Guided Dipolar Exciton Polaritons

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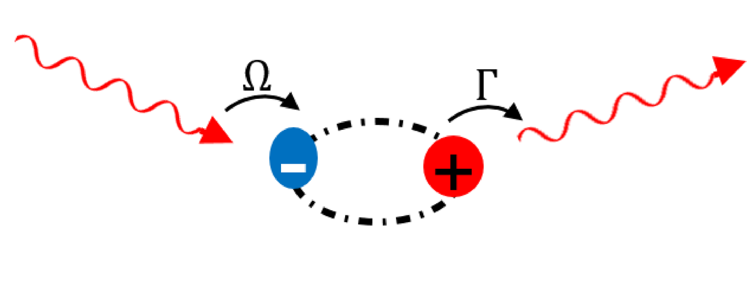
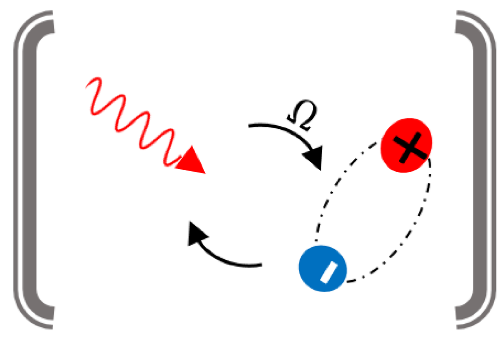
Exciton Polariton

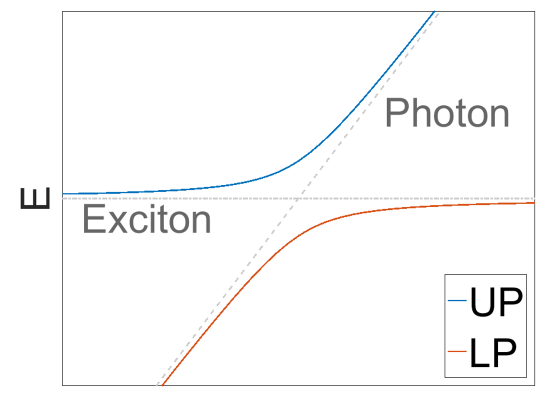
- Quasi-particles formed by strong coupling between **confined photons** and **excitons in quantum wells**.



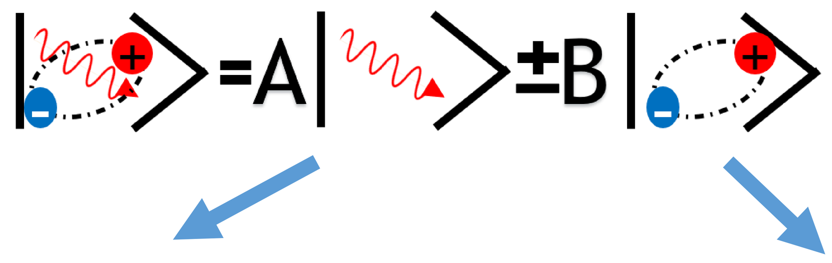
Free space exciton



Confined in cavity



Admixture of Light and Matter

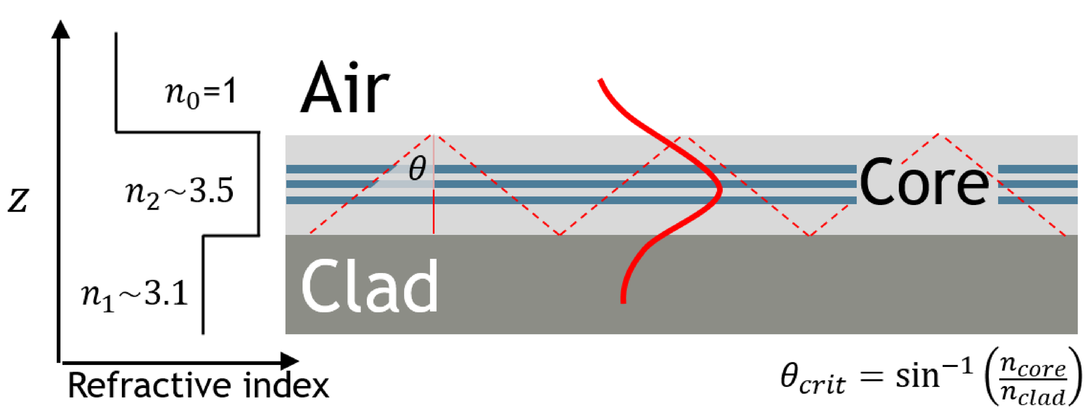


- Very small effective mass
- Very high group velocity
- Collective phenomena at high T

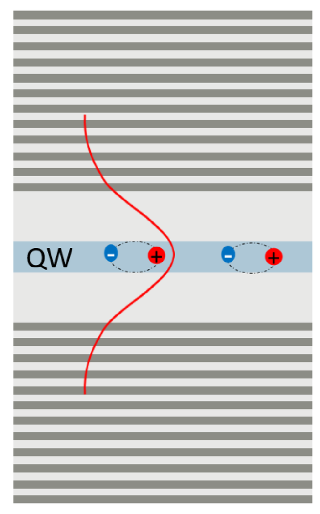
- Particle – particle interactions
- Interaction with external fields
- Nonlinear devices

Polaritons in Waveguides

- QWs embedded inside a waveguide core
- Photons confined by total internal reflection
- Easy access to the polaritons (optically and electrically)



$\theta_{crit} = \sin^{-1}\left(\frac{n_{core}}{n_{clad}}\right)$



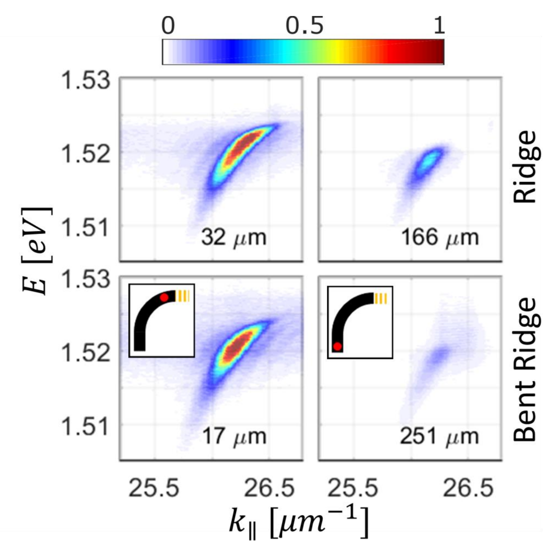
Illustrations of a waveguide and a microcavity

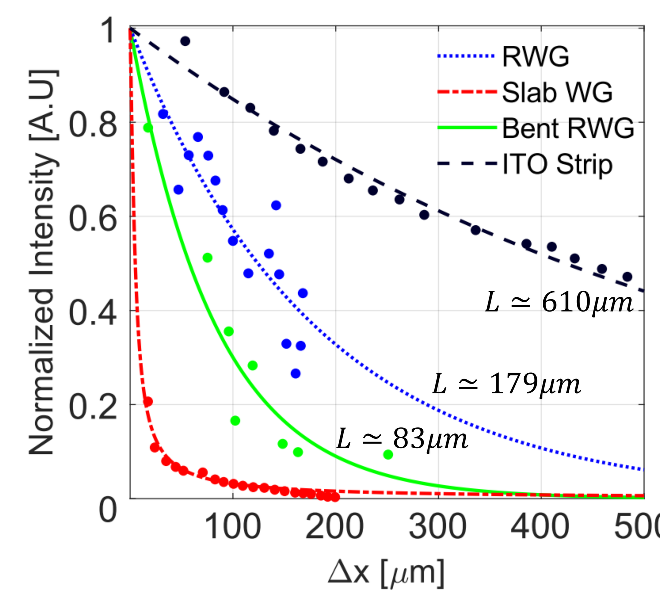
Propagation

- Evidence of **guided polaritons!**
- Polaritons propagating along **curved trajectories**
- **Recorded high propagation length.**

PL measurements of the dispersion, bottom line shows the signal from the bent ridge sample, proof for the full guiding.

Insets shows point of excitation on the curved trajectory,





Compression of the propagation distance in the different geometries.

- *While there is no lateral confinement (Slab WG) we expect the decay to be $\propto \tan^{-1}\left(\frac{w}{2\Delta x}\right)$, because of the spatial dependence.*
- *With lateral confinement we expect exponential decay $\propto \exp\left(-\frac{\Delta x}{L}\right)$*

Electrical Control

- Tunable exciton and polariton energy
- Dipolar interactions
- *Longer range and stronger interactions*

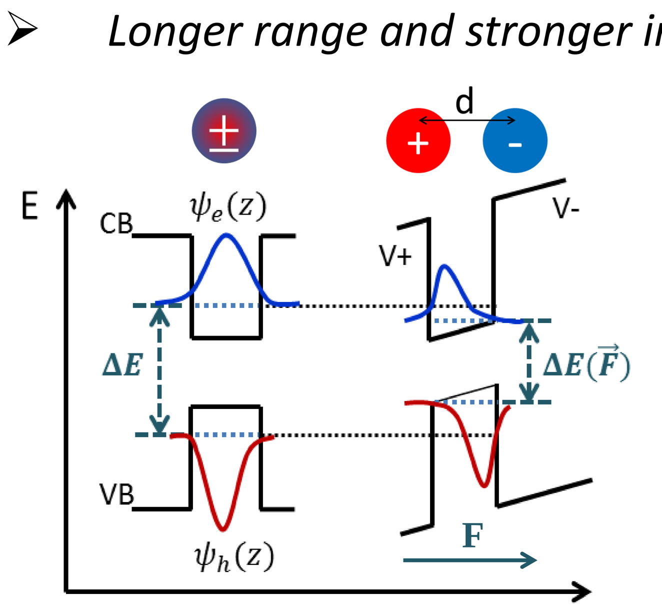
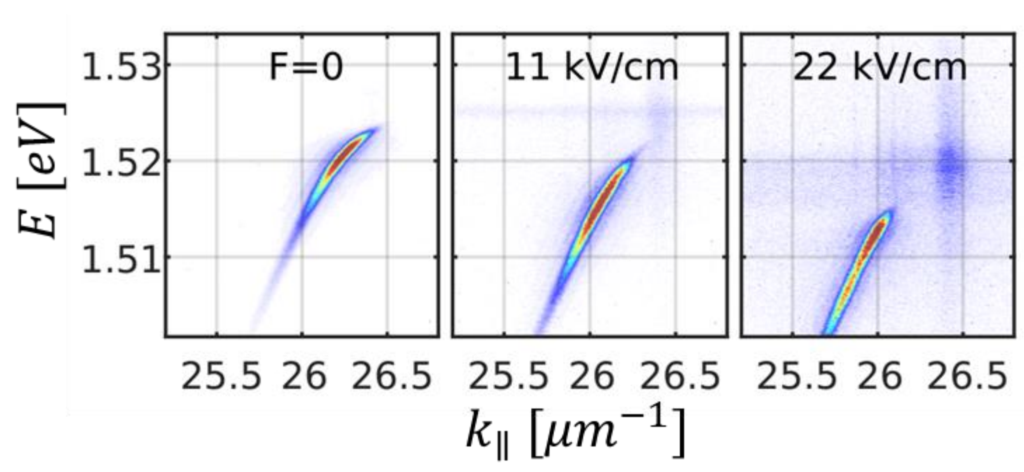


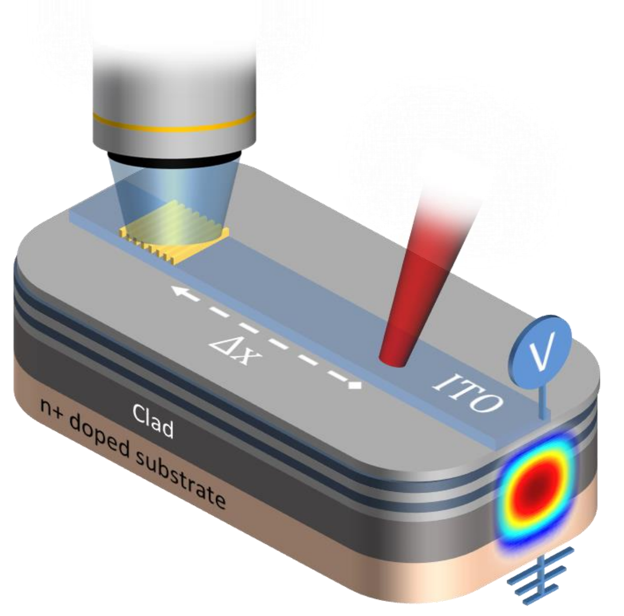
Illustration of the QW potential and the exciton dipole, with and without electric field.

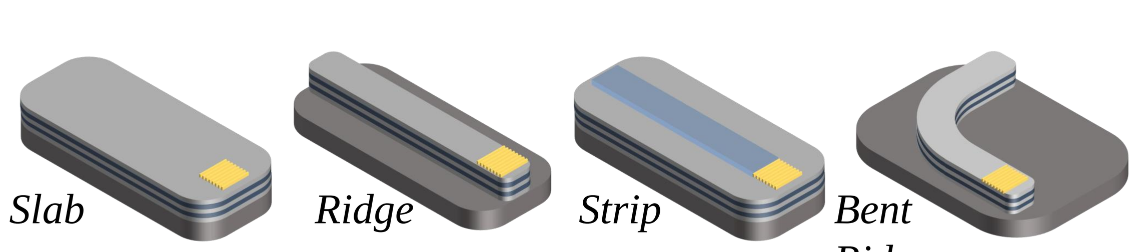


Measured dispersion under three different fields. The exciton and the entire polariton branch undergo a redshift as the field intensity grows.

The Experiment

Illustration of our excitation scheme . A non-resonant laser excitation on the sample surface at a distance Δx from the grating creates polaritons which propagate along the channel and couple out through the grating coupler.



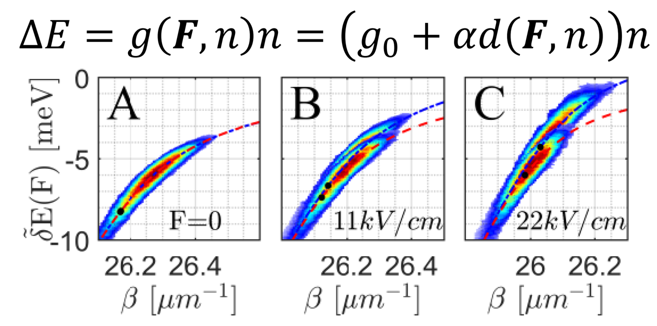


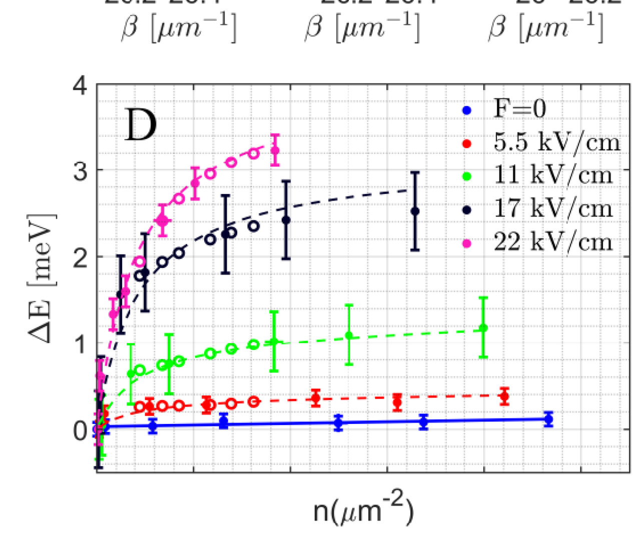
Illustrations of the different geometries

Interactions

- Dipolar interactions
- Electrically **controlled interactions**
- **Enhanced interactions**

$\Delta E = g(\boldsymbol{F},n)n = \left(g_0 + \alpha d(\boldsymbol{F},n)\right)n$





Power scan measurements:

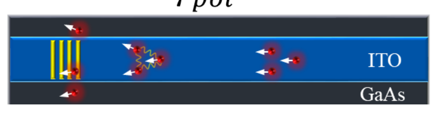
By exciting the sample with various pump powers, different polariton densities emerge.

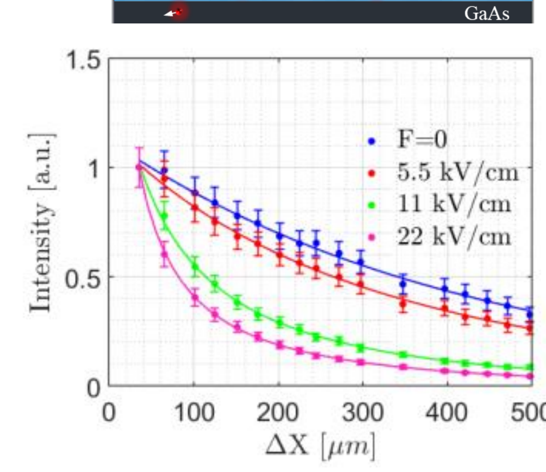
(A-C) PL measurements at different densities . The red line follows the low density polaritons, The blue line follows the high density polaritons.

The energies are plotted relative to the bare exciton energy.

(D) Blueshift of the polaritons vs. the density at various electric fields. Using F=0, $g_0 = 18 \pm 8 \mu eV\ \mu m^2$ is calculated

$$n(x) = \frac{e^{-x/L}}{n_0^{-1} + \frac{\gamma_{col}}{\gamma_{pol}}\left(1 - e^{-x/L}\right)}$$



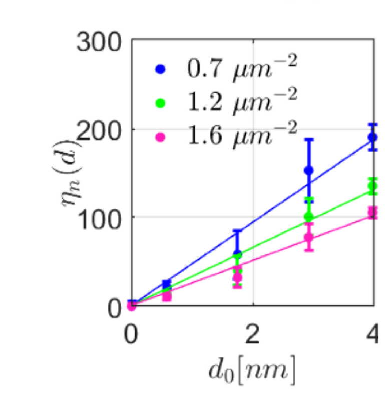


Position scan measurements:

The polariton density that reaches the grating, varies with the propagation distance. This is achieved by scanning the excitation distance relative to the grating.

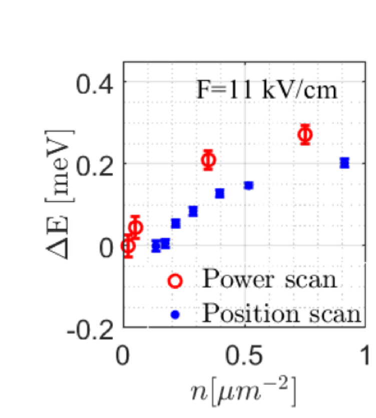
The density decreases as the distance grows because of inter-particle collisions.

$$\eta_n(d_0) = \frac{\alpha d(n)}{g_0}$$



Interaction enhancement factor $\eta_n(d)$ as a function of d_0.

The enhancement is almost up to 200-fold.



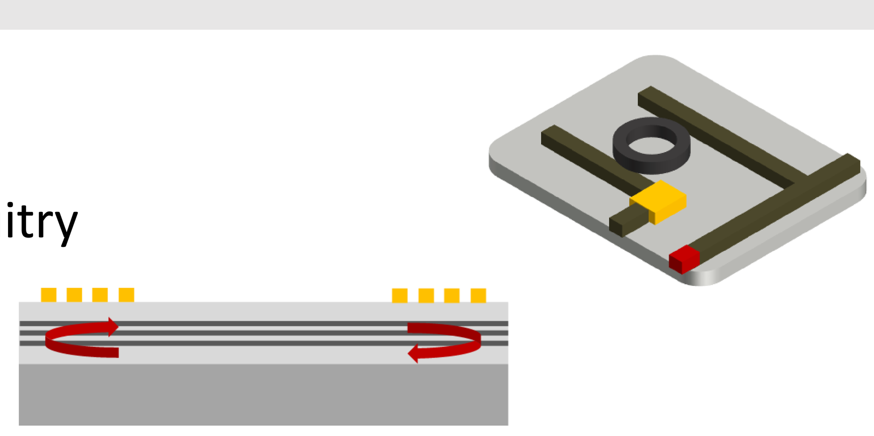
***Comparison** between the energy shift measured by the power scan and the position scan.*

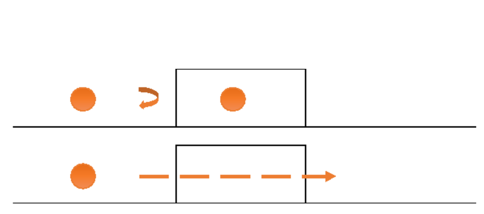
The similarity between the two experiments suggests that the measured blueshifts results from local interactions.

Summary and Outlook

- ✓ **Fully guided** polaritons
  - ✓ *Curved trajectories*
  - ✓ *Near mm propagation length*
- ✓ **Very high** and controlled **interactions**

- Creating a complex polaritonic circuitry
- Building blocks:
  - ❑ *Waveguide cavity*
  - ❑ *Two-polariton interactions*
  - ❑ *Polariton blockade in a waveguide*





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