Appl. Phys. B 31, 191–192 (1983)

Applied Physics B Photophysics and Laser Chemistry



# Amplified Phase-Conjugate Reflection of $\lambda = 10.51\,\mu m$ Radiation in Gaseous $SF_6$

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Received 21 October 1982/Accepted 7 February 1983

**Abstract.** Phase-conjugate reflection at the $P(12)$ $CO_2$ line ($\lambda = 10.51\,\mu m$) has been obtained in gaseous $SF_6$ with a power reflection coefficient of 220% and an energy reflection coefficient of 115%.

**PACS:** 42.65

Optical phase conjugation is interesting for its ability to correct optical aberration of radiation passing through inhomogeneous media, to provide optimum focusing of light pulses in plasma studies, etc. [1, 2]. The possibility of optical phase conjugation of $CO_2$-laser radiation in resonant media [3–6] is of a particular interest.

This paper reports on the study of phase-conjugate reflection of $CO_2$-laser radiation at the vibrational molecular transitions in $SF_6$ by degenerate four-wave mixing. The reflection has been obtained with the power and the energy of the reflected radiation exceeding those of the probe wave.

## Experimental

The experimental apparatus used is shown in Fig. 1. As a pump source, single-mode radiation ($TEM_{00q}$) of a pulsed TEA $CO_2$-laser "1" tuned with a grating (100 lines/mm, blaze angle: 30°) was used. The temporal behavior of output pulse has the shape of a narrow peak, on a wide background, with a duration of $\tau_{0.5} = 100$ ns and $\tau_{0.1} = 1.5\,\mu s$. A germanium 50% beam splitter "2" devided the $CO_2$-laser radiation into 3 beams. Two of them, of approximately equal intensity, were reflected from the mirrors "3" and formed counterpropagating pump waves in the gaseous medium $SF_6$. The third one, of lower intensity, was reflected from another face of the beam splitter "2" to form a probe wave. It was directed into the cell "5" by a ZnSe beam splitter "4". To provide a better overlap with the pump beam, the lens "6" was used to focus the probe wave. Four-wave mixing of the pump and probe waves in $SF_6$ results in a third-order polarization causing a phase-conjugate wave counterpropagating to the probe one. This radiation may be treated as a result of phase-conjugate four-wave-mirror reflection of the signal wave. The reflected wave was selected and recorded by the detector "12" consisting of a photon-drag detector ($\tau_{const} = 1$ ns) and a Ge–Au photoresistance ($\tau_{const} \sim 2\,\mu s$). To ensure operation in the linear of the photoresistance, a preliminary calibrated attenuators "11" were used. To find the reflection coefficient, the recording system was calibrated with the 100% mirror "7". A precisely backward-travelling probe wave reflect-

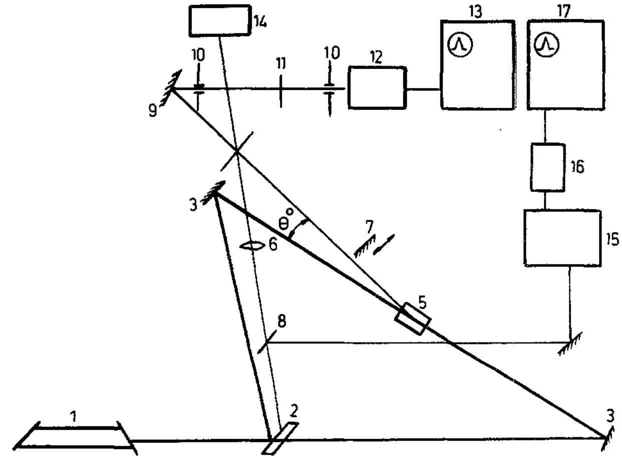


Fig. 1. Experimental arrangement

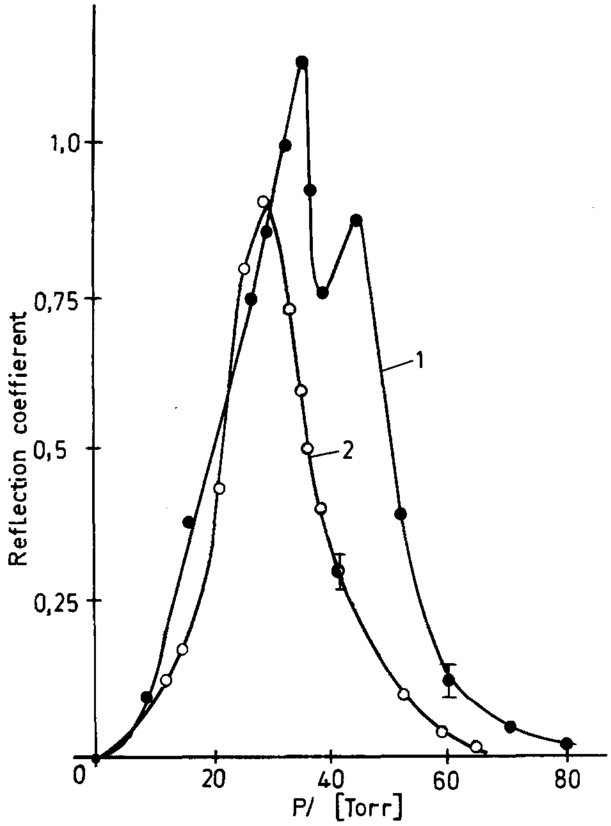


Fig. 2a and b. Reflection-coefficient dependence on $SF_6$ pressure [Torr] at $\lambda = 10.51\,\mu m$ for the $P(12)$ $CO_2$-laser line: (a) $I_p = 6.25\,MW/cm^2$; (b) $I_p = 3\,MW/cm^2$

ed from mirror "7" passed through the ZnSe beam splitter "4" and entered the photodetector "12". The signal obtained corresponded to a 100% reflection. The reflection coefficient for power was measured by a photon-drag detector and that for energy by a photoresistor.

## Results

Experimental studies of the dependence of the reflection coefficient on the pump wavelength for the discussed scheme showed, unlike [4, 5], that the maximum reflection coefficient corresponds to the $P(12)$ output line ($\lambda = 10.51\,\mu m$). It should be noted that for each generating line there is own optimum $SF_6$ pressure.

Figure 2 illustrates the dependence of energy reflection coefficient $R_e$ for the $P(12)$ $CO_2$-line on the $SF_6$ pressure at two different pump intensities $I_p$. For $I_p = 6.25\,MW/cm^2$ (Curve *a*) the maximum energy reflection coefficient is $R_e \simeq 115\%$ and the power one $R_p \simeq 220\%$; they were obtained at a $SF_6$ pressure of $P = 34$ Torr. At $P = 38$ Torr a dip is observed, while at lower pump intensities $I_p = 3\,MW/cm^2$ (Curve *b*) the dip is absent.

The dip appearance is obviously, caused by the competing coherent parametric and noncoherent linear and nonliear processes in a strong pump field. It is interesting that just in this pressure region ($P \simeq 38$ Torr) at $I_p = 6.25\,MW/cm^2$ the pressure dependence of the transmission coefficient for one of the pump waves has a plato. This plato was not observed at $I_p = 3\,MW/cm^2$. The study of the reflection-coefficient dependence on the pump intensity at the fixed pressure of $P = 34$ Torr showed that the growth is faster than quadratic. A similar peculiarity has been observed in [4] when studying nonliear optical phase conjugation for the $P(20)$ $CO_2$-laser line. The study of the dependence of the reflected light power on the probe-wave intensity at the fixed pump intensity $I_p = 6.25\,MW/cm^2$ showed a deviation from linearity at $I_{probe}/I_p > 5 \times 10^{-2}$.

In conclusion, using degenerate resonant four-wave mixing in gaseous molecular media provides, at optimum conditions, an effective amplification of the reflected conjugate radiation.

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