

White light in white paint

Spectroscopy of random photonic media

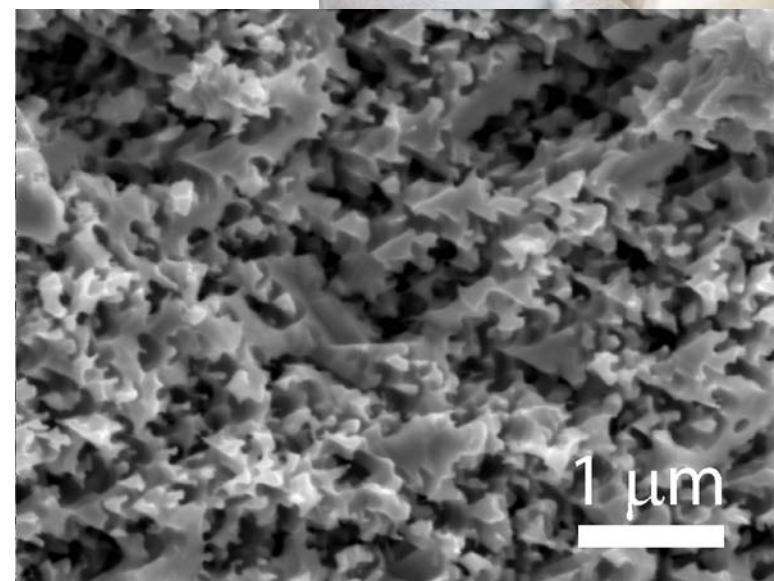
Otto Muskens

Short colloquium, 18 february 2008



Thanks to:

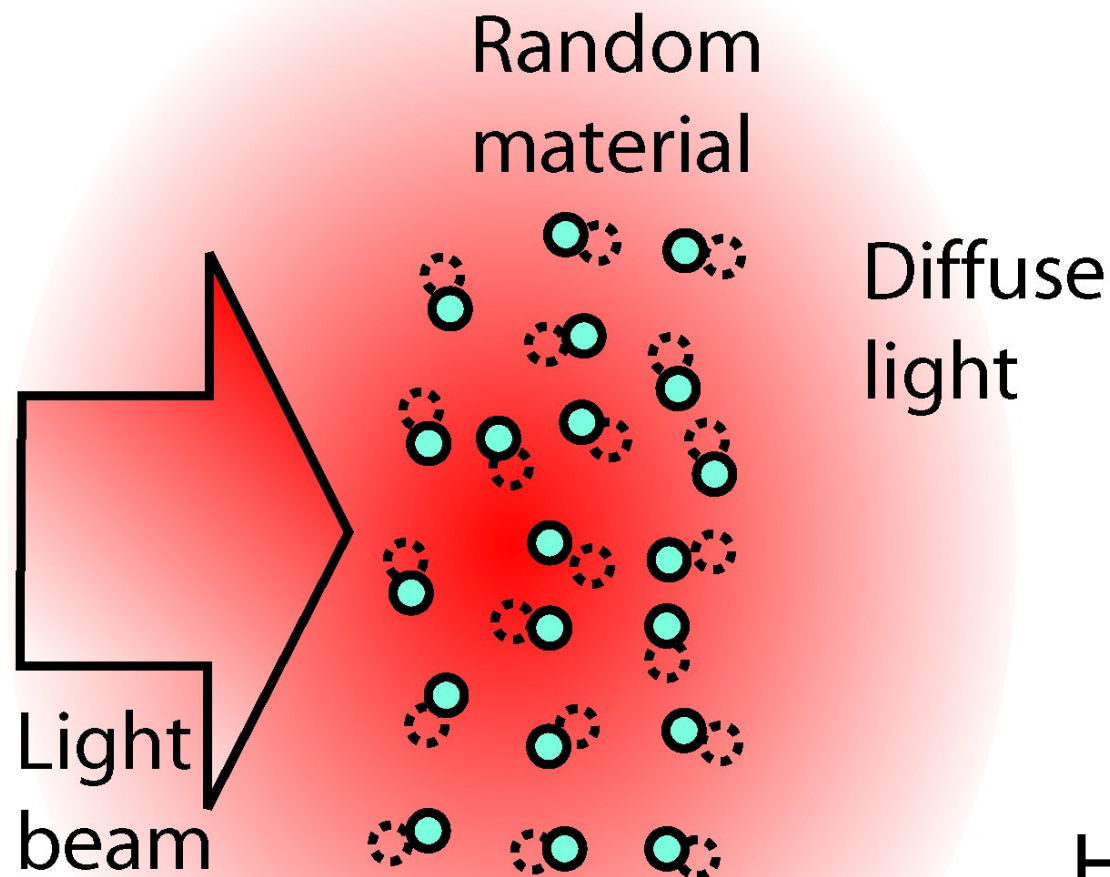
Timmo van der Beek
Ad Lagendijk
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Erik Bakkers



Outline

- Interference in random media
- White-light enhanced backscattering spectroscopy
- Application: photonic nanomaterials

Interference in random media

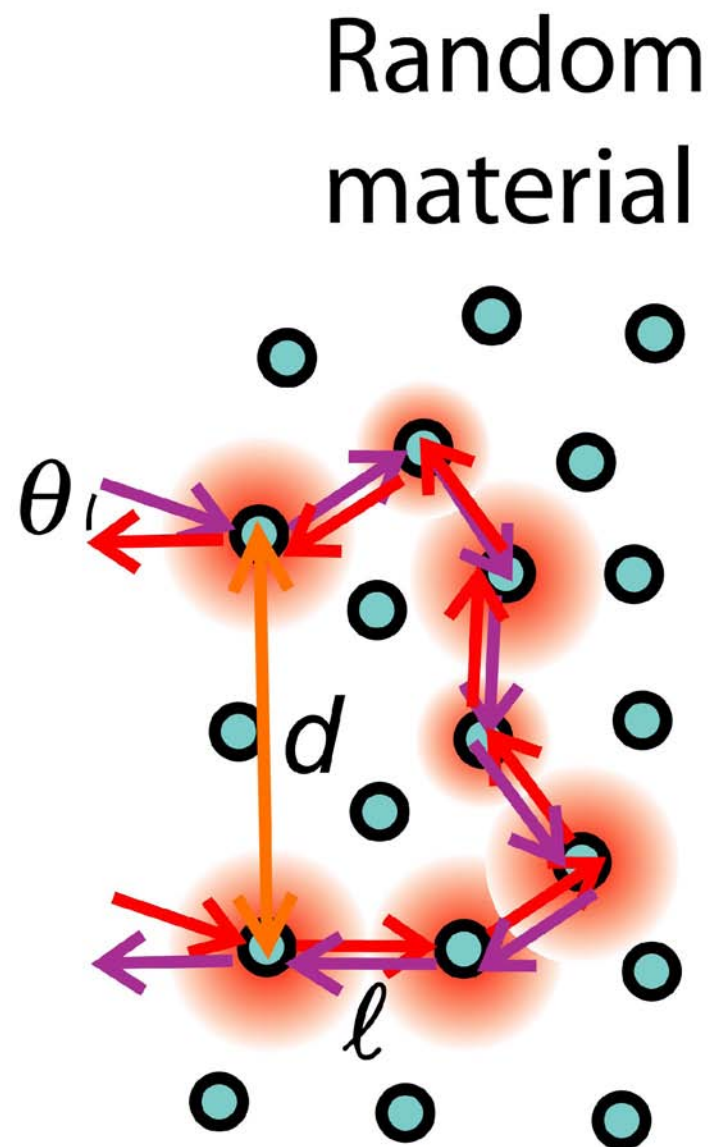


- Light follows random multiple scattering paths
- Paths have different phase
- Interference gives speckle
- Averaging over disorder gives diffusion

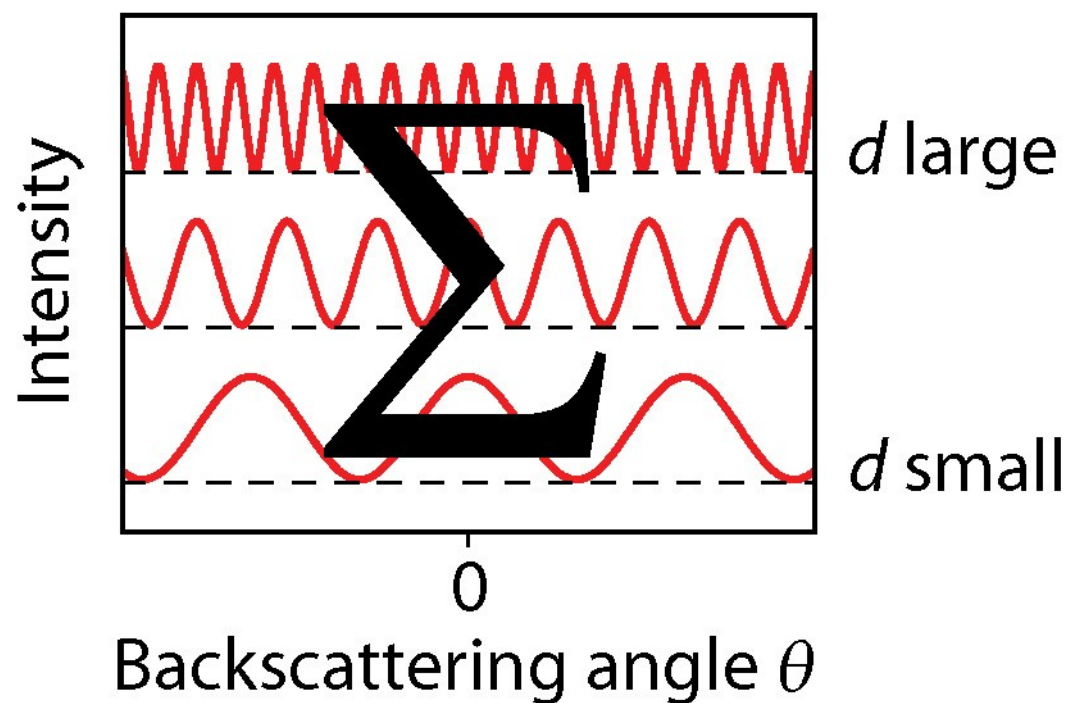
However,

- Some interferences survive averaging

Enhanced backscattering (EBS)

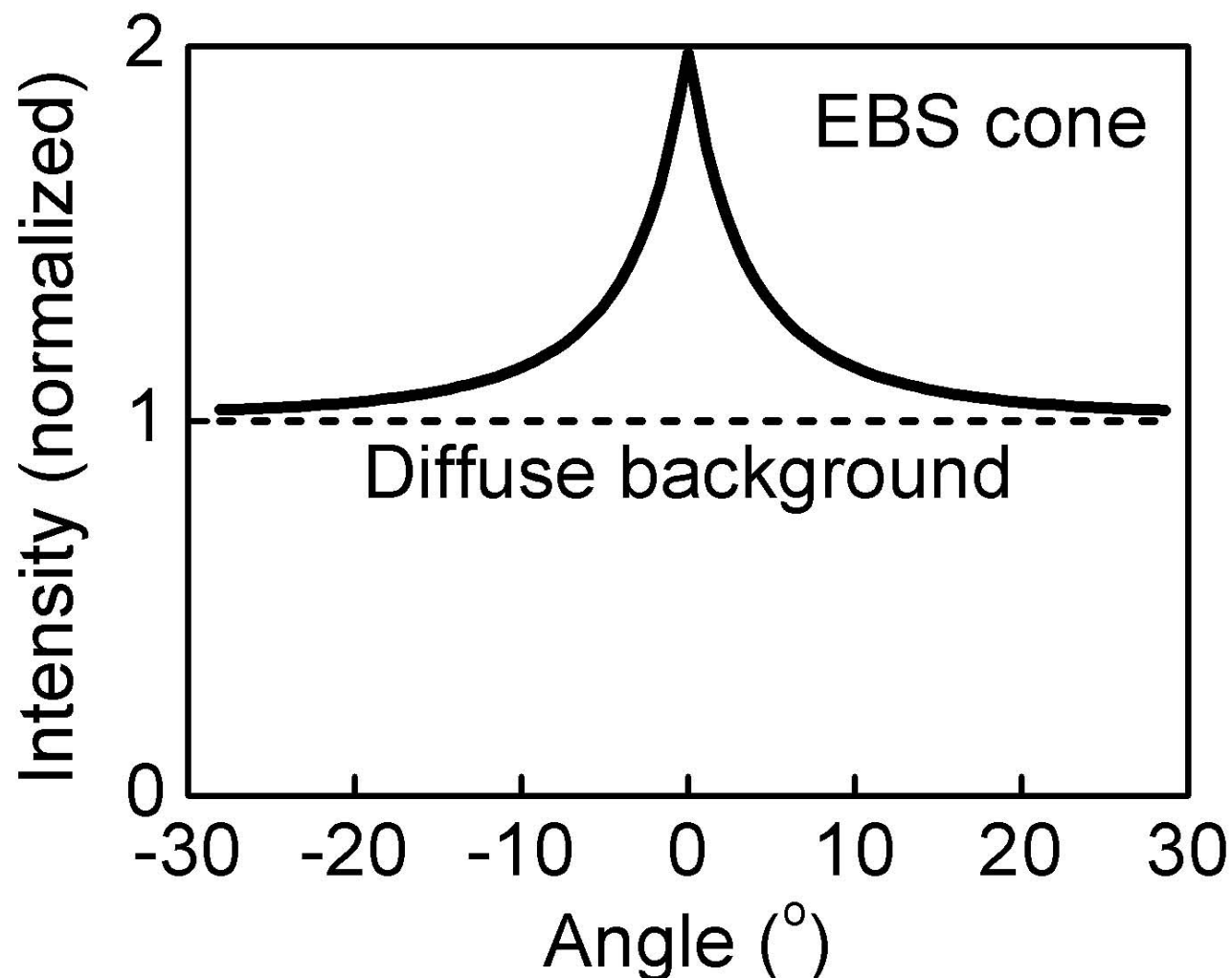


- Every light path in reflection has a reciprocal path
- Reciprocal paths interfere constructively in exact backscattering
- Dephasing of paths with θ



Enhanced backscattering (EBS)

- EBS: manifestation of weak localization of classical waves. (Van Albada, Lagendijk, PRL 1985)



- Calculated EBS-cone

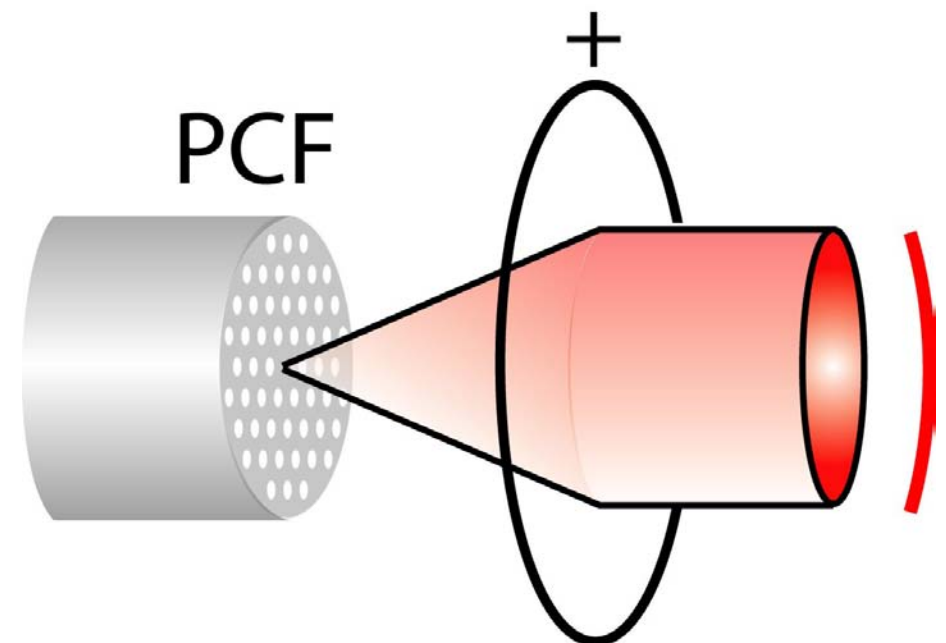
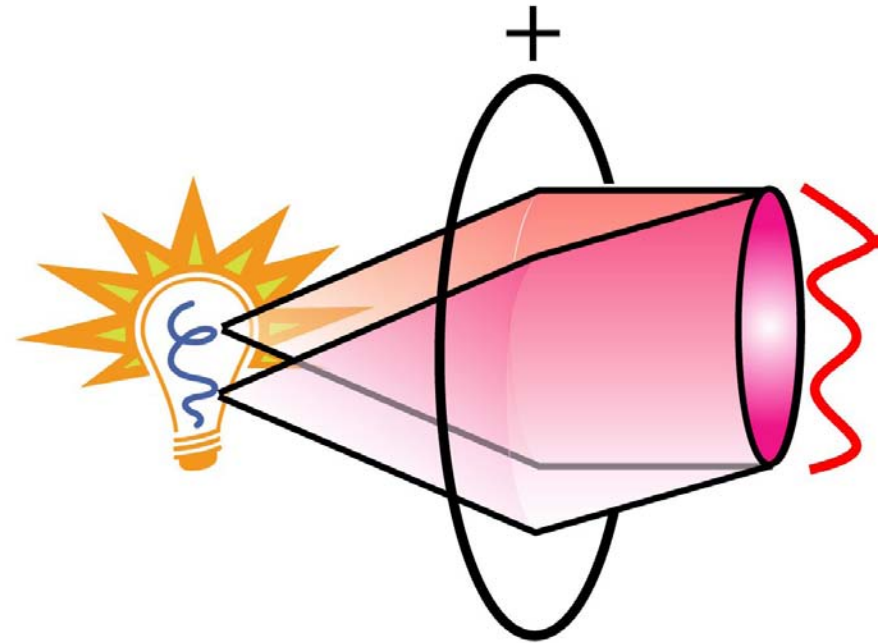
- EBS enhancement up to 2

- Cone width

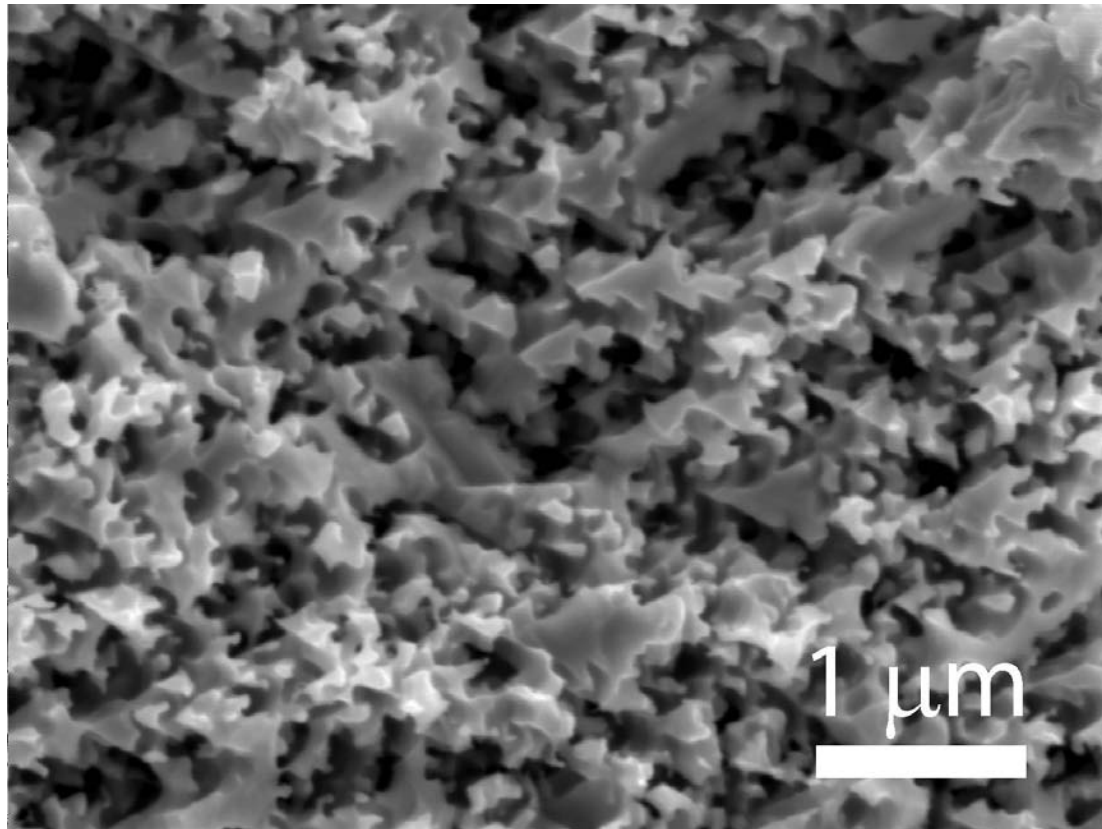
$$\theta_{\text{FWHM}} \approx \frac{0.7}{k_0 \ell}$$

White-light EBS: what is new?

- EBS requires spatially coherent source (laser)
- New idea: supercontinuum white-light for broadband EBS
 - High spatial coherence
 - High spectral intensity
- White-light EBS: investigate spectral signatures of
 - Resonant scattering
 - Photonic bandgaps
 - Anderson localization

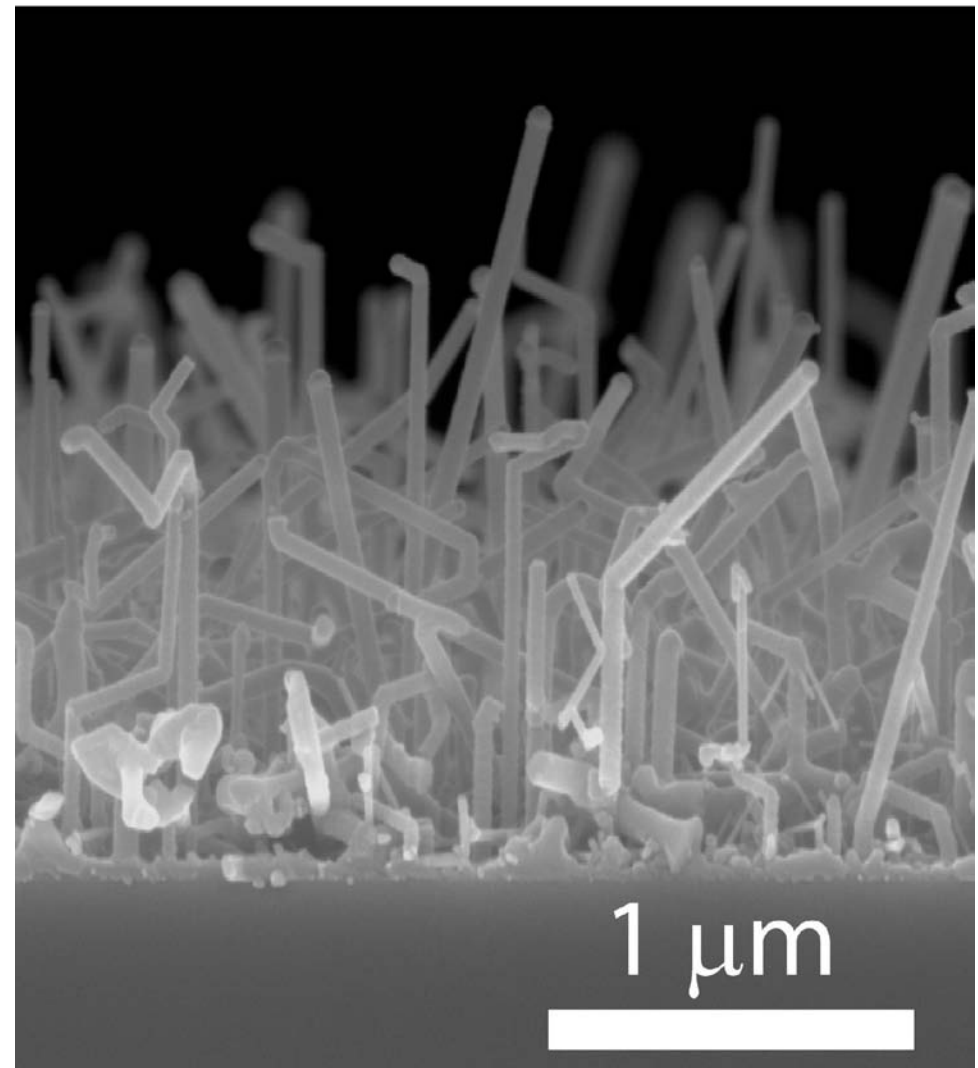


Our white paint: nanomaterials



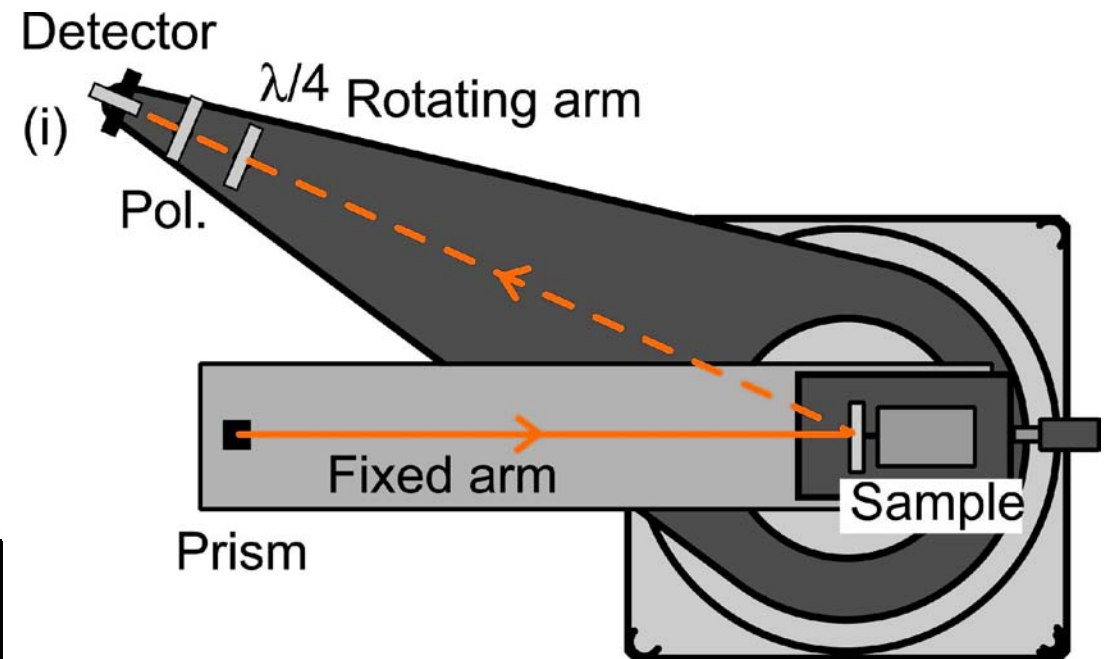
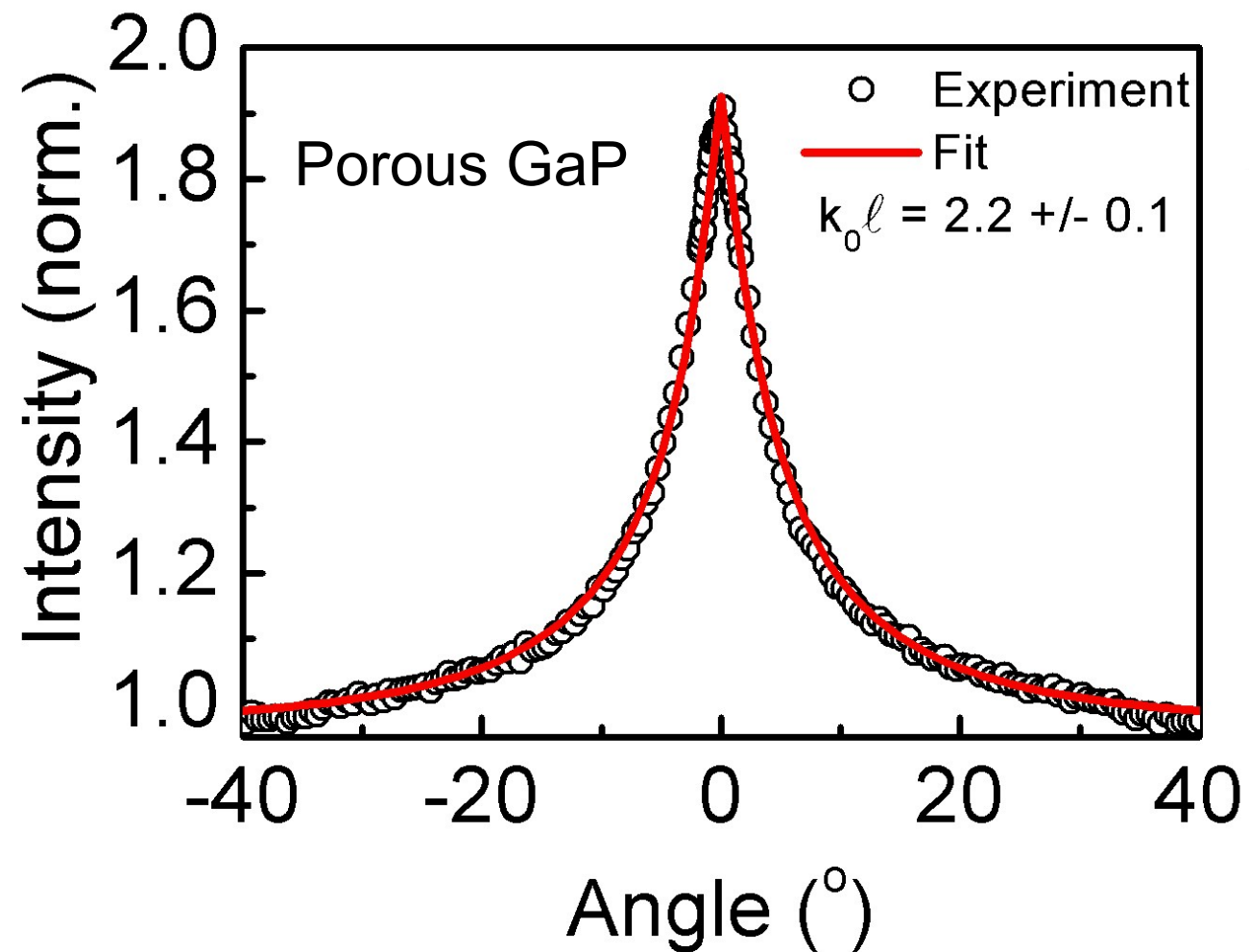
Porous gallium phosphide
(GaP)

Semiconductor nanowires
GaP, InP, Si, ...



Experiment: Setup

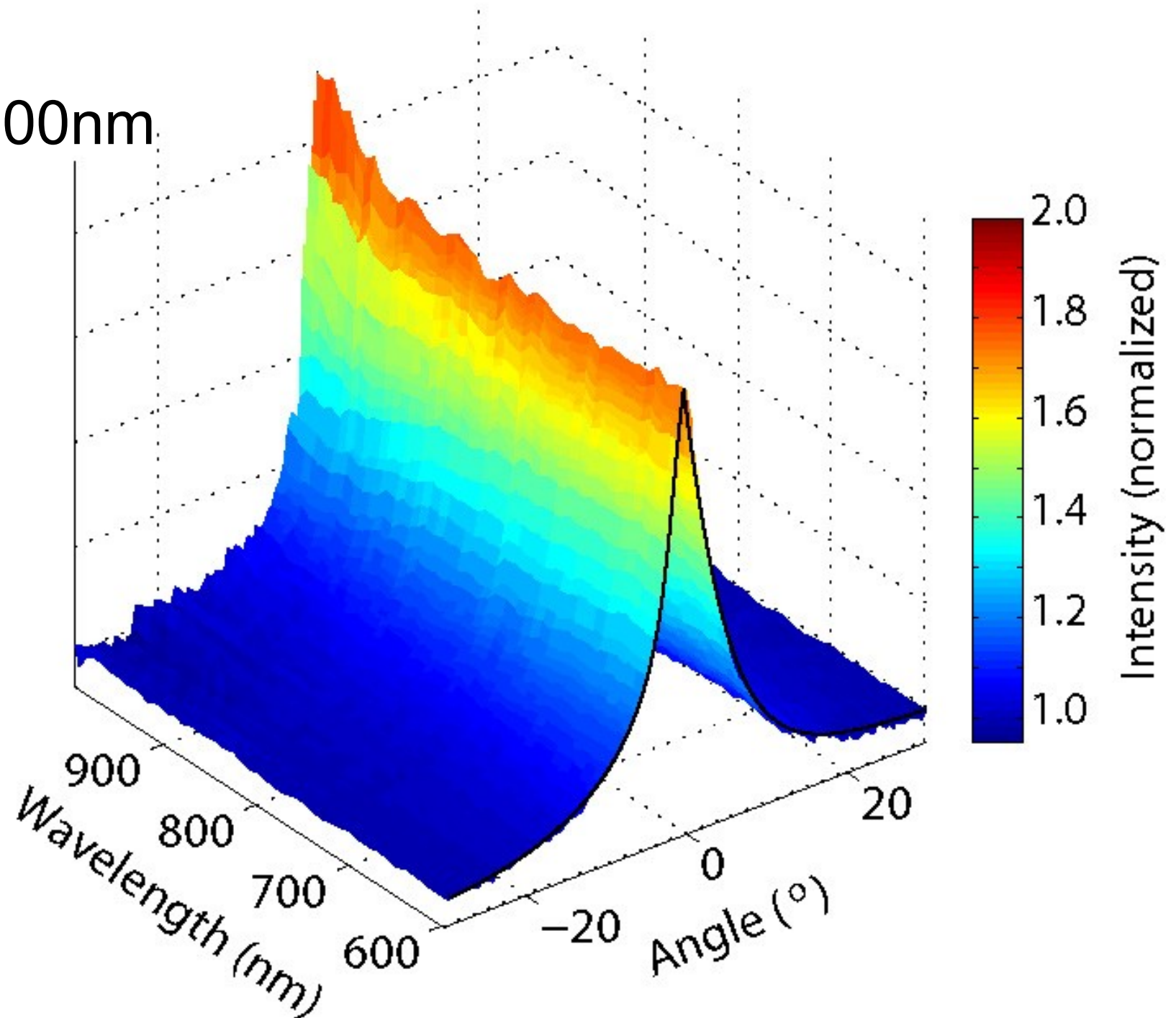
- Rotating detector arm
- Prism is changed to beamsplitter for small angles



- EBS at $\lambda = 650\text{nm}$
- Fit using theory:
 $k_0 l = 2.2 \pm 0.1$

Experiment: white-light EBS

- Spectrally-resolved EBS using white-light supercontinuum
- Range 550-1000nm
- IR available



Muskens, Lagendijk,
Opt. Express (2008)

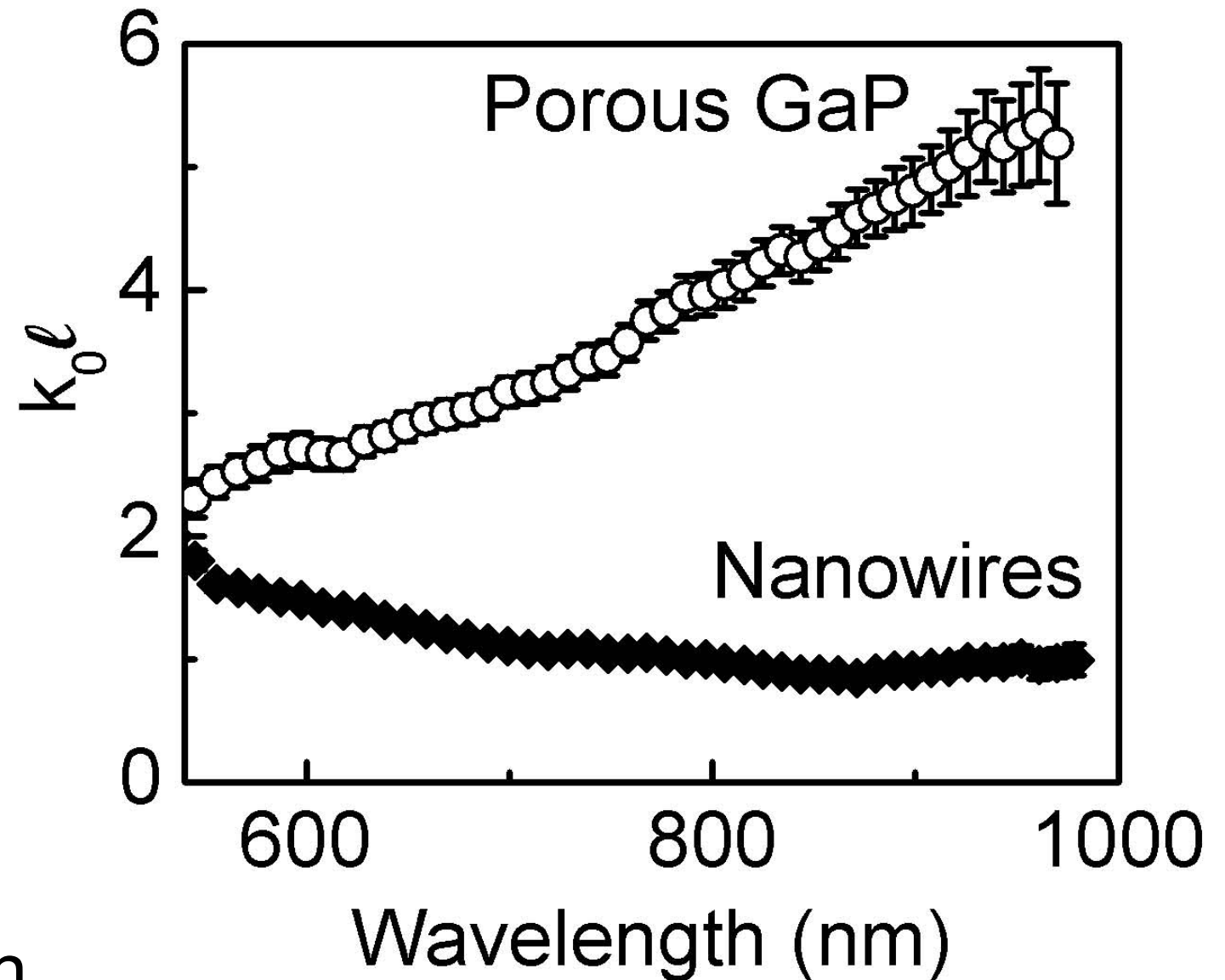
Experiment: white-light EBS

- Spectrally-resolved photonic strength $1/k\ell$

- Strong difference between P-GaP and nanowires

- P-GaP is to date strongest scattering material (Schuurmans et al., Science 1999)

- $1/k\ell \sim 1$ signifies Anderson localization



Conclusions

- White-light enhanced backscattering from 530-1000nm
- New tool in designing strongly photonic random nanomaterials
- Prospects: exploration of interference in random media, white-light speckle correlation