Modern Optics 2009 — Homework 3

Due Wednesday, 5:30 p.m., February 18, 2009

1. Consider the Gires–Tournois interferometer. (a) As explained in the text, the reflectivity is $R = \text{constant} = 1$, while the phase shows a strong variation with frequency. Does this violate the Kramers–Kronig relation? Explain your answer. (b) Derive the transfer functionEq. (2-30).

2. Consider the 3-mirror ring resonator sketched in Fig. 1. Two of the mirrors are flat and 100% reflecting, while one mirror of field reflectivity $r = 0.9999\%$ and 60 cm curvature, serves as input and output of this resonator. We are operating at a wavelength of 800 nm. The perimeter of the ring is 60 cm. A beam with a train of pulses, of average incident power of P_0 = 1 mW is sent, properly aligned, into the input path of this resonator.

   (a) Derive an expression for the field inside the resonator E_i as a function of the input field E_0.

   (b) Consider this passive cavity being irradiated from the outside by a train of femtosecond pulses, for its use as a photon storage ring. Show that two conditions need to be fulfilled for this cavity to be exactly resonant, which may not always be simultaneously met.

   (c) Let us assume next that the train of pulses, with a wavelength near 800 nm, corresponds to exactly a "resonance" of this resonator, both in frequency and repetition rate. A fast electro-optic switch is included in the ring, such that it directs the electromagnetic wave out of the resonator for a round-trip time of the cavity, every N round-trip times (cavity dumping). The switch opens in a time short compared to the round-trip time. Explain how this device can be used to create short output pulses with a larger single-pulse energy than the incident pulses. What energy could be obtained in the case of (i) $N = 100$ and (ii) $N = 5000$.

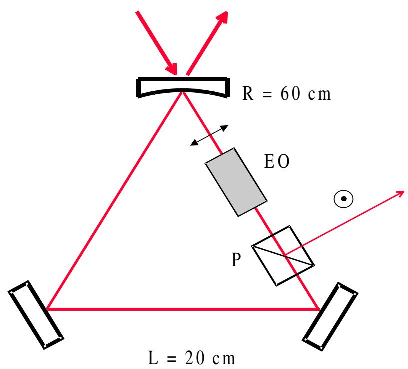

Figure 1: Ring resonator. Consider the electro-optic switch (EO, Pockel's cell) and the polarizing beam splitter only for part (d). The polarization of the beam circulating in the cavity gets rotated from the plane of the ring into the orthogonal direction when an electrical pulse is applied to the Pockel's cell, and extracted from the cavity by a polarizing beam splitter. The risetime of the electrical pulse is short compared to the cavity round-trip time.