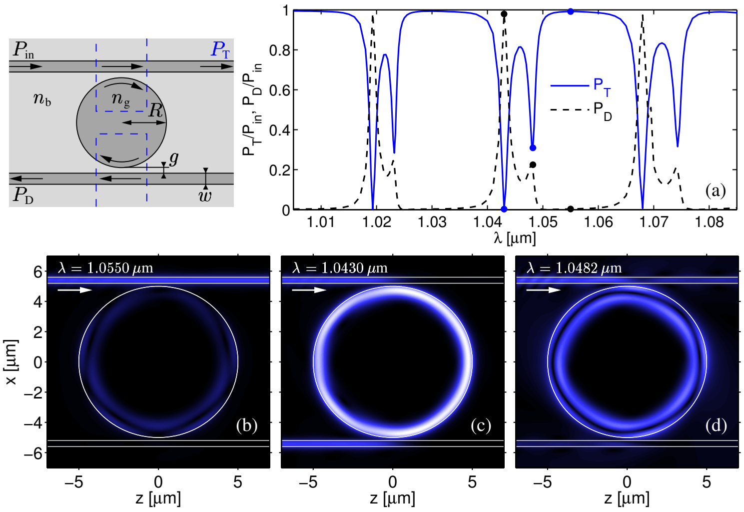
MSc Project TW/EL/TN 25.05.2005

Time domain resonances of circular integrated optical microresonators

Candidate: — requested —
Supervisors: Manfred Hammer, Brenny van Groesen, Department of Applied Mathematics, AAMP group
Time: To be started as soon as possible.



A circular dielectric cavity is evanescently coupled to two parallel straight waveguides. If guided light waves are inserted into one of the channels, the transmission properties of the device depend strongly on the wavelength λ, i.e. the color of the incoming light. For suitable parameters, on observes pronounced resonances where a substantial part of the input power is transferred to the so called drop port (peaks in $P_{\rm D}$), while off-resonance most of the optical power arrives at the through port ($P_{\rm T} \approx 1$).

Besides several other applications, such devices can be employed as versatile and quite compact wavelength filter elements in optical telecommunication systems. In our group we could recently establish a quite successful frequency domain model for these microresonators, see e.g. the paper [1]. By that approach, however, we are unable to characterize directly the wavelengths (or frequencies), at which the device exhibits its resonances. Thus we propose to address the following topics and questions:

- An analytical formalism should be established and implemented, that permits to identify the complex resonance frequencies associated with isolated circular dielectric cavities in two spatial dimensions, and to compute the related electromagnetic field profiles. An ansatz based on complex Bessel and Hankel functions will lead to a complex eigenvalue problem [2].
- Once the resonance frequencies and associated mode profiles for a specific device are at hand, one can consider what happens if the structure is perturbed. Perturbations of different kinds are of interest:
  - Small changes of the permittivity that constitutes the dielectric cavity; one expects that the resonance frequencies are slightly shifted. Can an (approximate) analytical relation be found that allows to express the shift of the resonances as a function of the perturbation?
  - If (as in the figure above) waveguides are placed beside the cavity and optical power is fed into the structure by evanescent coupling, is it possible to establish a model for the interaction of the optical waves in the different parts of the structure, based on the time-domain modes?

Probably the thorough investigation of these questions goes far beyond a MSc project of half a year, but we shall see how far we can come . . .

If you have some background in the concepts of optical waveguides (or think that you could find them interesting), if you know how to operate a C/C++ compiler or a simulation environment like MATLAB, and if you are interested in a modeling task that is located somewhere between Applied Mathematics, Applied Physics, and Electrical Engineering, you are invited to contact

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for further information.

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[1]: K. R. Hiremath, R. Stoffer, M. Hammer, *Modeling of circular integrated optical microresonators by 2-D frequency domain coupled mode theory*, Optics Communications (submitted, 2005)

[2]: L. Prkna, J. Čtyroký, M. Hubalek, *Ring microresonator as a photonic structure with complex eigenfrequency*, Optical and Quantum Electronics **36**(1-3), 259-269 (2004).