Analysis of Molecular Transformations and Light Manipulation with Optical Microresonators
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Optical Microcavities
- High-Q whispering gallery modes (WGMs) (Q~10^6).
- Highly sensitive to refractive index (polarizability) perturbations.
- Evanescent field probing of ultra-thin molecular layers.
- Sensitive to molecular binding events and changes within the structure of immobilized molecules.
- Binding events and conformational changes conveyed as shift in resonant frequency of WGMs.

Bacteriorhodopsin
- Model biological membrane system.
- Known 3D structure. Highly oriented, optically anisotropic system. Large polarizability changes upon isomerization.
- Self-assembles as a monolayer.
- Technologically important biological photochrome. Applications in photonics and optoelectronics.
- Shares structure with G-protein coupled receptors.

Trans-cis isomerization and orientation of the retinal
- Photoinduced all-trans to 13-cis isomerization of the chromophore retinal monitored off-resonance with a 1,310nm probe.
- Novel pump-probe spectroscopy tool.
- Direct measurements of polarizabilities of molecules in complex proteo-lipid environments.
- Average retinal polarizability change:
  \[ \langle \Delta \alpha_{\text{mol}} \rangle = \frac{1}{2} \langle \Delta \alpha \rangle_{\text{mol}} + 2 \langle \Delta \sigma \rangle_{\text{mol}} \approx 0.384 \text{ a.u.} \]
- Direct orientation measurements of molecular self assembles TE/TM resonant shift:
  \[ \Delta \lambda \approx \frac{1}{2} \left( 1 + \cos^2 \theta \right) - 10 \left( \sin \theta \right) - 6 \theta \]

All-optical switching in the near-infrared
- All-optical resonant coupler.
- Optical functionality provided by ultra-thin molecular layer.
- Operation at frequencies far from bR molecular transitions.
- Full-linewidth shift achieved by multiple bR layering (bR/PDAC).
- Switching speed limited by the speed of the photochromic transitions (~50µs).
- Faster all-optical switching at arbitrary optical frequencies with molecular monolayers is possible.