University of Calgary
Fall semester 2008

PHYS 673: Quantum and Nonlinear Optics

Second midterm examination

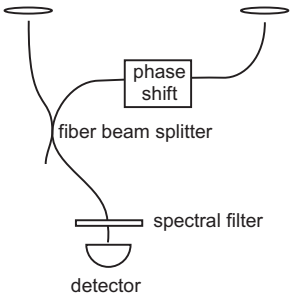
November 6, 2008

Open books. Attempt all problems. Partial credit will be given.

Problem 1. Light from a star is coupled into single-mode fibers at two separate locations on the Earth surface, defined by radius vectors $\vec{r}_1$, $\vec{r}_2$. Interference is observed as shown in the figure. The star is at its zenith, its distance from the Earth is L. Assume the star to be a white disk with a Gaussian intensity distribution, w being its $1/e$ intensity radius. Neglect the atmosphere effects.

a) Write the visibility of the interference fringes as a function of $\vec{r}_1$, $\vec{r}_2$ assuming that the spectral filter is narrow enough to ensure a high degree of temporal coherence (35 pts).

b) Make a very rough estimate of the required spectral filter bandwidth (10 pts).



Problem 2.

a) The squeezing Hamiltonian $\hat{H} = i\beta[\hat{a}^2 - (\hat{a}^\dagger)^2]$ is applied to the single-photon state for a short time ($\beta t \ll 1$). Find the photon number decomposition of the resulting state $|\psi\rangle$ up to $n = 3$. **Hint:** Use the Taylor expansion of $\exp(-i\hat{H}t)$ to the first order (25 pts).

b) Determine the photon number decomposition of the odd Schrödinger cat state $|\phi\rangle = \mathcal{N}(|\alpha\rangle - |-\alpha\rangle)$ for small α up to $n = 3$. Don't forget to find the norm $\mathcal{N}$ (25 pts).

c) What is the relation between α and βt such that $|\psi\rangle$ approximates $|\phi\rangle$ (5 pts)?