(5.8) A beam with a photon flux of 1 000 photons s^{-1} is incident on a detector with a quantum efficiency of 20%. If the time interval of the counter is set to 10 s, calculate the average and standard deviation of the photocount number for the following scenarios:

(a) the light has Poissonian statistics;

(b) the light has super-Poissonian statistics with $\Delta n = 2 \times \Delta n_{\text{Poisson}}$;

(c) the light is in a photon number state.

(6.6) Calculate the values of $g^{(2)}(0)$ for a monochromatic light wave with a square wave intensity modulation of $\pm 20\%$.

(6.7) The 632.8 nm line of a neon discharge lamp is Doppler-broadened with a linewidth of 1.5 GHz. Sketch the second-order correlation function $g^{(2)}(\tau)$ for τ in the range 0–1 ns.

(7.6) For the coherent states $|\alpha\rangle$ with $\alpha = 5$, calculate:

(a) the mean photon number;

(b) the standard deviation in the photon number;

(c) the quantum uncertainty in the optical phase.

(7.7) A ruby laser operating at 693 nm emits pulses of energy 1 mJ. Calculate the quantum uncertainty in the phase of the laser light.

(8.5) For the coherent state $|\alpha\rangle$ with $\alpha = |\alpha|e^{i\phi}$, show that $\langle\alpha|\hat{X}_1|\alpha\rangle = |\alpha|\cos\phi$, and $\langle\alpha|\hat{X}_2|\alpha\rangle = |\alpha|\sin\phi$. Show further that $\Delta X_1 = \Delta X_2 = 1/2$.

(8.6) Prove that for two coherent states $|\alpha\rangle$ and $|\beta\rangle$,

$$|\langle\alpha|\beta\rangle|^2 = \exp(-|\alpha - \beta|^2).$$