

[Answer in Finnish, Swedish or English]

1. Explain **briefly**:
 - A) Babinet's principle
 - B) Surface plasmon polariton
 - C) Homogeneous and inhomogeneous line broadening
 - D) Rayleigh scattering
2. Two stars have an angular separation of 10^{-6} radian. They both emit light of wavelength 577 nm and 579 nm.
 - a) How large a diameter of the lens in the telescope is needed to separate the images of the two stars?
 - b) How large a diffraction grating is needed to separate the two wavelengths present in the light?
3. Consider a gas of two-level atoms interacting with resonant light of frequency ν . What are the processes you should take into account in the interaction?

Derive the steady-state value for the absorption coefficient

$$\alpha = -\sigma(N_2 - N_1),$$

where σ denotes the cross-section for stimulated transitions [$B\rho(\nu) = \sigma I/h\nu$] and N_2 and N_1 are the population densities of the upper and lower level, respectively. The intensity of the light is I , and the number density of atoms, $N = N_1 + N_2$, is constant. Write your answer in the form

$$\alpha = \frac{\alpha_0}{1 + I/I_s},$$

and identify the constants α_0 and I_s . Sketch α as a function of I and interpret the result.

4. What is optical activity? Which types of materials show optical activity? Consider light polarized in the x direction and propagating in the z direction. It goes through a material that is optically active and has a thickness of L . Show that the polarization state of the light after the material is still linear, but it has been rotated. By how much?
5. Newton's rings are formed between a spherical lens and an optical flat. If the tenth bright ring of light at 500 nm is 2.89 mm in diameter, what is the radius of the curvature of the lens surface?

