Statistical Optics and Image Formation

Homework Set 2 **Due: Nov. 22, 2019**

1. **<u>Reduction of Degree of Coherence</u> (30%)**

   Define the degree of coherence for two points on an optical field as $\gamma_{12}(\vec{a}, \tau)$; the two points are separated laterally by a distance $\vec{a}$ and longitudinally by a time τ. Under what conditions will this degree of coherence be expressed a product of the spatial and temporal degrees of coherence like $\gamma(\vec{a}, \tau) = \gamma_{\perp}(\vec{a}) \cdot \gamma_{\|}(\tau)$.

2. **<u>Power spectrum of a random process</u> (30%)**

   Consider a random process $X(t) = a \cdot e^{j(\Omega t - \Phi)}$, where a denotes a fixed amplitude, and Ω is the frequency of the random variable with a probability density function $p_{\Omega}(\omega)$. The phase delay Φ is also a random variable which is independent of Ω and uniform in the interval $(-\pi, \pi)$. Is *X(t)* a wide-sense stationary with zero mean? If your answer is yes, find its power spectrum.

3. **<u>Young's double-slit experiments (40%)</u>**

   Explore Young's double-slit experiments with matlab scripts for the following possible scenarios: The apertures on the sampling screen are 0.5 mm radius separated by 5 mm positioned at 30cm behind a light source. The resulting two interfering light beams could be longitudinally shifted with a time delay τ. The light source can be a) a monochromatic (λ_0=600 nm) point light source, b) a point source with a finite spectral bandwidth of Gaussian profile (λ_0=600 nm and $\Delta\lambda_{FWHM}$=60 nm), and c) a quasi-monochromatic (λ_0=650 nm and $\Delta\lambda_{FWHM}$=5 nm) circularly shaped coherent light source with a diameter of *d*=1mm. Present the major results from your numerical exploration. Based on your findings, make a conclusion to summarize your findings.