] Yu.M. Popov, Doctoral Dissertation, FIAN, 1963.

[3] N. G. Basov and O. V. Bogdankevich, JETP **44**, 1115 (1963), Soviet Phys. JETP **17**, 751 (1963).

[4] Vavilov, Egorov, Nolle, and Vintovkin, FTT **6**, 1406 (1964), Soviet Phys. Solid State **6**, 1099 (1964).

[5] R. Bäuerlein, Z. Physik **176**, 498 (1963).

Translated by J. A. Armstrong
221

PULSED LASER ACTION IN MOLECULAR HYDROGEN

P. A. BAZHULIN, I. N. KNYAZEV, and G. G. PETRASH

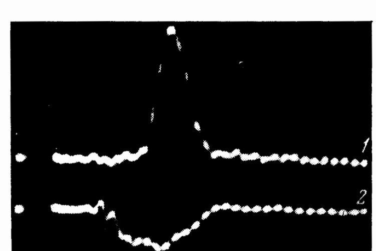
P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor June 9, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) 47, 1590-1591 (October, 1964)

A great deal of attention has recently been given to the problems of obtaining coherent emission in the optical region of the spectrum, to the discovery of new materials for laser action, and to the investigation of the physical mechanisms leading to population inversion. We have observed pulsed laser action in an active medium consisting of a plasma discharge in hydrogen. The laser discharge tube, which had Brewster angle windows, was 145 cm. long and had an inside diameter of 15 mm. External confocal mirrors with a separation of 2 m were used. Both multilayer dielectric mirrors and silver coated mirrors were used. The discharge was excited with a voltage of up to 35 kV. The pulse repetition rate was usually 20 cps. The output radiation was studied with a grating monochromator constructed in our laboratory. An FÉU-22 photomultiplier was used as a detector. The laser pulses and the current pulses were recorded on a DESO-1 oscilloscope.

Laser action was observed as a short emission pulse of approximately triangular form. The length of this pulse between half-power points was about 0.2 μsec. The laser action occurred during the current pulse. In the figure we show: 1- the laser pulse, and 2- the oscilloscope trace of the current pulse. Laser action was observed on six lines; their wavelengths and wave numbers are given in the table. The wavelengths of these lines are measured to an accuracy of about ±5 Å. The error for the line at 13,100 Å may be somewhat larger. The use of different mirrors might make



1 – laser pulse; 2 – current pulse in the discharge. The time markers are 0.05 μsec. apart.

λ, Å	ν, cm⁻¹	Proposed band of the $E'\Sigma_g^+ \to B'\Sigma_u^+$ system
8 335	11 998	2→1
8 879	11 263	1→0
8 892	11 246	
11 147	8 971	0→0
11 205	8 925	
13 100	7 634	0→1

it possible to obtain laser action at only one or two of these lines.

The observed laser lines may, within the accuracy of the measurements, be ascribed to transitions in the band system $E'\Sigma_g^+ \to B'\Sigma_u^+$ of the hydrogen molecule. The band to which each line is assigned is shown in the table. In all cases the observed lines may be attributed to transitions belonging to the P-branch of the band; the rotational quantum number J does not exceed 4. Insufficient resolving power in the instrument with which we worked prevents us at present from more definite assignment of the observed lines to particular transitions.

All of the experimental results are consistent with the following mechanism for producing inversion. The equilibrium internuclear separations for the states of the hydrogen molecule under consideration are appreciably different. However the shape of the potential energy curves is such [1,2] that, according to the Franck-Condon principle, in a discharge one will preferentially populate relatively high vibrational levels of the state $B'\Sigma_u^+$ with $v'' = 5, 6, 7, 8, 9$. The vibrational levels with smaller v'' must be relatively less populated. On the other hand the population of the state $E'\Sigma_g^+$ is in the lower vibrational levels $v' = 0, 1, 2, 3$. Moreover the shape of the potential curves is such that there must be relatively large probabilities for the transitions $E'\Sigma_g^+$ $(v' = 0, 1, 2, 3) \to B'\Sigma_u^+$ $(v'' = 0, 1, 2)$. Hence one would expect these transitions to be inverted, at least during the initial moments of the discharge when the level populations are determined primarily by electronic excitation from the ground state.

It can be expected that such a mechanism for producing inversion would have wide application for producing laser action in molecular electronic vibrational-rotational transitions.

[1] J. Tobias and J. T. Vanderslice, J. Chem. Phys. 35, 1852 (1961).

[2] W. Kolos and C. C. J. Roothaan, Revs. Modern Phys. 32, 219 (1960).

Translated by J. A. Armstrong
222

COMPTON EFFECT ON MOVING ELECTRONS

O. F. KULIKOV, Yu. Ya. TEL'NOV, E. I. FILIPPOV, and M. N. YAKIMENKO

Moscow State University; P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor June 24, 1964
J. Exptl. Theoret. Phys. (U.S.S.R.) 47, 1591-1594 (October, 1964)

UP to the present time the Compton effect has been studied experimentally for stationary (nonrelativistic) electrons. With the development of methods of accelerating elementary particles, in particular electrons, the possibility has appeared of investigating the scattering of photons by electrons moving almost with the speed of light. The creation of new powerful photon sources - lasers - permits us to achieve the scattering of photons of visible light by electrons moving in the orbit of a cyclic accelerator.

The theory of the Compton effect on relativistic electrons, described by Akhiezer and Berestetskiĭ,[1] has been discussed in detail for the case of interaction of laser photons with relativistic electrons by Milburn,[2] Arutyunyan and Tumanyan,[3] and Arutyunyan et al.[4] According to these theoretical treatments, for a head-on collision of laser radiation ($\lambda = 6943$ Å) and relativistic electrons with an energy of the order of 500 MeV, we should expect the appearance of γ rays of energy about 7 MeV in the direction of motion of the electrons.

Since this effect can be very important in the study of the bunching of accelerated electrons and since the scattered γ rays can be utilized in various nuclear investigations, we have attempted to detect the scattered γ radiation arising in the interaction of colliding beams of photons from a ruby laser and electrons accelerated in the FIAN 600 MeV synchrotron. A diagram of the equipment is shown in the figure. The laser light is directed by the mirror M along a tangent to the electron orbit O in the accelerator vacuum chamber VC, in a direction opposite to the accelerated electrons. The γ-rays resulting from the scattering move along the same tangent to the electron orbit but in the opposite direction to the laser photons. Passing through the mirror M, they are incident on a scintillation counter with a NaI crystal. The signal from the photo-multiplier is fed through the amplifier and single-channel analyzer SCA to the