point T_N of this compound. We can use here the fact that $H_n^2(T)$ follows a simple linear law near the magnetic-transformation temperature (Fig. 2b). The Neel point of the compound FeGe can be determined by extrapolating the $H_n^2(T)$ plot to zero field. This yields $T_n = 411 \pm 2°K$.

Assuming that H_n is proportional to the magnetization σ_s of the lattice of the antiferromagnet, this means that the $\sigma_s^2(T)$ is also linear near the Neel point, as predicted by the thermodynamic theory developed for antiferromagnets [3].

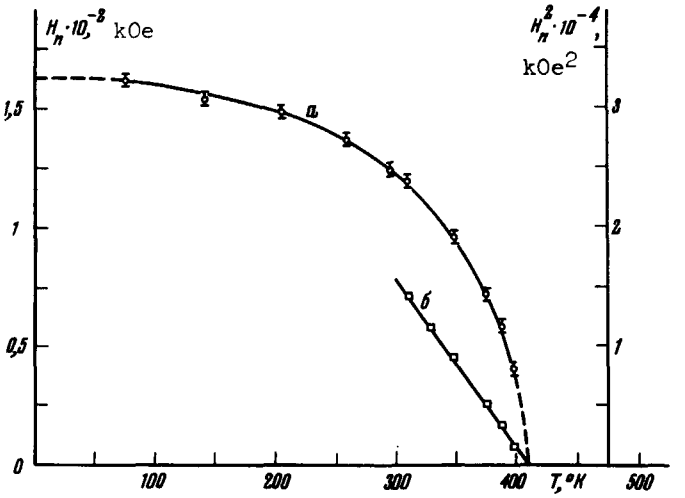

Fig. 2. a - Temperature dependence of the local field H_n acting on the iron nuclei in the crystal lattice of the compound FeGe; b - plot of $H_n^2(T)$.

We note that the relation $H_n^2 \sim (\theta - T)$ (θ - temperature of the magnetic transformation) is apparently a general characteristic of substances with ordered magnetic structures - ferromagnets, antiferromagnets, and ferrimagnets [4].

We take this occasion to thank I. K. Kikoin for continuous interest in the work and Yu. M. Kagan for useful discussions. We are grateful to N. N. Kuznetsov and V. I. Bogachev for help in adjusting the experimental setup, and to P. N. Petrov and V. A. Somenkov for the x-ray structure analysis of the sample.

[1] Ohoyama, Kanematsu, and Jasukochi, J. Phys. Soc. Japan 18, 589 (1963).
[2] K. Kanematsu and T. Ohoyama, J. Phys. Soc. Japan 20, 236 (1965).
[3] I. E. Dzyaloshinskii, JETP 32, 1547 (1957); Soviet Phys. JETP 5, 1259 (1957).
[4] Nikolaev, Dubovtsev, Ugodnikov, and Yakimov, Paper at All-union Conference on Ferromagnetism and Antiferromagnetism, Sverdlovsk, 1965.

MULTIPHOTON IONIZATION OF THE HYDROGEN MOLECULE IN THE STRONG ELECTRIC FIELD OF RUBY LASER EMISSION

G. S. Voronov, G. A. Delone, N. B. Delone, and O. V. Kudrevatova
P. N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 27 August 1965

Multiphoton ionization of the hydrogen molecule, induced by radiation from a ruby laser at an electric field intensity $E \sim 10^7$ V/cm, was observed. The ratio of the ionization potential ($I = 15.43$ eV) to the quantum energy ($\hbar\omega = 1.79$ eV) shows that the ionization can result

from the absorption of nine quanta.

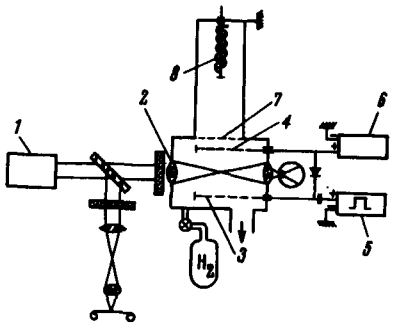

Fig. 1.

The experimental setup was similar to that described earlier [1]. An exception was the system for recording the ions (Fig. 1). The radiation from a Q-switched ruby laser (1) was focused by a lens (2) inside a vacuum chamber in which hydrogen pressure ~10^{-4} mm Hg was maintained. A pulsed voltage (5) synchronized with the giant laser pulses was applied between grids (3) and (4) to draw the ions out of the focusing region. A dc voltage from source (6), applied between grids (4) and (7), accelerated the ion bunch. Reliable separation of the signals from the molecular and atomic hydrogen ions was ensured by choosing the accelerating voltage and the length of the travel gap to the electron multiplier (8).

The following results, characterizing the multiphoton ionization of the hydrogen molecule, were obtained.

A plot of the number of molecular ions N_i produced when N_j photons pass through the focusing region is shown in Fig. 2. Using the method described in [2], we obtain from this plot that the number of quanta whose absorption probability determines the ionization probability is $K = 7.67 \pm 0.36$. Data from control experiments show that the true error is larger than the quoted statistical error. At the present time we cannot determine the true error, since it is connected with difficult-to-calculate systematic changes in the spatial distribution of the laser emission.

The probability of multiphoton ionization of a hydrogen molecule with production of a molecular ion is $W = 10^{6.3^{+1.5}_{-1.7}}$ sec^{-1} at a field intensity $E = (1.1 \pm 0.3) \times 10^7$ V/cm (the photon flux is $F = 10^{30.0 \pm 0.2}$ $cm^{-2}sec^{-1}$.

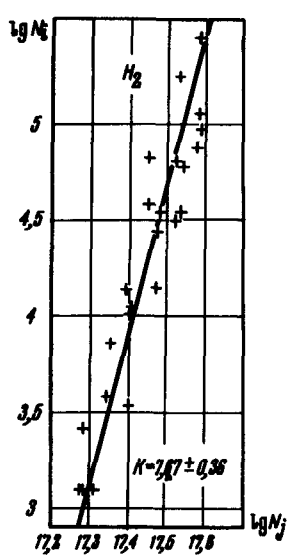

Fig. 2.

The ionization probability of the hydrogen molecule is determined by the probability of absorbing fewer than nine quanta. The reason, as in the case of the ionization of the xenon atom, may be the existence of resonant transitions in the hydrogen spectrum and the broadening of the upper levels in a strong electric field.

A calculation based on the theory of multiphoton ionization of atoms [3], applied to the hydrogen molecule, shows that the experimentally observed probability $W = 10^{6.3}$ sec^{-1} of the 8-photon process can be realized in an electric field $E = 8.5 \times 10^7$ V/cm. This is much larger than the experimental $E = 1.1 \times 10^7$ V/cm. We note that in the case of 6-photon ionization of a xenon atom, calculation based on [3] agrees much better with experiment.

In a strong field, both molecular ions H_2^+ and atomic ions H^+ are produced. At a field intensity $E \simeq 1.2 \times 10^7$ V/cm, the ratio of the observed ions is $10 \lesssim N(H_2^+)/N(H^+) \lesssim 100$. The atomic ions can be pro-

duced by dissociation of a molecule with subsequent ionization of the resultant neutral atoms, or by ionization of the molecule with subsequent dissociation of the molecular ion. Additional experiments are necessary to determine the probabilities of these processes.

The authors thank V. S. Karyukhin and S. A. Ob"edkov for help with the work, and L. V. Keldysh and M. S. Rabinovich for valuable discussions.

[1] G. S. Voronov and N. B. Delone, JETP Letters 1, no. 2, 42 (1965), translation p. 66.

[2] Voronov, Gorbunov, Delone, Delone, Keldysh, Kudrevatova, and Rabinovich, Paper at the 3rd All-union Conference on the Physics of Electronic and Ionic Collisions, Khar'kov, 1965.

[3] L. V. Keldysh, JETP 47, 1945 (1964), Soviet Phys. JETP 20, 1307 (1965).

MONOPULSE GENERATION WITH $CaF_2:U^{3+}$ CRYSTALS

B. A. Ermakov, A. V. Lukin, A. A. Mak, and D. S. Prilezhaev

Submitted 31 August 1965

Q-switched lasers using ruby and glass or calcium tungstate activated with Nd^{3+} are by now universally known. Attainment of monopulse generation in the 2.36 μ infrared region with $CaF_2:Dy^{2+}$ has recently been reported [1]. In this paper we report attainment of monopulse generation with $CaF_2:U^{3+}$ crystals at wavelengths 2.2 and 2.51 μ. A diagram of the experimental setup is shown in Fig. 1. The crystals were cooled to 80 - 90°K by a jet of nitrogen gas evaporated from the liquid phase. To prevent distortion of the resonator by condensation of water vapor and by the convection currents, the space between the crystal and the protective window was evacuated. The protective window was a plane-parallel plate of quartz glass finished to high tolerances. A semitransparent coating with reflection coefficient R = 0.95 ± 0.6 was deposited on one end of the crystal. The cavity switching was by means of a rotating total internal-reflection prism. The pump-lamp ignition was synchronized with a photoelectric system coupled to the rotating prism. The prism was rotated at 1 - 2 x 10^4 rpm. The crystals used were 3 - 55 mm in diameter and 20 - 30 mm long. The radiation receiver was a Ge:Au photoresistance, and the over-all resolution of the measuring apparatus was 2 x 10^{-7} sec. The generated energy was measured with a bolometer.

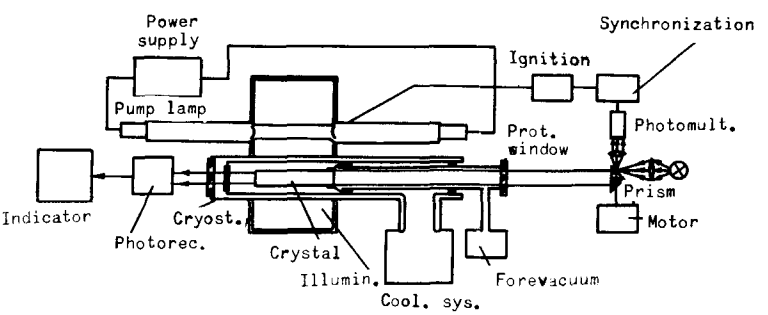

Fig. 1.

It was shown in [2] that either 4-level (λ_4 = 2.61 μ) or 3-level (λ_3 = 2.22 μ) lasing is possible in $CaF_2:U^{3+}$ crystals. A transition from 4-level to 3-level lasing is possible when the excess over the threshold pump energy, necessary for the excitation of lasing action in the