# Faraday effect in compressed hydrogen during stimulated Raman scattering

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The excitation of stimulated emission in a gaseous Raman-active medium intensifies the Faraday effect at the frequencies of the exciting light and of the Stokes (anti-Stokes) components.

The changes caused in the physical properties of various substances by intense laser beams have attracted considerable research interest in recent years. Among the interesting studies in this direction we might note the discovery of cooperative phenomena accompanying stimulated Raman scattering,[1] research on the anharmonicity of the hydrogen molecule,[2] and studies of the changes in the polarizability of this molecule.[3,4]

In this letter we are reporting experimental observation of a change in the gyrotropic properties of gaseous hydrogen during stimulated Raman scattering. If linearly polarized light is passed through gaseous hydrogen, the polarization plane of the light will rotate if a magnetic field is imposed (this is the Faraday effect). Under ordinary conditions the rotation angle would be exceedingly small: The Verdet constant for gaseous hydrogen under standard conditions is $6\times10^{-6}$ min/(cm·Oe) at $\lambda = 0.57$ $\mu$m (Ref. 5).

We have observed a significant increase in the Verdet constant in compressed hydrogen upon excitation of stimulated Raman scattering in the hydrogen. The experimental layout is shown schematically in Fig. 1. The beam from a $Q$-switched single-mode ruby laser 1 passes through an auxiliary polarizer 2 (a Rochon prism) and is focused into the cell holding the compressed hydrogen, 3 ($p = 30$ atm), which is inside solenoid 4. After the cell there is a second Rochon prism, 5, which is crossed with the first (in the experiments the angle between the principal planes of the prisms was set equal to 89° and 85°). The measurement system (photodetectors 6 and 7 and wide-band oscilloscope 8) could detect orthogonal components of the light which passed through the cell and could determine from the change in their ratio the angle and direction of the rotation of the polarization plane with respect to the polarization plane at the entrance to the cell. An interchangeable system of filters 9, 10 made it possible to carry out these measurements at various wavelengths [at the frequencies of the ruby laser ($\lambda = 0.69$ $\mu$m), of the Stokes component ($\lambda = 0.97$ $\mu$m), and of the anti-Stokes component ($\lambda = 0.53$ $\mu$m)]. The rotation of the polarization plane was detected for various directions of the magnetic field, which ranged in strength from 500 Oe to 1400 Oe, and also in the absence of a magnetic field. The length of the Raman-active region, required for the calculations, was taken to be 50 mm, in accordance with Ref. 6.

Our study showed that when the stimulated Raman scattering is excited in the

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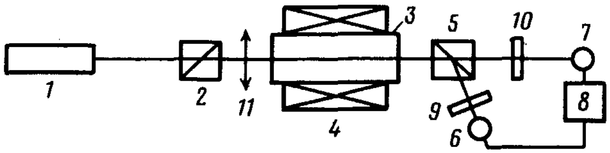


FIG. 1. Schematic diagram of the experimental layout. 1—Ruby laser; 2—polarizer; 3—cell with compressed hydrogen; 4—solenoid; 5—analyzer; 6,7—photodetectors; 8—wide-band oscilloscope; 9,10—optical filters; 11—focusing lens.

medium (compressed hydrogen), the angle through which the polarization plane of light with a wavelength of 0.69 $\mu$m rotates upon the imposition of a magnetic field increases significantly (Fig. 2). The measurements show that the magnitude of the rotation angle is proportional to the strength of the magnetic field and that the rotation direction depends on the direction of the magnetic field and corresponds to a positive value of the Verdet constant.

The rotation angle in the case in which Raman scattering is excited depends on the power density of the exciting light, $I$, increasing with $I$.

We also observed a rotation of the polarization plane of light at the frequencies of the Stokes component (0.97 $\mu$m) and the anti-Stokes component (0.53 $\mu$m) of the Raman scattering in hydrogen in a magnetic field. The rotation angle increased even further when the Raman-active medium was placed in an optical resonator or in a cell with a hydrogen optical delay line, which made it possible to achieve a multifocus system for exciting Raman scattering.

Analysis of the results (with allowance for the anisotropy of the active medium which arises during the excitation of Raman scattering[6]) revealed that the magnitude of the Verdet constant of gaseous hydrogen at the wavelength $\lambda = 0.69$ $\mu$m during the excitation of Raman scattering, expressed in terms of standard conditions at $I \sim 10^8$ $W/cm^2$, is on the order of $4 \times 10^{-5}$ min/(cm·Oe). The value of the Verdet constant of the anti-Stokes component under the same conditions turned out to be $\sim 8 \times 10^{-5}$ min/(cm·Oe).

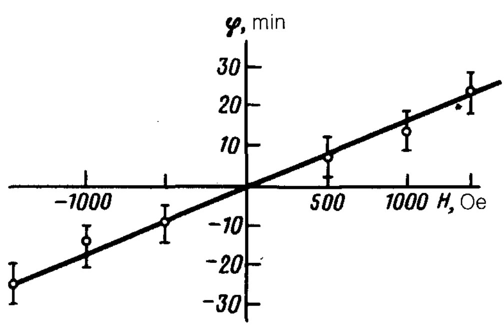


FIG. 2. Angle through which the polarization plane of light with $\lambda = 0.69$ $\mu$m rotates versus the strength of the magnetic field.

In summary, it has been established that the excitation of stimulated Raman scattering in gaseous hydrogen increases the angle through which the polarization plane rotates in a magnetic field by about an order of magnitude.

[1]S. G. Rautian, V. P. Safonov, and B. M. Chernobrod, Izv. Akad. Nauk SSSR. Ser. Fiz. **50**, 640 (1986).
[2]I. P. Angelov, G. V. Venkin, D P. Esikov, and G. M. Mikheev, Dokl. Akad. Nauk SSSR **275**, 858 (1984) [Sov. Phys. Dokl. **29**, 299 (1984)].
[3]N. V. Kravtsov and N. I. Naumkin, Pis'ma Zh. Eksp. Teor. Fiz. **21**, 551 (1975) [JETP Lett. **21**, 257 (1975)].
[4]N. V. Kravtsov and N. I. Naumkin, Opt. Spektrosk. **51**, 190 (1981) [Opt. Spectrosc. (USSR) **51**, 104 (1981)].
[5]Smithsonian Physical Tables, Washington, D. C., 1954.
[6]N. V. Kravtsov and N. I. Naumkin, Kvant. Elektron. (Moscow) **7**, 905 (1980) [Sov. J. Quantum Electron. **10**, 519 (1980)].

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