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ANTICORRELATION EFFECTS IN RAMAN SCATTERING

P.SZLACHETKA and S.KIELICH

Institute of Physics, A.Mickiewicz University, Grunwaldzka 6, 60-780 Poznań (Poland)

J.PEŘINA and V.PEŘINOVÁ

Laboratory of Optics, Palacký University, Leninova 26, 771-46 Olomouc (Czechoslovakia)

ABSTRACT

Photon anticorrelation effects in Raman scattering are considered in the short-time approximation. The existence and magnitude of the anticorrelation effects are discussed in their dependence on the initial statistical properties of the photons and phonons.

INTRODUCTION

The present paper is intended to complete an earlier one (ref. 1) in which we dealt with the dynamics of anticorrelation effects in Raman scattering. Here, we consider the dependence of intermodal anticorrelation effects in Raman scattering due to interaction of photons with chaotic phonons on the statistical properties of the incident beam.

RESULTS

Intermodal photon correlations are defined by the following correlation functions:

$$\langle \Delta W_i \, \Delta W_j \rangle = \langle a_i^+(t) \, a_j^+(t) \, a_i(t) \, a_j(t) \rangle - \langle a_i^+(t) \, a_i(t) \rangle \langle a_j^+(t) \, a_j(t) \rangle \qquad (1)$$

$$i,j=1,s,a.$$

where a_i, a_i^+ are annihilation and creation operators relative to the i-th mode.

Let us evaluate the correlation function for laser and Stokes photons i.e. $\langle \Delta W_l \Delta W_s \rangle$ using the procedure described in our previous paper (ref. 1). If, at the time t=0, the laser and Stokes photons are coherent whereas the anti-Stokes mode is in vacuum state, we have

$$\langle \Delta W_l \Delta W_s \rangle = -|K_s|^2 t^2 n_l n_s (2n_p+1) \tag{2}$$

whereas if the laser mode is initially chaotic we obtain

$$\langle \Delta W_l \Delta W_s \rangle = |K_s|^2 t^2 n_l^2 \{(n_p+n_s+1) - n_l n_s (2n_p+1)\} \tag{3}$$

The symbols n_l, n_s and n_p denoted the average number of bosons at the time t=0 in the laser, Stokes and phonon mode, respectively; K_s in the coupling constants for the Stokes process.

Comparing (2) and (3), we see that an initially chaotic laser mode destroys the anticorrelation effect (2). The functions (2) and (3) convey information about the interaction between the laser and Stokes photons in the presence of stimulated as well as spontaneous Stokes emission. If only spontaneous Stokes emission occurs i.e. if $n_s=0$, we have

$$\langle \Delta W_l \Delta W_s \rangle = 0 \tag{2a}$$

$$\langle \Delta W_l \Delta W_s \rangle = |K_s|^2 t^2 n_l^2 (n_p+1) \tag{3a}$$

Therefore, in the presence of spontaneous Stokes scattering no anticorrelation effect (3) occurs.

Let us now consider interaction between laser and anti-Stokes photons. If the laser and anti-Stokes modes are initially coherent whereas the Stokes mode is in vacuum state, we have

$$\langle \Delta W_l \Delta W_a \rangle = |K_a|^2 t^2 n_l n_a (2n_p + 1) \tag{4}$$

whereas if the laser mode is initially chaotic we obtain

$$\langle \Delta W_1 \Delta W_a \rangle = |K_a|^2 t^2 n_1^2 \left\{ (n_p - n_a) - n_1 n_a (2n_p + 1) \right\} \qquad (5)$$

where K_a is the coupling constant for the anti-Stokes process.

In the presence of stimulated anti-Stokes emission the equations (4) and (5) have the following form:

$$\langle \Delta W_1 \Delta W_a \rangle = 0 \qquad (4a)$$

$$\langle \Delta W_1 \Delta W_a \rangle = |K_a|^2 t^2 n_1^2 n_p \qquad (5a)$$

On comparison of the functions (3) and (5) we may emphasize that in the presence of spontaneous phonon emission i.e. when $n_p = 0$ anticorrelation takes place between laser and anti-Stokes photons whereas correlation occurs between laser and Stokes photons.

Other anticorrelation effects in Raman scattering (for example photon-phonon anticorrelation) have been considered in our paper (ref. 1) in a similar approach.

REFERENCES

1 P.Szlachetka, S.Kielich, J.Peřina and V.Peřinová, J. Phys., 9 (1979) in press.