The dispersive element based on porous silicon photonic crystal for ultra-compact optical spectrometers

S.E. Svyakhovskiy,

Department of Physics, Lomonosov Moscow State University, Moscow, Russia

sse@shg.ru

Theory: Goos-Hänchen effect

The wave reflected by total internal reflection has transversal shift called Goos-Hänchen effect.

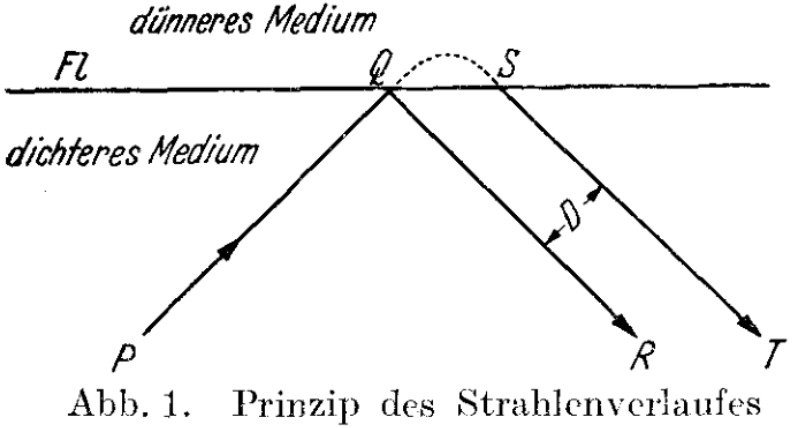
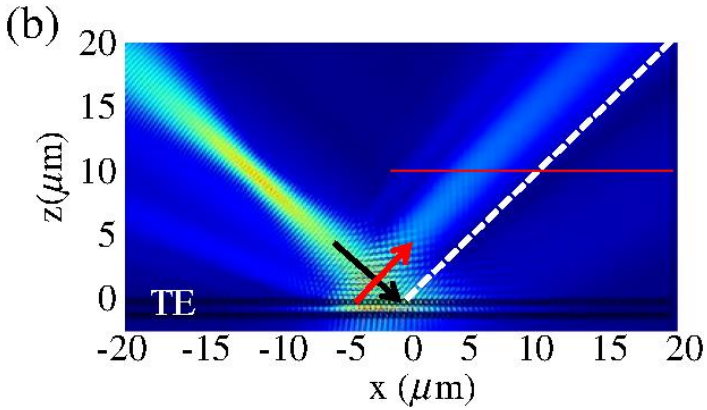


Abb. 1. Prinzip des Strahlenverlaufes

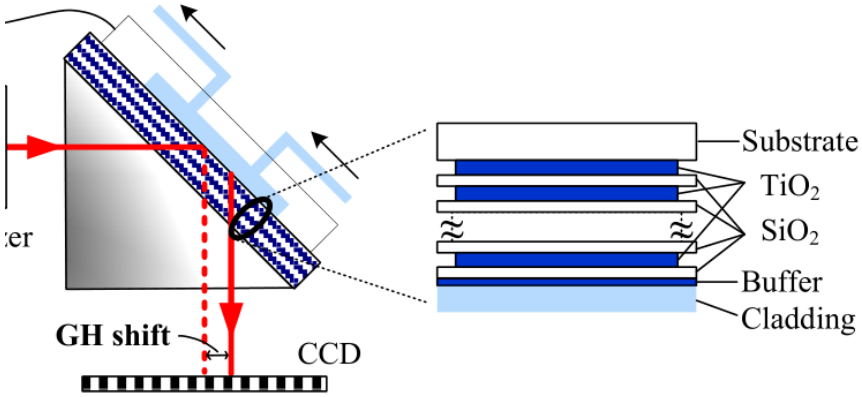
Dielectrics

Ann. Phys. **436**, 7-8, 333 (1947)



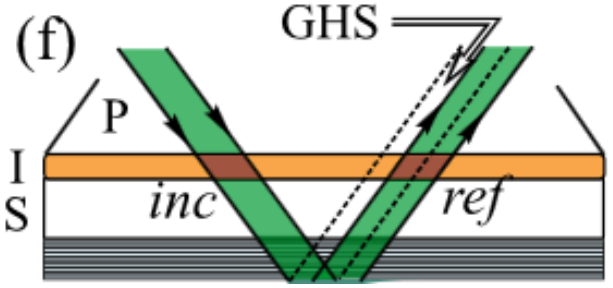
Metamaterials

J. Nanophoton. **8**(1), 084093 (2014)



Bloch surface waves

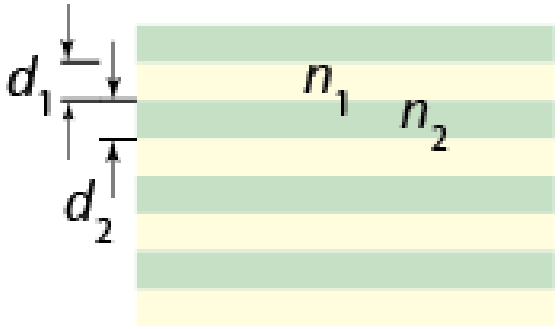
Opt. Exp. **20**, 8, 8998 (2012)



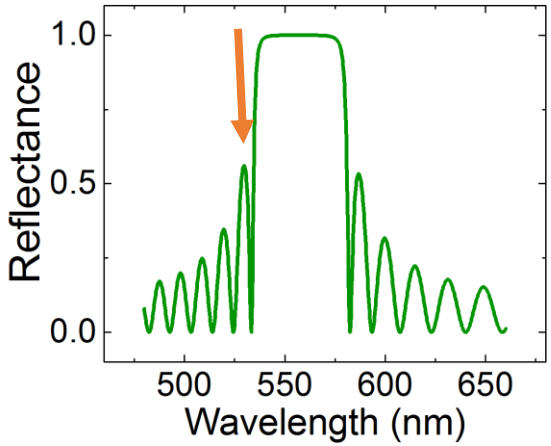
Photonic crystals

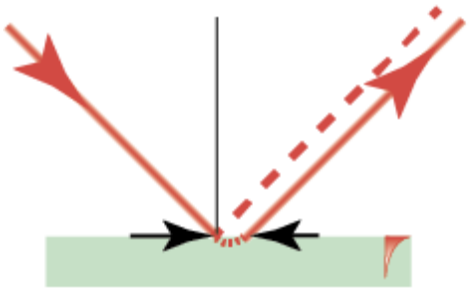
Phys. Rev. Lett. **108,** 123901 (2012)

G-H enhancement in photonic crystals

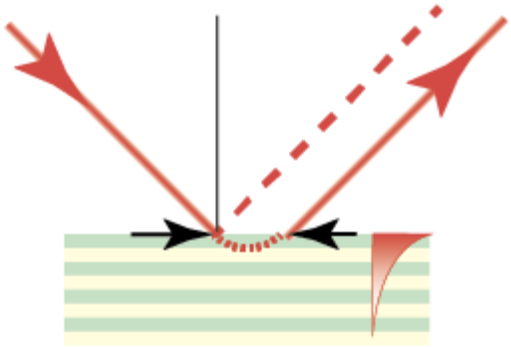


1D photonic crystal (PhC)

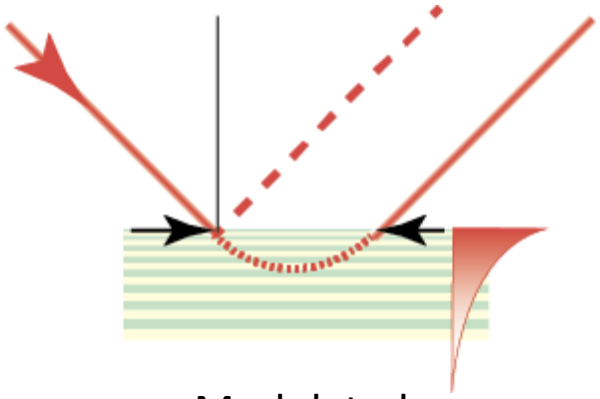




Dielectric slab



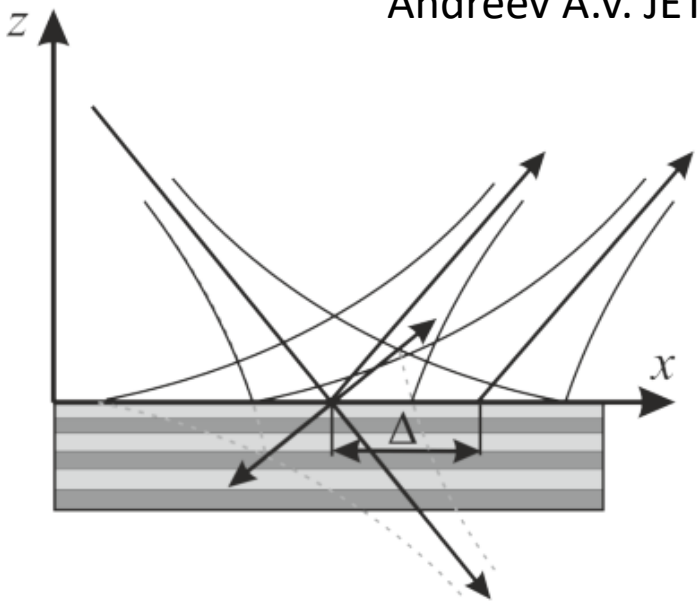
Photonic crystal

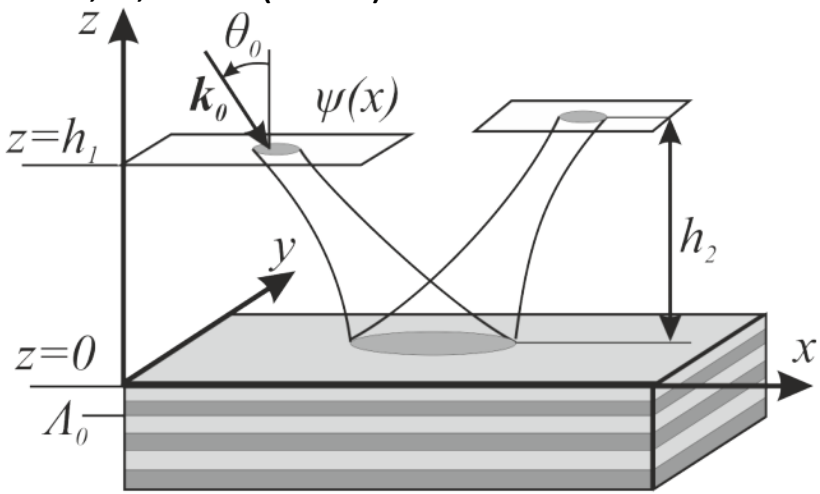


Modulated
Photonic crystal

Reflection of the Gaussian beam

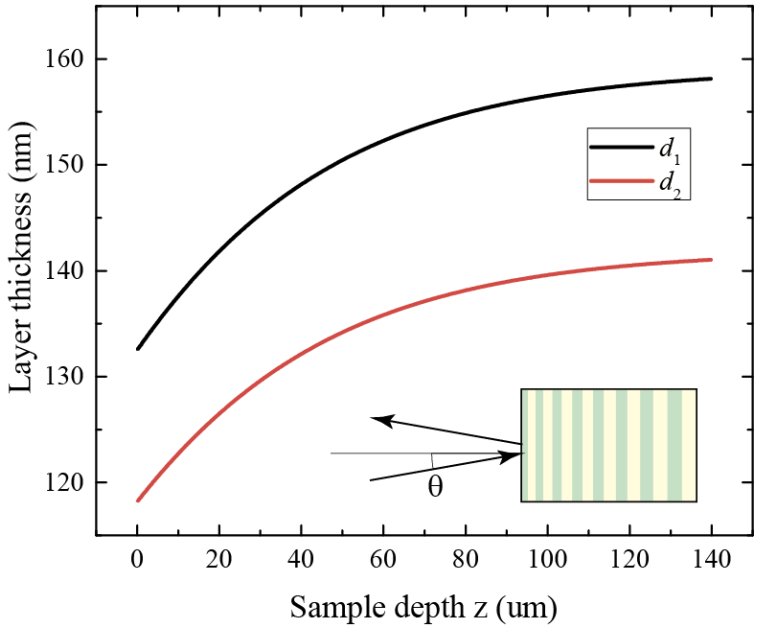
Andreev A.V. JETP Lett. **74**, 1, 8-11 (2001).



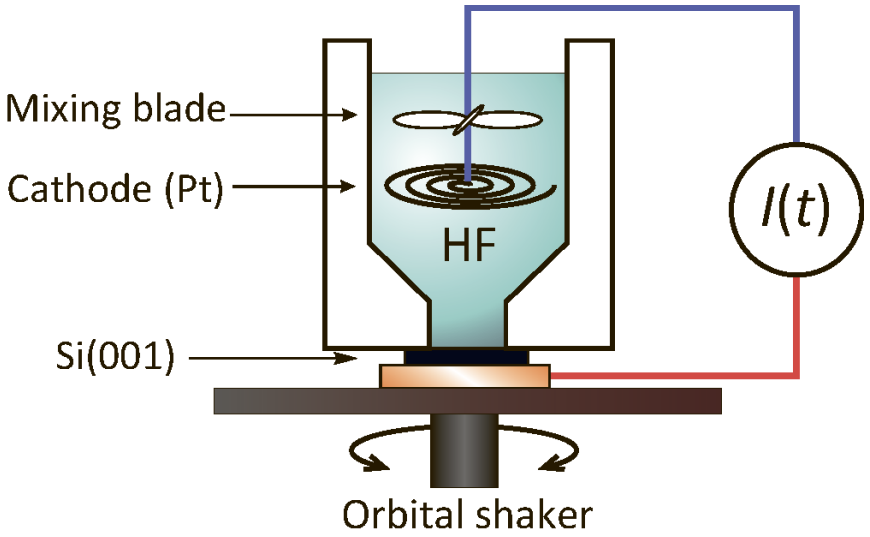


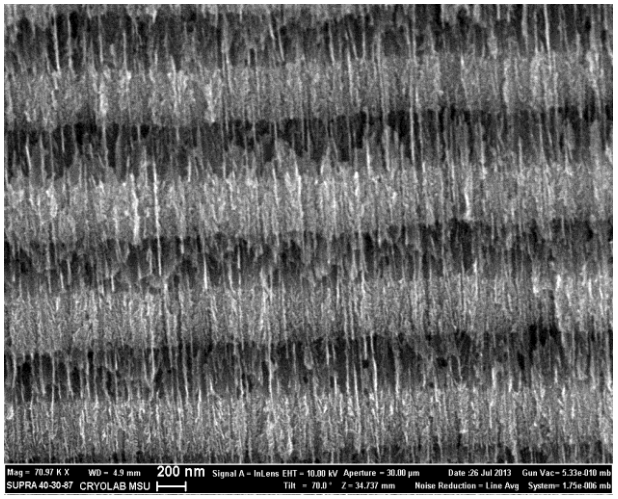
$$\frac{1}{\Lambda(z)} = \frac{1}{\Lambda}\left(1 + \frac{u_0}{z_0} e^{-z/z_0}\right)$$

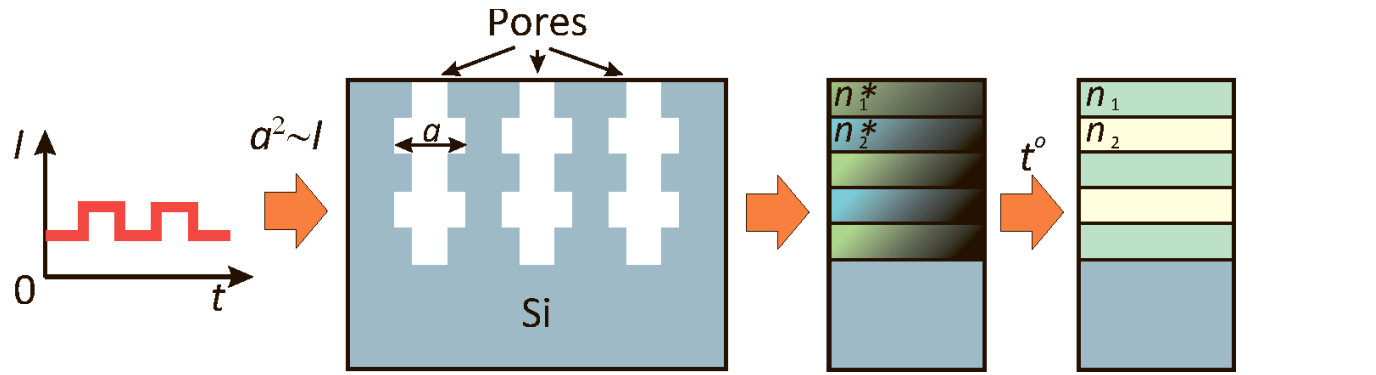
The modulated photonic crystal has giant Goos-Hanchen effect



Production of the samples







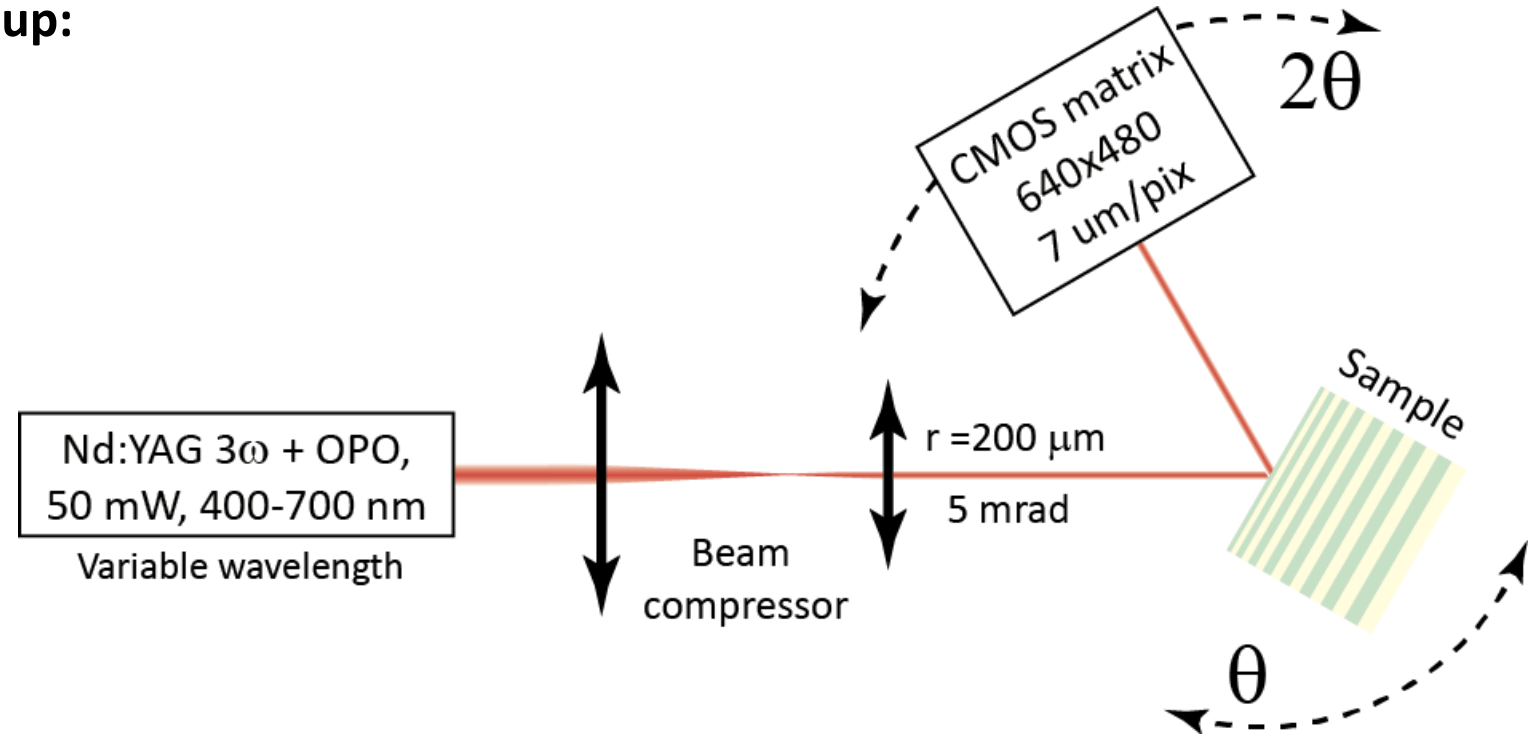
S. E. Svyakhovskiy et al. J. Appl. Phys. **112**, 1, 013106 (2012)

Experiment: Goos-Hänchen shift

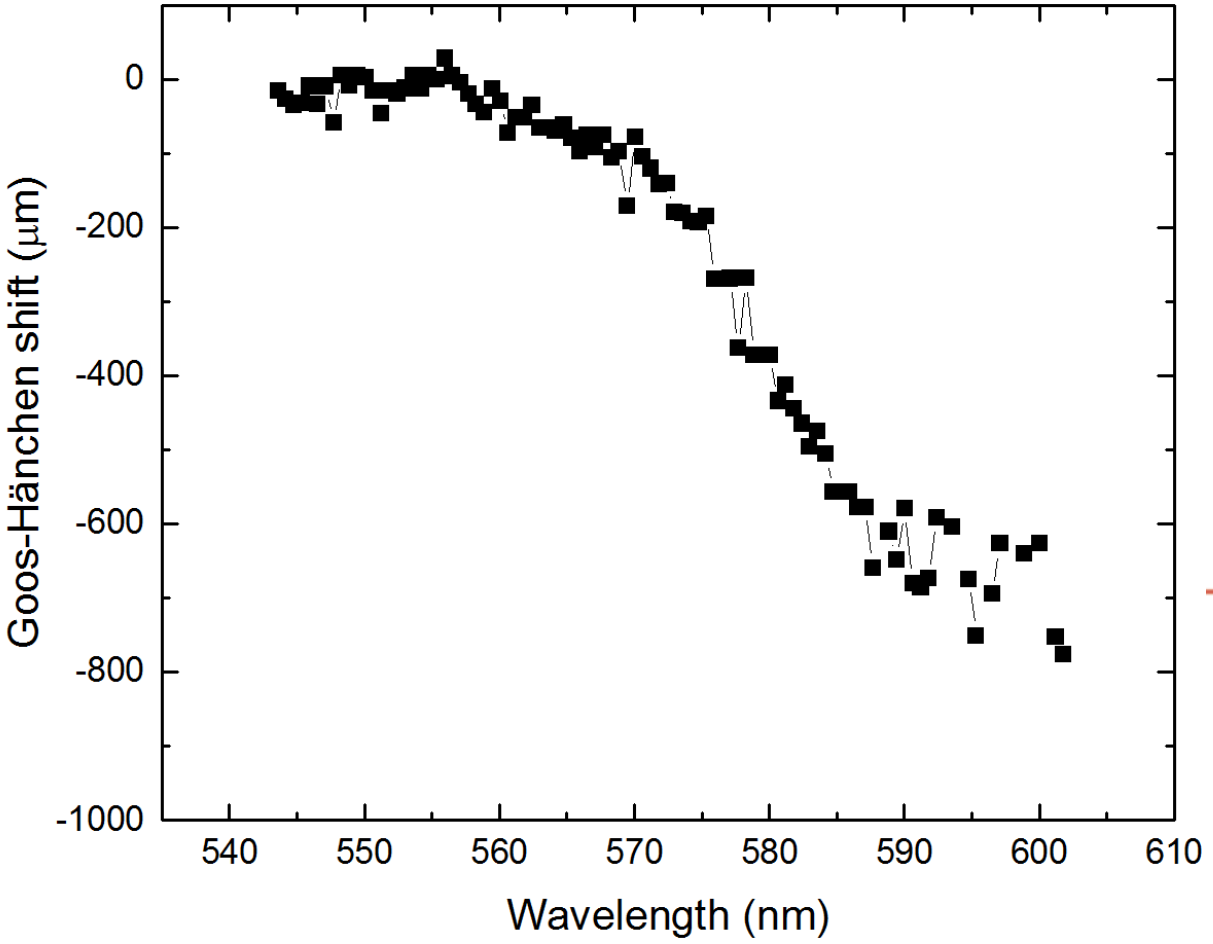
Samples:

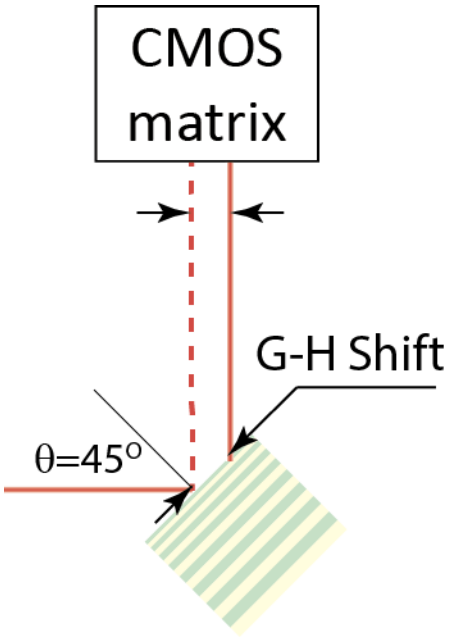
1. Silicon plate (reference)
2. Modulated PhC (1100 layers, z_0=40 μm, u_0=8 μm, Λ=210 nm)

Setup:



Experiment: Goos-Hänchen shift

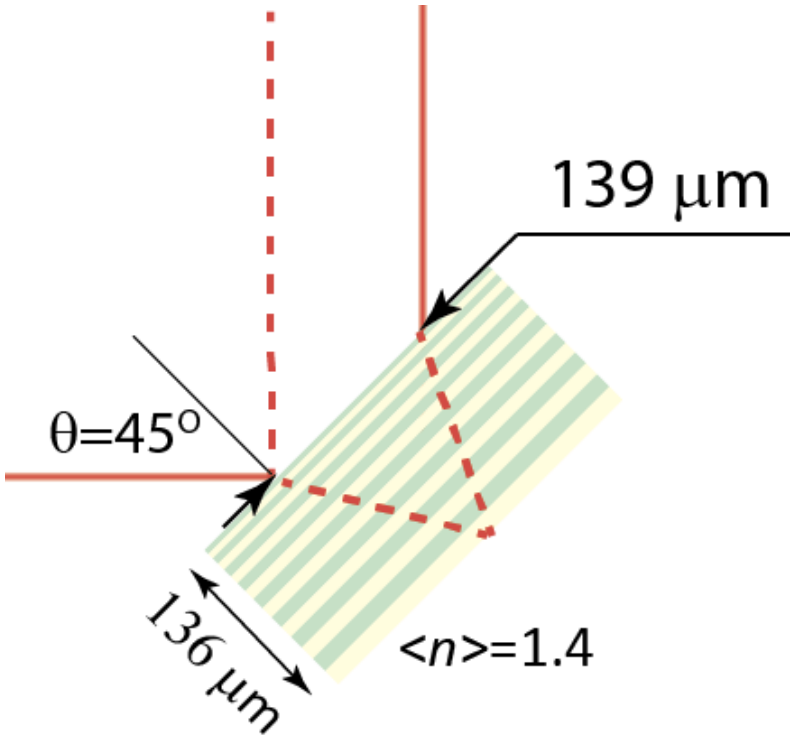




Spatial shift of the beam center depending on the wavelength

Goos-Hänchen shift

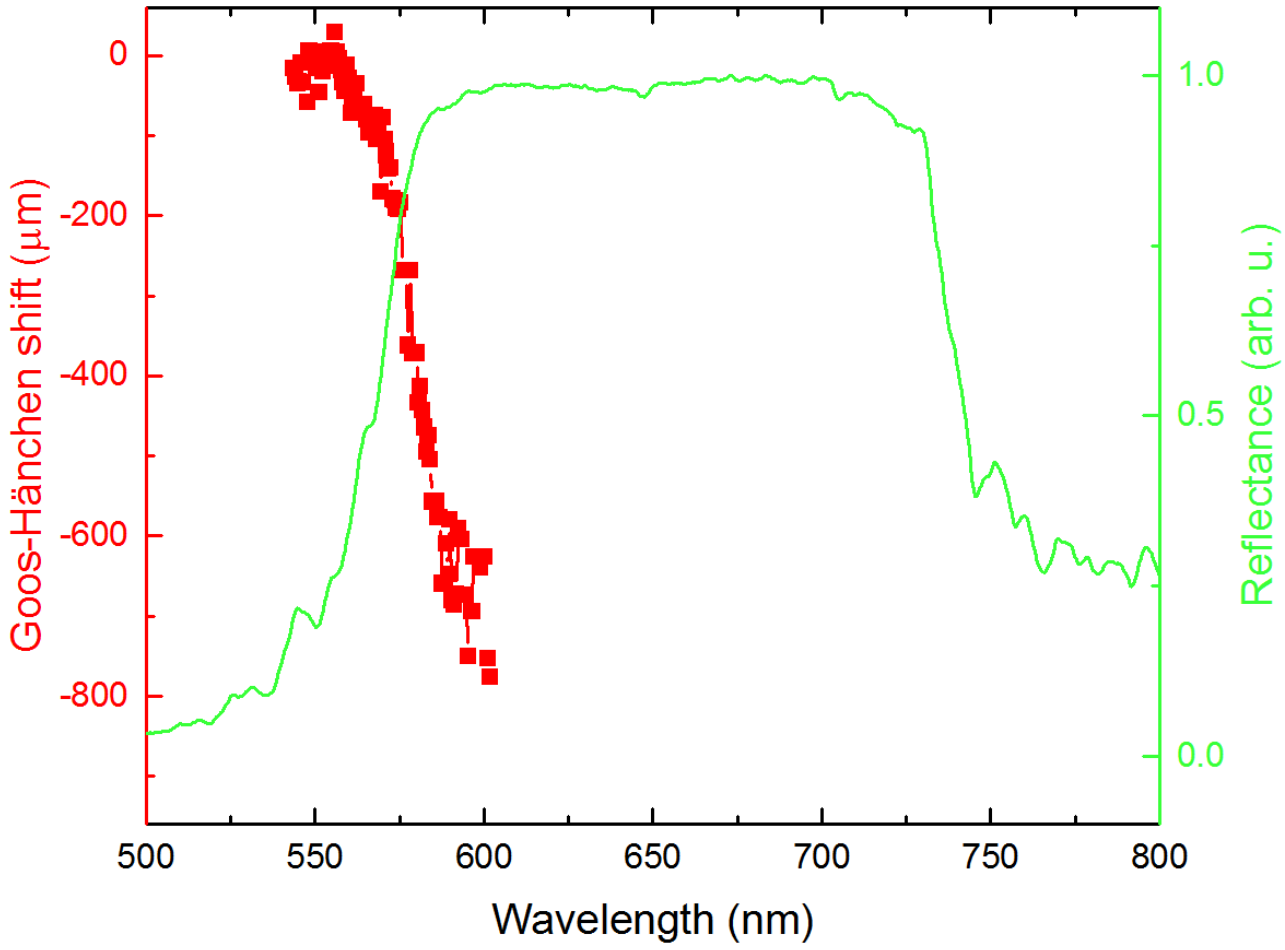
Simple geometric interpretation



Expected shift is much lower than measured

Simple geometric interpretation does not work.

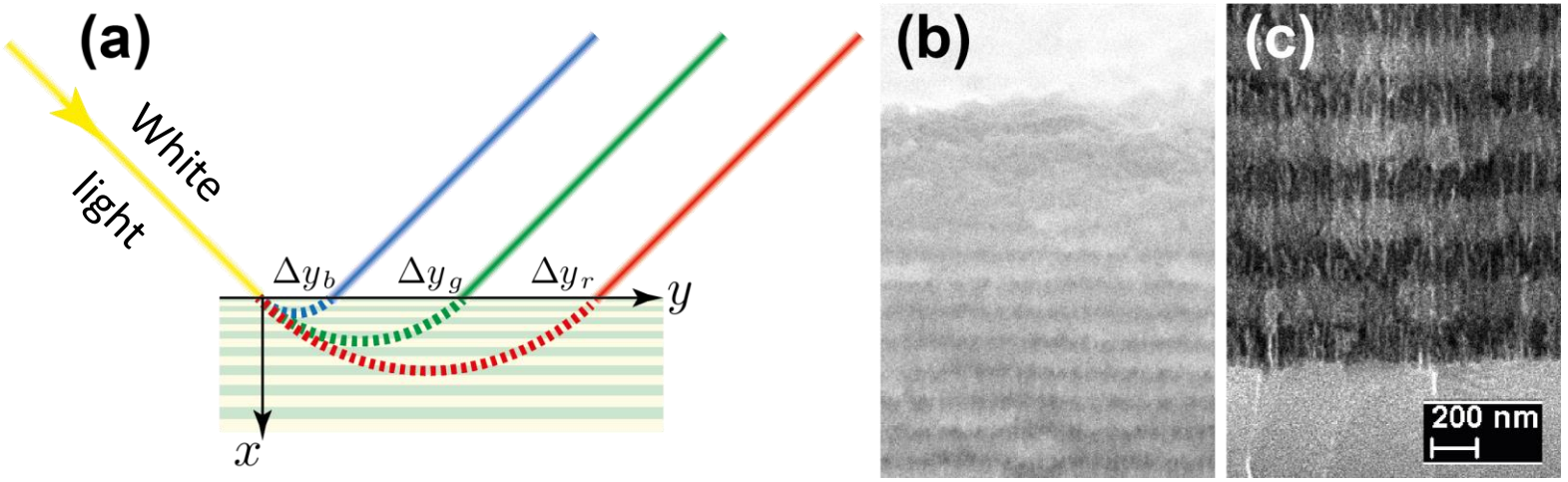
Experiment: Goos-Hänchen shift



Goos-Hänchen shift sufficiently depends on the wavelength of light

Proposal of the spectrometer

The giant Goos-Hänchen shift enormously depends on the wavelength of light. Therefore it can be used for spatial separation of different wavelengths.

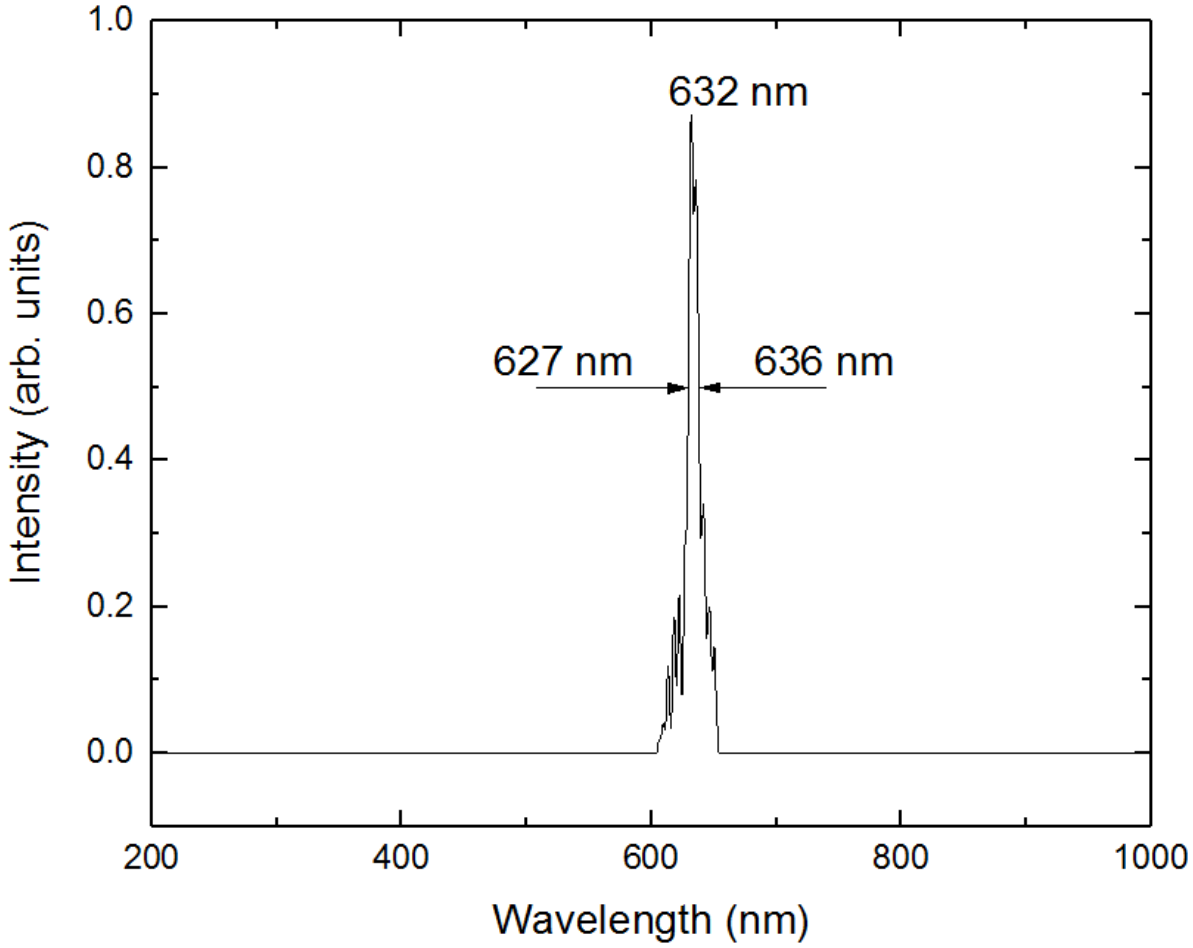


Fiber coupling

The dispersive element is radiated by light from the optical fiber (9 um core, 125 um cladding)

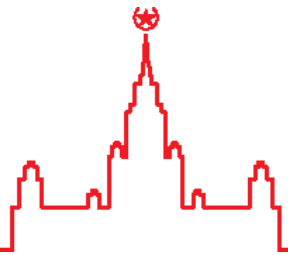
The reflected light is decomposed into spectrum.

Spectrum of He-Ne laser



The spectrum of helium-neon laser measured by the prototype spectrometer.

Conclusions



- The new type of the dispersive element for spectrometers is proposed, the prototype spectrometer has been built.
- The size of the photonic structure used in experiment is 2x2x0.5 mm, can be smaller.
- The prototype spectrometer has a resolution of 9 nm, its spectral range is limited by the sensitivity of the detector, the spectrometer does not require filtration of higher diffraction orders.