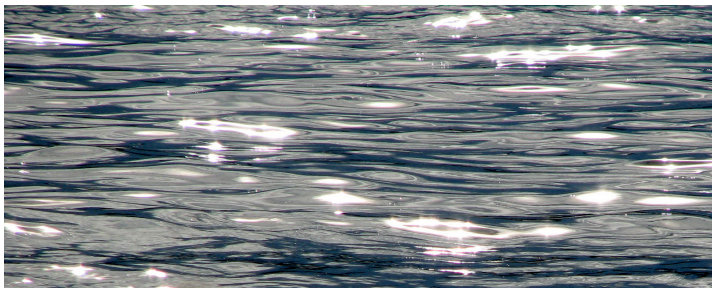

Oblig 1 – The nature of light

The parts marked with an asterisk * are intended to challenge your understanding a bit, just so you are warned, but they are not difficult :-)

Problem 1 – Light rays

a) Our modelling of light relies on several assumptions which we do not always state explicitly. We normally take for granted that when two light rays intersect, for example two crossing laser beams, then one ray does not affect the other. What is the underlying assumption that must hold to ensure that rays do not interact?
b) Consider the image of waves on the sea above, with bright reflections of the sun. Explain how these reflections arise in terms of Fermat's principle and in terms of the local shape of the sea surface.
c) * Is it possible for one of these sea reflections to subtend a larger solid angle than the sun seen from the same observation point, or is it not? Why?

Problem 2 – Polarization

A beam of linearly polarized light with flux (power) φ_0 is propagating in the z direction with the electric field oriented along the x axis. A polarizer is inserted into the beam. The polarizer only passes a component of the field that is oriented at an angle θ to the x axis ($0 \leq \theta \leq \pi$).
a) Calculate the flux of the transmitted beam as a function of θ.
b) Assume that the polarizer is fixed at the angle where the transmitted beam is zero. Now let another polarizer be placed in the beam before the fixed polarizer, oriented at an angle θ'. Calculate the flux transmitted through the two polarizers as a function of θ'.
c) * It may seem strange that inserting an extra polarizer can "help" a part of the beam energy to pass the polarizer that was blocking the beam. How can we understand the result in terms of small oscillating dipoles in the polarizers?

Problem 3 – Optics of the sunset

Consider a fish swimming in the sea at a depth of 1 m on a sunny day. Assume that the sea surface is perfectly flat with no waves, and that the refractive index of the water is 1.33. Consider the movement of the sun over the sky from directly overhead (zenith, normal incidence) to the horizon. Assume first that the sun is an unpolarized point source with apparent intensity I_0 when viewed above the water.
a) Make a graph of the angle of arrival of the sunlight, as seen from the fish, as a function of solar angle of incidence on the surface, from zenith to the horizon.
b) Make a graph of the intensity of the sun, as seen from the fish, as a function of solar angle.
c) Make a graph of the "degree of linear polarization" of the sunlight reaching the fish, defined as

$$DOLP = \frac{|\, I_s - I_p \,|}{I_s + I_p}$$

where I_s and I_p are the intensities of s- and p-polarized light after transmission through the surface
d) * Now consider the sun as an extended source with an angular diameter of 0.5 degrees seen from above the water surface. Make graphs of the apparent angular width of the sun, seen from the fish, in the elevation (angle of incidence) and azimuth (parallel to the horizon) directions, for solar positions from zenith and until bottom of the solar disc is at the horizon.
e) * The surface of the sun approximates a 5800 K blackbody spectrum quite well, but the spectrum of light reaching the fish is very different. What phenomena must be taken into account to give a proper description of the spectrum of light reaching the fish? Can you describe this spectrum, at least qualitiatively?
e) * For an observer above water, the refractive index of air causes a time shift of the apparent sunset away from the time where the sun should set according to the orientation of earth relative to the sun. Make an order-of-magnitude estimate of this time shift. Choose yourself what approximations to make, and look up the data you need.

Hecht problem 4.19 (Beam diameter)

Solve this problem using your best judgement.
* What is the problem with the formulation of this problem in the book?

Hecht problem 4.34 (Lateral offset of a refracted ray)

Hecht problem 4.35 (Angle of ray emerging from a refracting stack)

*** Ekstraoppgave for de som tar mastergradsversjon av kurset, TEK4010

Bestem tema for særoppgaven i kurset, i samråd med Torbjørn (torbjorn.skauli@ffi.no). Omfang av oppgaven er antydningsvis 3 til 10 sider. Tema kan gjerne være relatert til masteroppgaven, eller til et tema du er interessert i. Oppgaven teller 15% av karakteren, og du kan få spørsmål i tilknytning til oppgaven på eksamen.