Problems for QO course.

1. Give an example of a non-stationary random process
2. Give an example of a non-ergodic random process
3. What will be the shape of the spectrum for light from a broadband source after passing through a monochromator with a narrow slit?
4. A broken diode laser emits two spectral lines, both with Gaussian shapes and the same width 0.1 nm. What will be the shape of the first-order correlation function?
5. What shape has the first-order correlation function for light with a rectangular spectrum? With a triangular spectrum?
6. What, approximately, is the coherence time of the sunlight?
7. What is the coherence radius (transverse coherence length) for the sunlight? (The Sun, as seen from the Earth, has angular size of approximately 1°.)
8. Find the coherence volume for a laser pointer emitting into a bandwidth of 10 nm around 650 nm. The beam has a diameter of 3 mm and a diffraction divergence (Why does it matter?) At what power will the laser pointer have a single photon in the coherence volume?
9. Thermal light with a Lorentzian spectrum of 1 nm width is fed into a Michelson interferometer. What will be the interference pattern if one of the mirrors is scanned?
10. What will be the shape of the second-order CF for this light measured in a HBT interferometer?
11. Find the mean intensity and the variance for the negative-exponential distribution $p(I) = \frac{1}{I_0}\exp\{-\frac{I}{I_0}\}$.
12. Find normalized second- and third-order correlation functions at zero time delay for this distribution.
13. Calculate the photon-number variance and mean for a coherent state and for a Fock state.
14. Calculate the bunching parameter for both these states.
15. Calculate k-th-order normalized CF for both these states.
16. Given a superposition of Fock states $|\Psi\rangle = |0\rangle + c|3\rangle$,
    (a) make it normalized;
    (b) find its mean photon number and the photon-number variance;
    (c) find its second-, third- and fourth-order normalized CFs at zero time and space delay, $g^{(2,3,4)}(0,0)$.
17. Linearly polarized radiation of a He-Ne laser with the spectral width 20 MHz is sent into a Mach-Zehnder interferometer. In one of the arms there is a lossless HWP, which turns the polarization by 90°. What should be the path length difference for the output light to be unpolarised in the second order in the field?
18. What should be the thickness of a quartz plate oriented at 45° to the vertical direction, in order to turn horizontally polarized light of Ti-Sa laser with the wavelength 800 nm and pulse duration 100 fs (Fourier-limited) into
    (a) vertically polarized;
    (b) Unpolarized. Assume the birefringence of quartz to be 0.01.
19. How can one make a $\frac{\lambda}{6}$ plate out of $\frac{\lambda}{2}$ and $\frac{\lambda}{3}$ plates?

20. There are QWPs for the radiation of YAG:Nd laser with the wavelength 1064 nm. Will two such plates work like one HWP? Will a single such plate work as a HWP for the second harmonic of the same laser?
21. Two orthogonally polarized monochromatic beams pass through similar phase plates and then are overlapped on a screen. Will there be interference?
22. How can one measure S_1?
23. How can one measure S_1+S_2? (In a single measurement, not first S_1 and then S_2.)
24. Prove the identity $S_0^2 =:S_0^2:+S_0$.
25. Calculate the commutator $[\mathbf{S}^2,S_1]$.
26. Find $\langle a^2\rangle$ for faint squeezed vacuum with the state $|0\rangle+c|2\rangle$, $c<<1$.
27. How can one measure an arbitrary quadrature of the field?

28. What kind of nonlinearity a medium should have to allow direct three-photon light generation? Write the Hamiltonian.
29. What physical values are measured for testing the Bell inequality in the CHSH form?
30. Write the Bogolyubov transformations for non-degenerate OPA. Show that they preserve commutation relations.