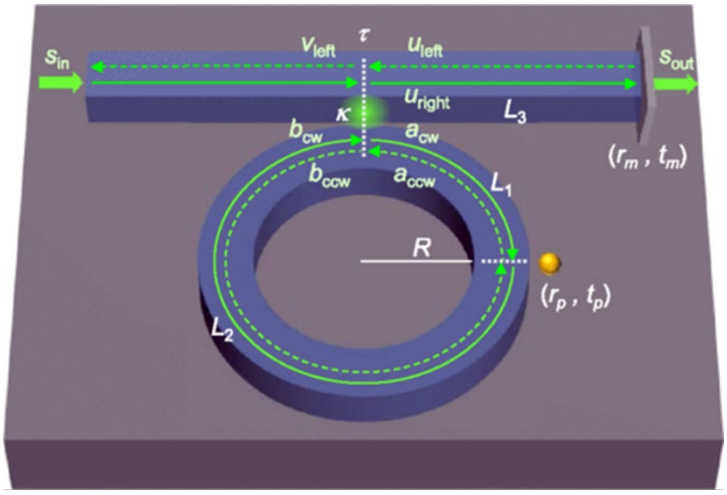
# Master assignments 2

**Sensing with enhanced sensitivity near the exceptional point**

For integrated optical sensing applications resonant cavities such as micro ring resonators are a common solution. A small perturbation to the environment shifts the resonance position of the cavity which can be observed by scanning a tunable laser over the resonance continuously thereby recording the transmission spectrum as a function of time. As the interest to measure smaller and smaller perturbations increases, these sensors run into the problem that temperature noise sources start to dominate limiting the achievable limit of detection. In principle this could be solved by increasing the sensitivity of the resonator to the given perturbation, it can however be shown that this similarly increase the sensitivity to the temperature noise, fundamentally limiting the sensor performance. A possible solution would be to make use of the resonance splitting of conjugate eigenmodes of the system. This can be done by introducing a scattering object, in our case a grating as they can be reproducibly fabricated, in the cavity. The resulting mode splitting is in first order independent of temperature while the grating response and thus the splitting can be modulated chemically to introduce sensitivity to the analyte of interest. A major disadvantage of this approach is the reduced sensitivity of the system. By introducing asymmetry to the system, this sensitivity can be significantly improved around the “exceptional point”. Your assignment will be to design and fabricate and characterize these devices. In this assignment you will use photolithography and Ebeam fabrication techniques along with reactive ion etching. Once the devices are fabricated they will be tested in our optical lab using our characterization setups with, tunable laser, pump lasers, optical spectrum analyzers, automated alignment stages and many more.




| Sensitivity | |
|---|---|
| Exceptional point | Diabolic point |
| $S \sim \Delta\omega = 2\sqrt{r\alpha\lvert\kappa\rvert^2}$ | $S \sim \Delta\omega = 2\sqrt{\lvert r\rvert^2}$ |

Figure 2. Schematic representation of a ring resonator with introduced asymmetry between the clockwise and counter clockwise mode resulting in a exceptional “surface” which can be exploited to exhibit enhanced sensitivity to a introduced scattering perturbation on the resonator.

For this project a previous student prepared simulations and prepared a mask allowing you to hit the ground running and maybe even get a second iteration in.