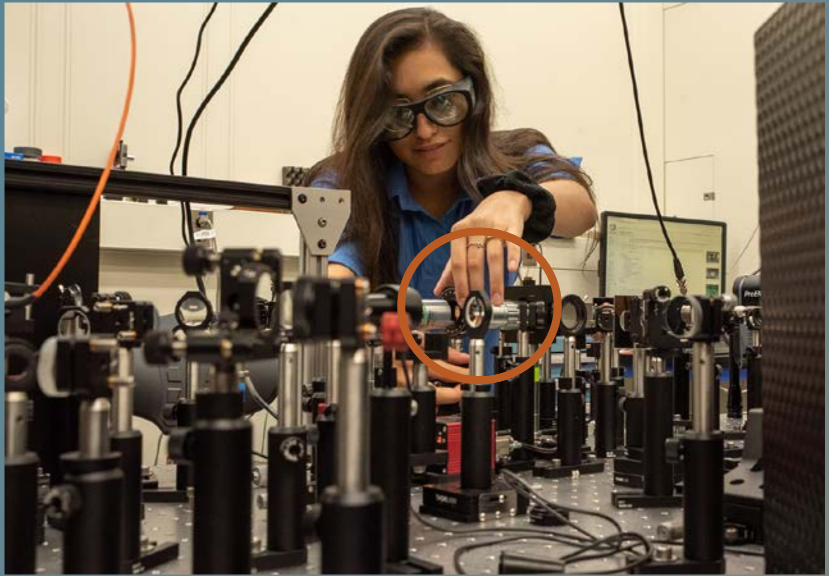
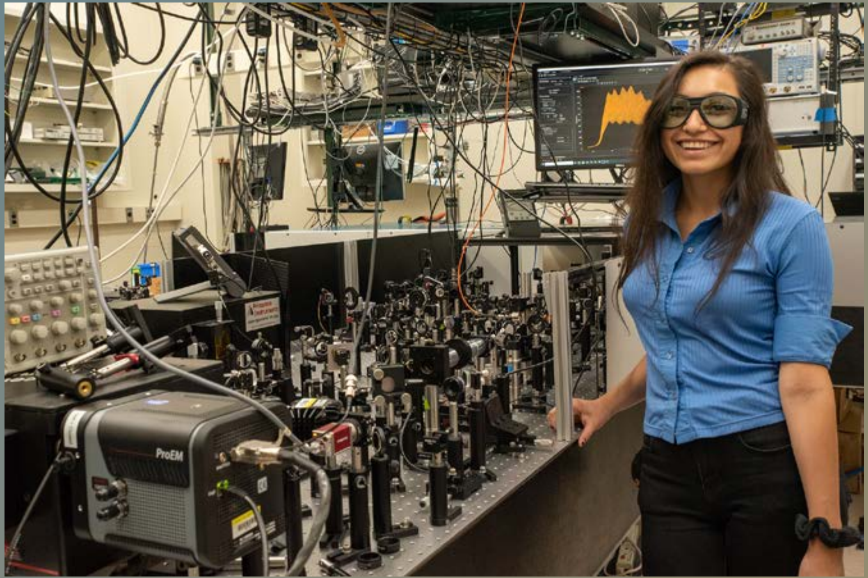
By: Valeria Viteri-Pflucker

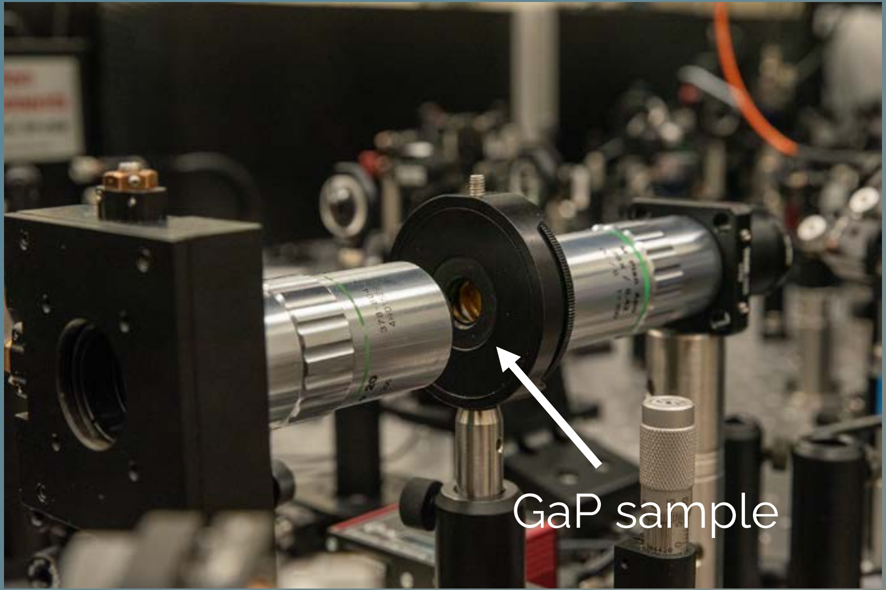
With: Jared Wahlstrand, Chad Cruz

PRECISE MEASUREMENTS of OPTICAL KERR EFFECT and TWO-PHOTON ABSORPTION in GALLIUM PHOSPHIDE





In the Lab



New experimental set up

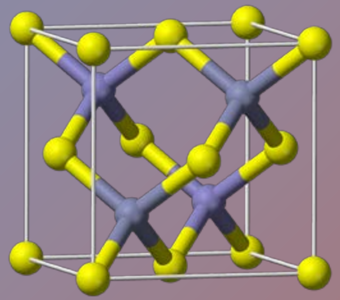
- Testing feasibility

Use GaP as first test material

- Integrated photonics

In the Lab ⟶ On a Chip

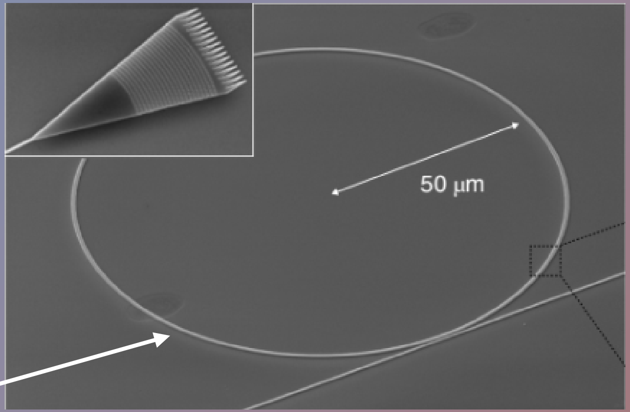
GALLIUM PHOSPHIDE



attributes

- Indirect band-gap (2.4 eV) semiconductor
- High refractive index (> 3)
- Transparent from visible to long-infrared
- Large $\chi^{(2)}$ and $\chi^{(3)}$ coefficients

Citation: [1] Wilson *et. Al.* Nat. Photonics (2020).



GaP ring resonator

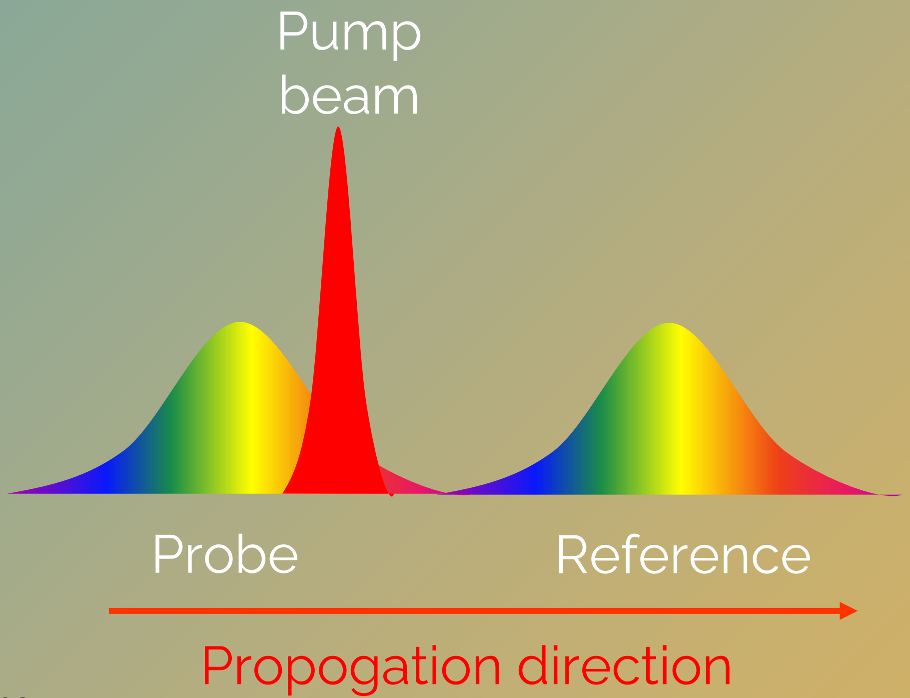
applications

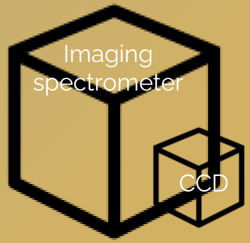
- Integrated photonics
- More nonlinearity, bigger toolbox

Coming up next …

- Set up spectroscopy experiment
- Perform derivations mapping data to final values
- Write Julia code to process data

WHAT I DID





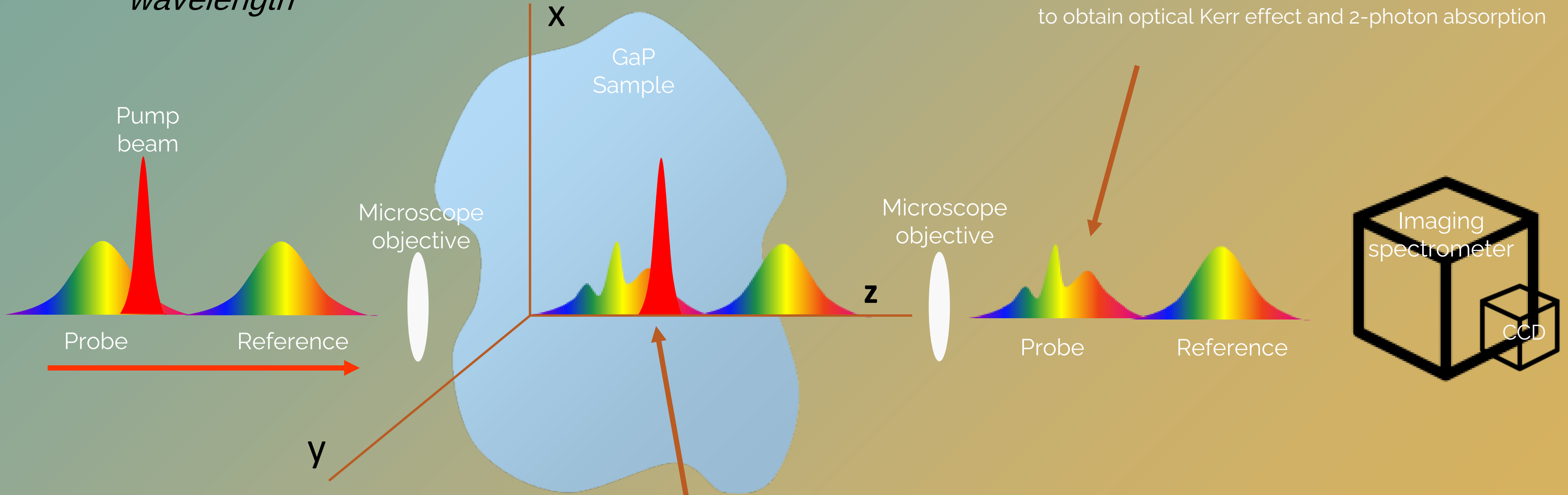
Probe temporal stretch: 6.5 ps
Probe bandwidth: 300 nm
Phase resolution: 100 μrad
Temporal resolution: 100 fs

PUMP-PROBE SPECTRAL INTERFEROMETRY

Due to probe chirp, time is encoded in

wavelength

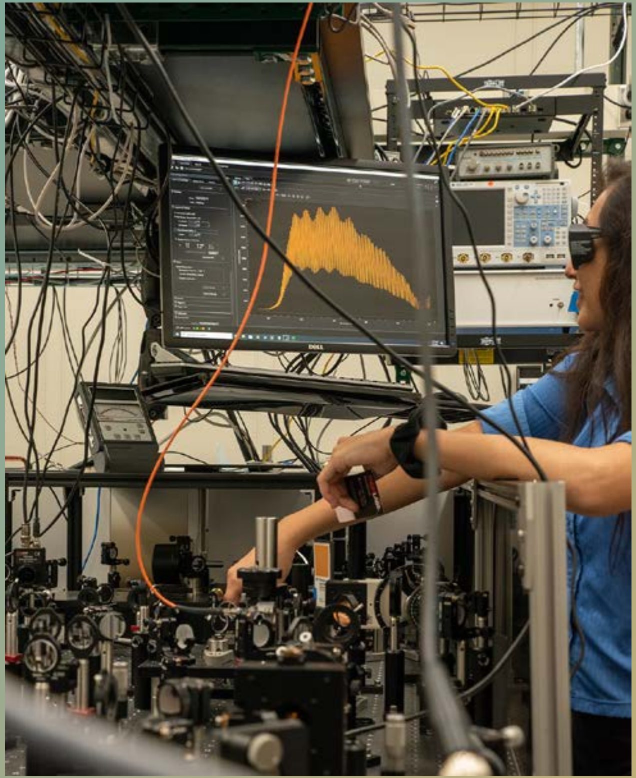
Extract $\triangle\Phi_{probe}(\lambda,\tau)$ and $\triangle A_{probe}(\lambda,\tau)$ to obtain optical Kerr effect and 2-photon absorption



A pump pulse generates transient refractive index Δn

Probe temporal stretch: 6.5 ps
Probe bandwidth: 300 nm
Phase resolution: 100 μrad
Temporal resolution: 100 fs

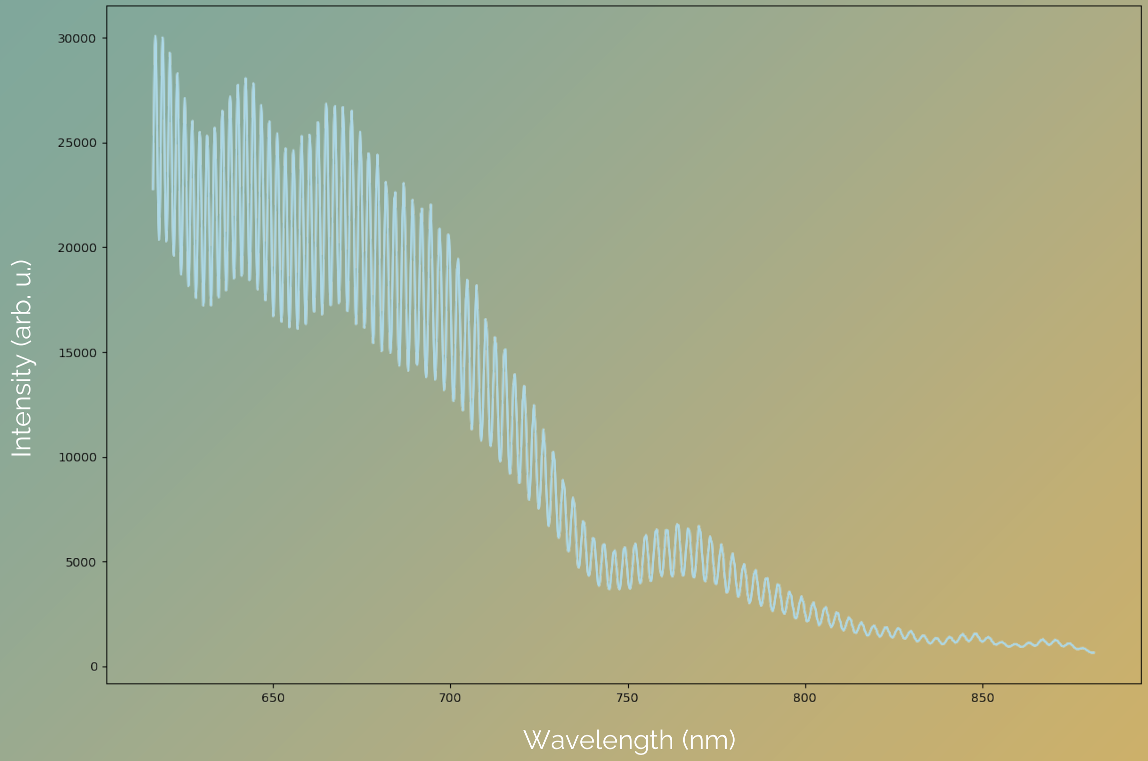
PUMP-PROBE SPECTRAL INTERFEROMETRY



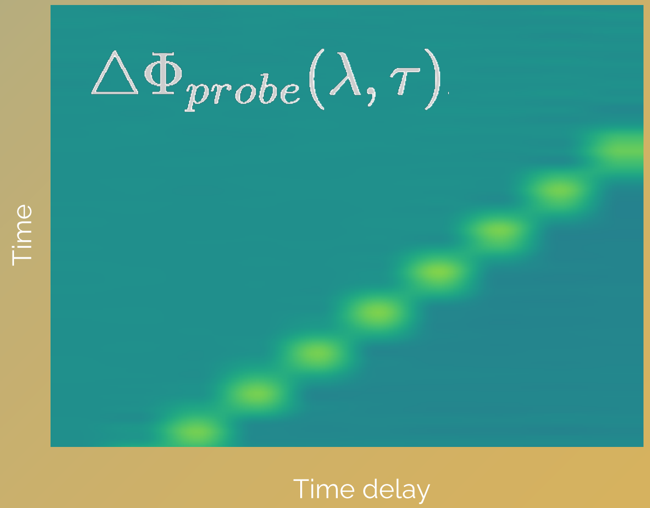
Extract $\triangle\Phi_{probe}(\lambda,\tau)$ and $\triangle A_{probe}(\lambda,\tau)$ to obtain optical Kerr effect and 2-photon absorption

PUMP-PROBE SPECTRAL INTERFEROMETRY

Example interferogram



Extract $\triangle\Phi_{probe}(\lambda,\tau)$ and $\triangle A_{probe}(\lambda,\tau)$ to obtain optical Kerr effect and 2-photon absorption



WHAT ARE n_2 & β

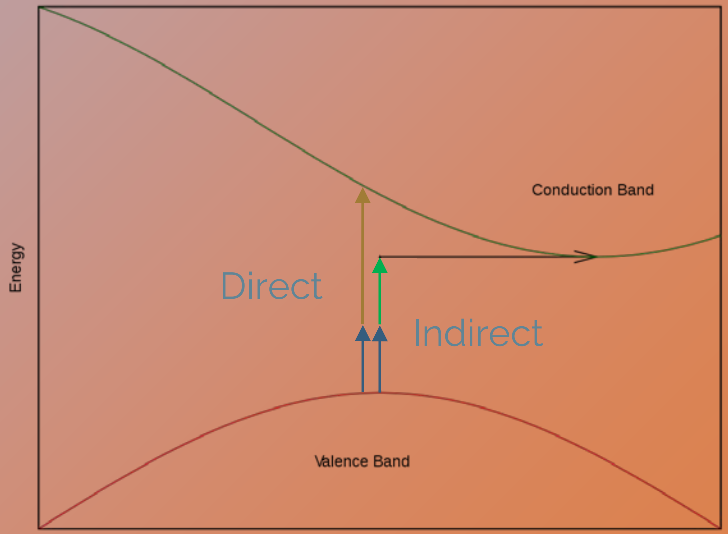
OPTICAL KERR EFFECT

$$n(\lambda, I) = n_0 + n_2 I$$

is the part that varies quadratically with an AC electric field

TWO-PHOTON ABSORPTION

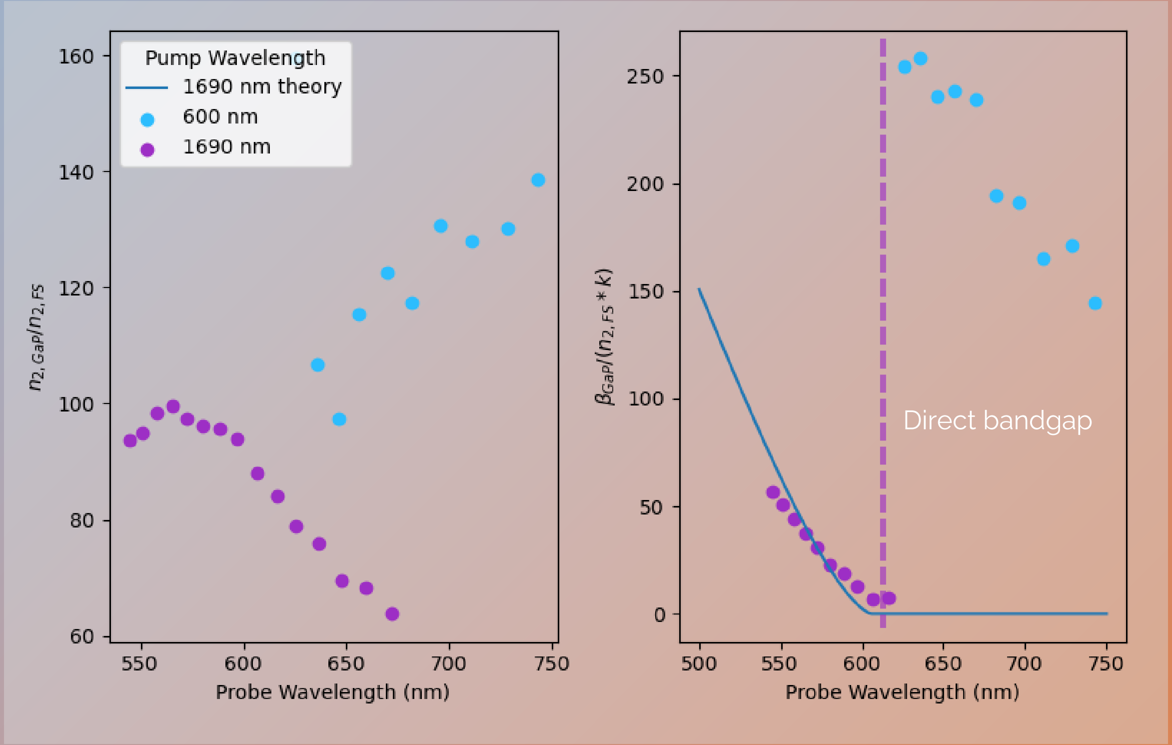
$$\alpha = \alpha_0 + \beta I$$



CURRENT RESULTS & POTENTIAL

Gallium Phosphide and Fused Silica

n_2



β

thanks! ANY QUESTIONS?

Citations

[1] Wilson, D.J., Schneider, K., Hönl, S. *et al*. Integrated gallium phosphide nonlinear photonics. *Nat. Photonics* **14**, 57–62 (2020).

[2] M. Sheik-Bahae, D. C. Hutchings, D. J. Hagan and E. W. Van Stryland, "Dispersion of bound electron nonlinear refraction in solids," in IEEE Journal of Quantum Electronics, vol. 27, no. 6, pp. 1296-1309, June 1991.

[3] Mitsuo Takeda, Hideki Ina, and Seiji Kobayashi, "Fourier-transform method of fringe-pattern analysis for computer-based topography and interferometry," J. Opt. Soc. Am. 72, 156-160 (1982).

[4] Berera, R., van Grondelle, R. & Kennis, J.T.M. Ultrafast transient absorption spectroscopy: principles and application to photosynthetic systems. *Photosynth Res* **101**, 105–118 (2009).

[5] J. K. Wahlstrand, S. Zahedpour, and H. M. Milchberg, "Optimizing the time resolution of supercontinuum spectral interferometry," J. Opt. Soc. Am. B 33, 1476-1481 (2016).

[6] David Milam, "Review and assessment of measured values of the nonlinear refractive-index coefficient of fused silica," Appl. Opt. 37, 546-550 (1998).