Tunable quantum counter for far-infrared radiation

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(Received 2 August 1976)

We report on a quantum counter which converts far-infrared radiation to visible light. The 891-GHz radiation of an HCN laser, absorbed in optically pumped ruby by the transition $\tilde{E}(E) - 2\tilde{A}(E)$, was detected by an increased $R_2$ fluorescence. By Zeeman splitting of the $\tilde{E}$ levels the narrow-band detector was tuned to the laser line.

PACS numbers: 85.60.Gz

Quantum counting with up-conversion of infrared radiation to visible light has been proposed by Bloembergen and was realized for the near infrared utilizing the energy levels of rare-earth ions in various crystals. Radiation of an $H_2O$ laser at a wavelength of 28 $\mu$m was detected using exciton levels in CdS for quantum-counter action.

We report on the development of a narrow-band tunable quantum counter for far-infrared radiation (FIR) utilizing the energy level system of $Cr^{3+}$ in $Al_2O_3$. The principle of this quantum counter is shown in Fig. 1(a). With the radiation of a suitable lamp the pump bands of ruby are excited, and hence the metastable $R_2$ level which is 29 cm$^{-1}$ above the $\tilde{E}$ level is essentially unpopulated and nearly no $R_2$ light is observed. FIR quanta at 29 cm$^{-1}$ are absorbed by the transition $\tilde{E} - 2\tilde{A}$ and $R_2$ quanta with a wavelength at 6922 $\AA$ are emitted.

Tuning of the detector is obtained by applying a magnetic field parallel to the crystal $c$ axis. The $\tilde{E}$ and $2\tilde{A}$ levels are split with g factors $g_{||}(E) = 2.445$ and $g_{||}(2\tilde{A}) = 1.46$. The splitting of the levels is indicated in the insert of Fig. 2.

In Fig. 1(b), the experimental arrangement is shown. The crystal is aligned with its $c$ axis parallel to the field of a superconducting magnet and is surrounded by liquid helium at 2 K. The 0.05% ruby crystal with a surface of $5 \times 5$ mm and a thickness of 1.5 mm has two 45° side faces for optical coupling of the crystal to fiber optics. As a pump source, a 700-W Hg-Xe lamp is used. The $R_2$ fluorescence radiation separated from the strong $R_1$ radiation by narrow-band interference filters is detected by a cooled RCA C-31034 photomultiplier. The chopped FIR of an HCN laser at a wavelength of 337 $\mu$m is guided to the crystal by a metal tube. The FIR-induced $R_2$ fluorescence radiation is

FIG. 1. Ruby far-infrared quantum counter. (a) Principle: FIR photons are absorbed by the transition $\tilde{E} - 2\tilde{A}$ and lead to additional $R_2$ fluorescence radiation. The $\tilde{E}$ level is populated by radiationless transitions (curly lines) from the ruby absorption bands. (b) Experimental arrangement.
Background suppression in coherent Raman spectroscopy*

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(Received 28 June 1976)

Background signals which appear in Coherent anti-Stokes Raman spectroscopy and in the Raman-induced Kerr effect can be eliminated using polarization techniques based upon four-wave mixing. Specific polarization conditions will suppress all signals with the exception of those arising from Raman modes. The interference between resonant and background contributions is eliminated, and undistorted line shapes are obtained.

PACS numbers: 42.65.Dr, 78.30.Cp

A major advantage of the various techniques of coherent Raman spectroscopy is the ability to suppress the incoherent fluorescence which often obscures the desired spectrum in a spontaneous Raman scattering experiment.1,2 There are, however, two kinds of effects—linear and nonlinear—which lead to background