Quantum Optics, Homework 3

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Interference between Gaussian pulses Consider two Gaussian pulses with wave vectors $\boldsymbol{k}_{1,2} = k(\pm\sin\theta, 0, \cos\theta)$, respectively. They are incident to a plane detector on the surface $z = 0$. The intensity distributions of the two beams are all

$$|\mathcal{E}|^2 \propto e^{-\left(x^2+y^2\right)/\sigma^2}, \tag{1}$$

with $\sigma \gg \lambda$. The pulses arrive at the detector simultaneously. The detector absorbs the pulses completely and there is no reflection. Calculate $P^{(1)}(\boldsymbol{r})$ and $P^{(2)}(\boldsymbol{r}_1, \boldsymbol{r}_2)$ for the following states of the optical field:

(a) $|\psi\rangle = \frac{1}{\sqrt{2^N N!}} \left(a_1^\dagger + a_2^\dagger\right)^N |V\rangle$.

(b) $|\psi\rangle = \frac{1}{N!} \left(a_1^\dagger a_2^\dagger\right)^N |V\rangle$.

(c) $|\psi\rangle = \frac{1}{\sqrt{2N!}} \left(\left(a_1^\dagger\right)^N + \left(a_2^\dagger\right)^N\right) |V\rangle$.

(d) $|\psi\rangle = D_1(\alpha) D_2(\alpha) |V\rangle, \quad D_j(\alpha) \equiv e^{\alpha a_j^\dagger - \alpha^* a_j}$.

(e) $|\psi\rangle = \frac{1}{\sqrt{2}} \left(D_1(\alpha) + D_2(\alpha)\right) |V\rangle$.

Solution

(a)

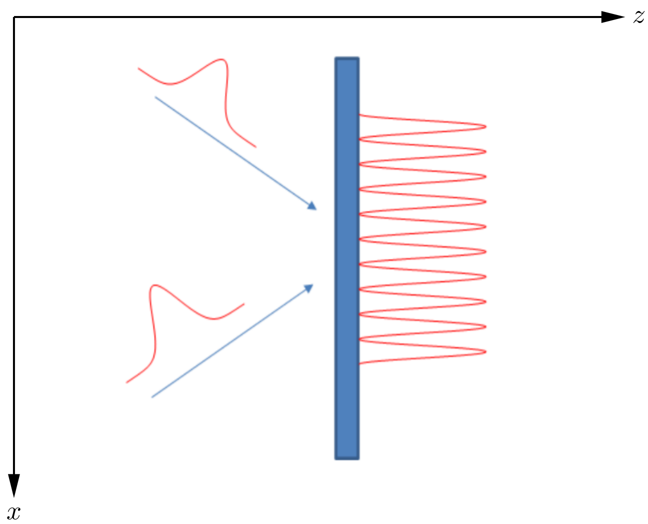

Figure 1: The two Gaussian beams incident to a detector