

Radiative Coupling Effects in Semiconductors

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COEDIP

Radiative coupling effects we have been studying for 6 years:

between planar microcavity mode and one or more quantum wells: Normal-mode coupling or vacuum-field Rabi splitting

G. Khitrova et al., *Rev Mod Phys.* **71**, 1591 (1999)

between a 3D nanocavity mode and a SQW

Spring 2000 COEDIP (Christine Spiegelberg)

Normal-Mode Coupling of Excitons and Photons in Laterally Confined Nanocavities

Fall 2000 COEDIP meeting (Claudia Ell)

Third peak disappears in nanocavity

C. Ell et al., *Phys. Rev. Lett.* **85**, 5392 (2000)

between a 3D nanocavity mode and a SQD:

might lead to genuine strong coupling, quantum entanglement, or single-photon-on-demand source.

Spring 1999 COEDIP meeting – set goal

Spring 2001 COEDIP

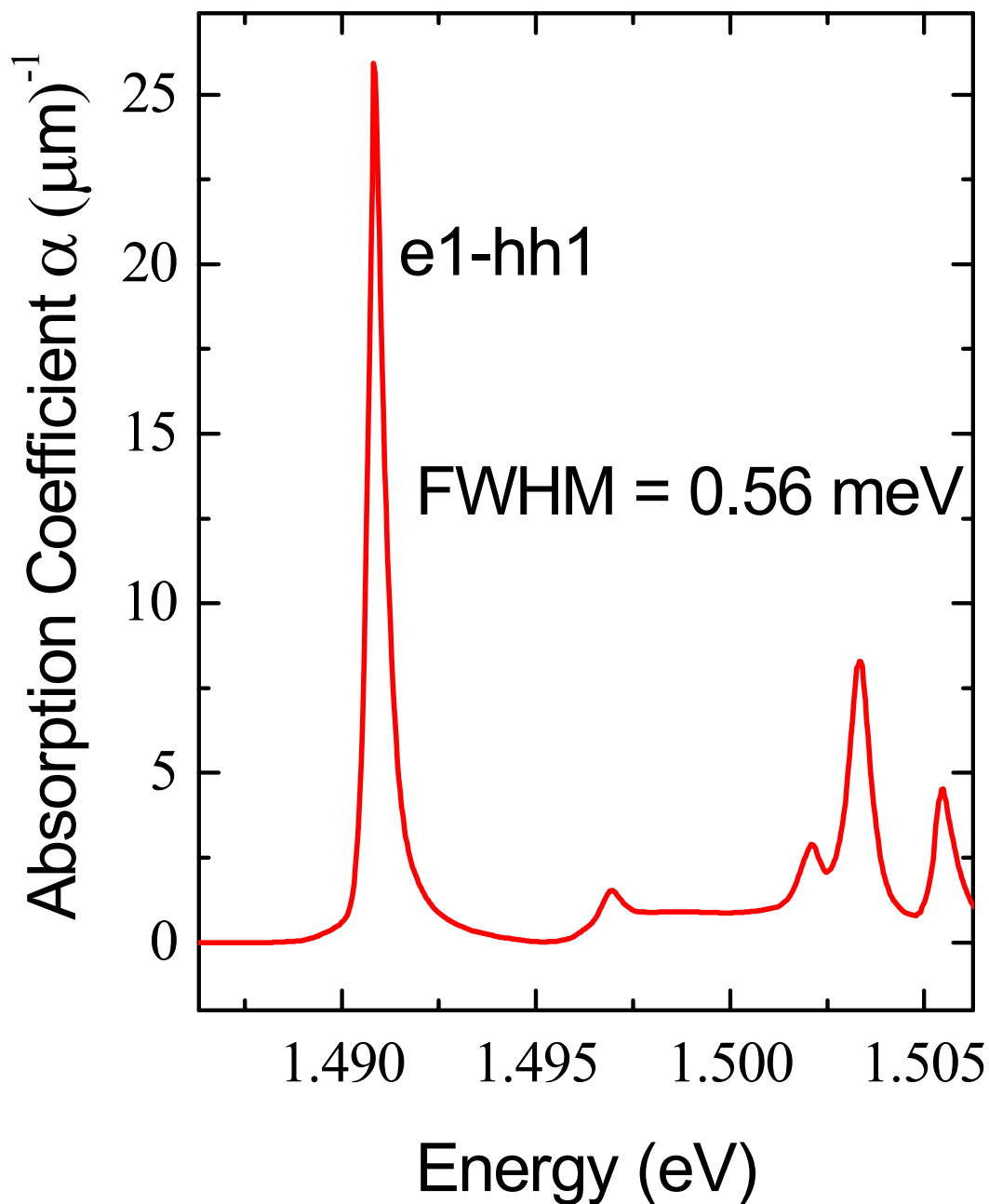
Poster “Quantum Dot Lifetime Calculations”

Angela Thränhardt and Claudia Ell

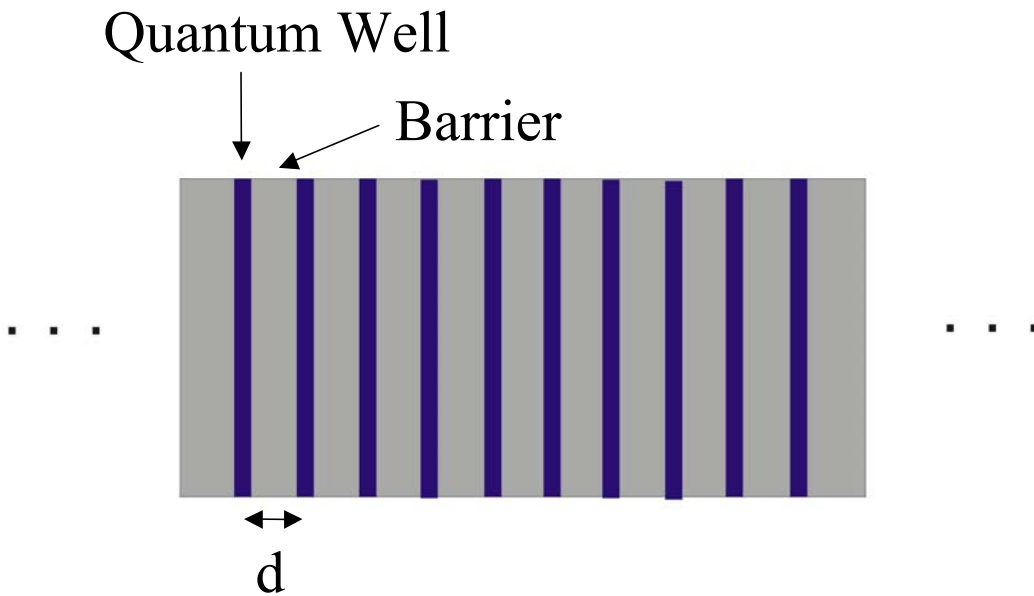
between periodically positioned QW's:

this talk

Absorption Coefficient of a $\text{In}_{0.04}\text{Ga}_{0.96}\text{As}$ Quantum Well

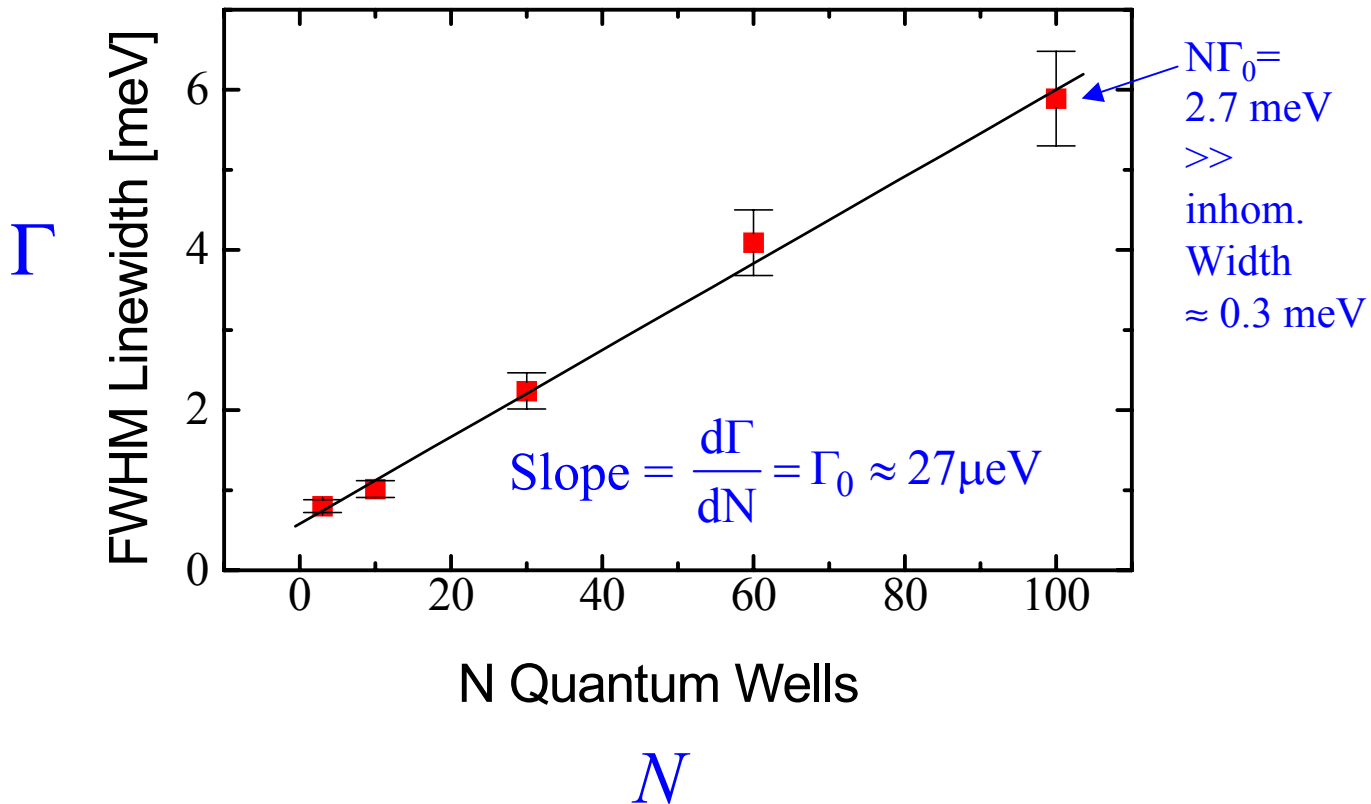
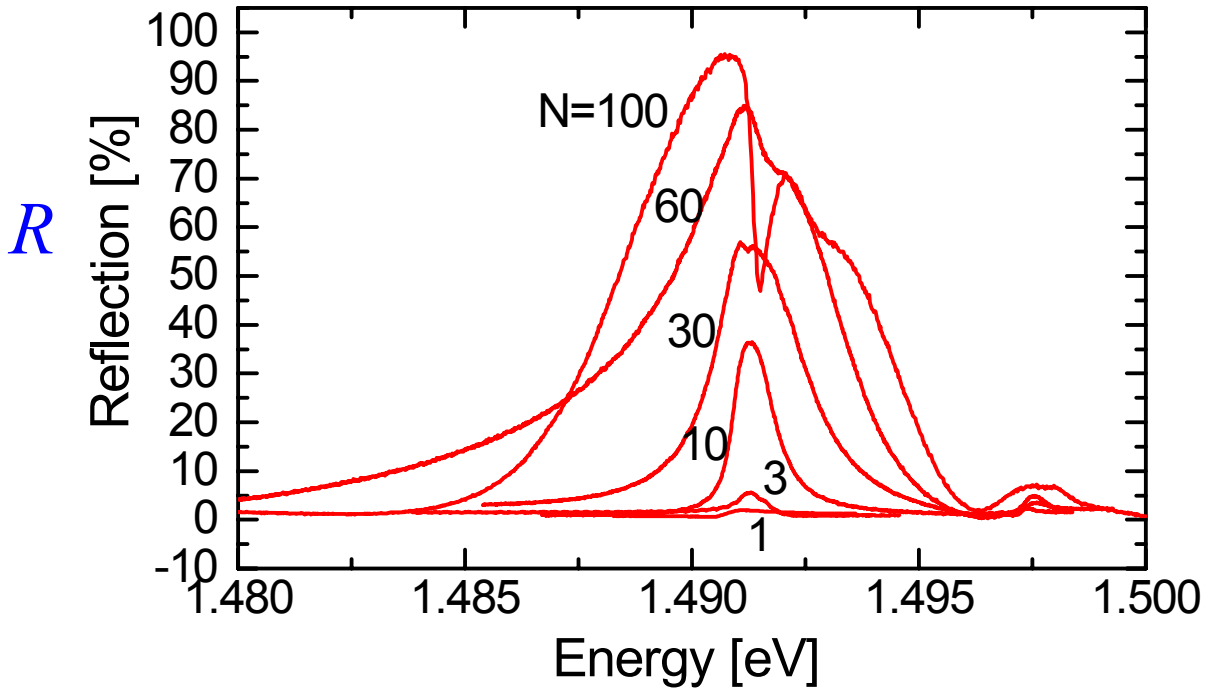


Multiple Quantum Wells

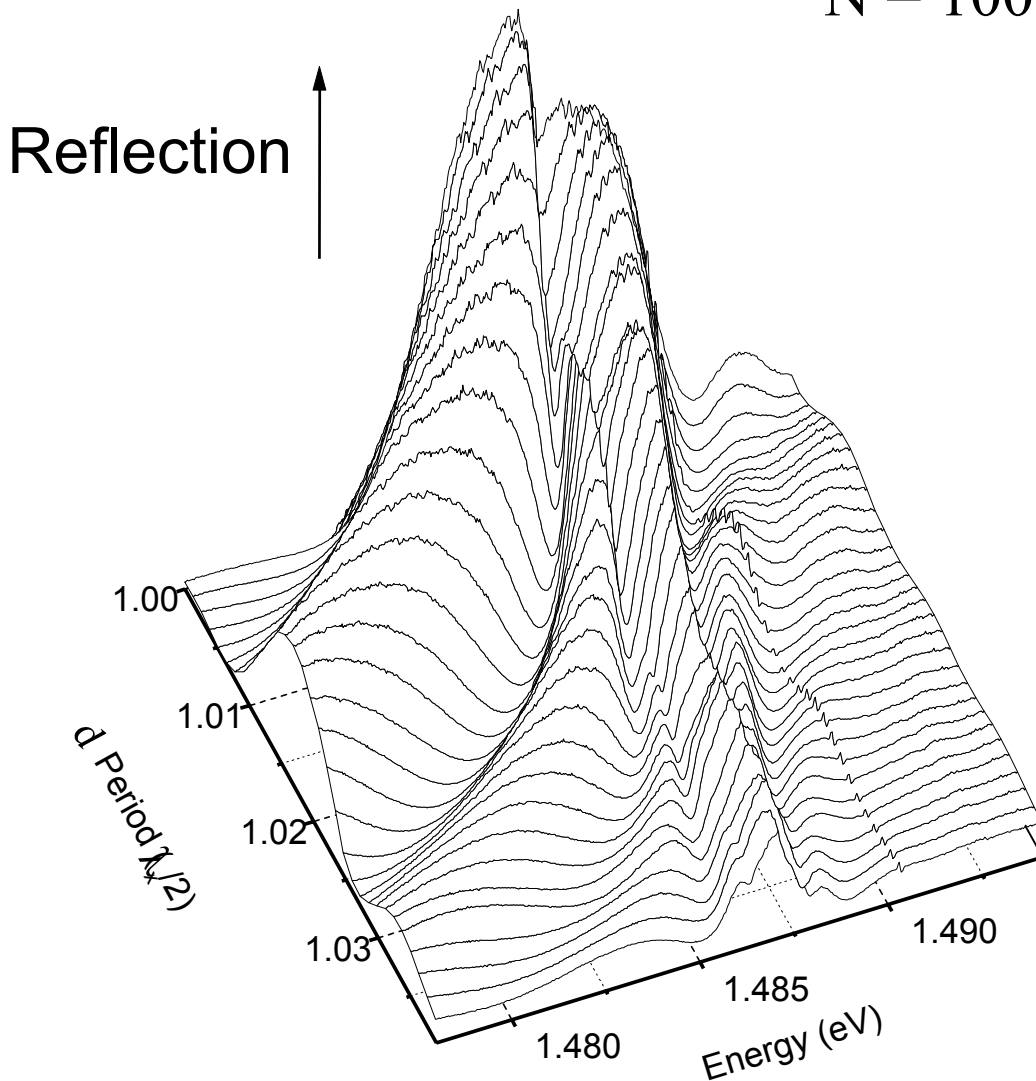


- d small: electronic tunneling
superlattice
- d large: no electronic tunneling
multiple quantum wells
- All d : radiative coupling

Evolution of Photonic Bandgap



$N = 100$

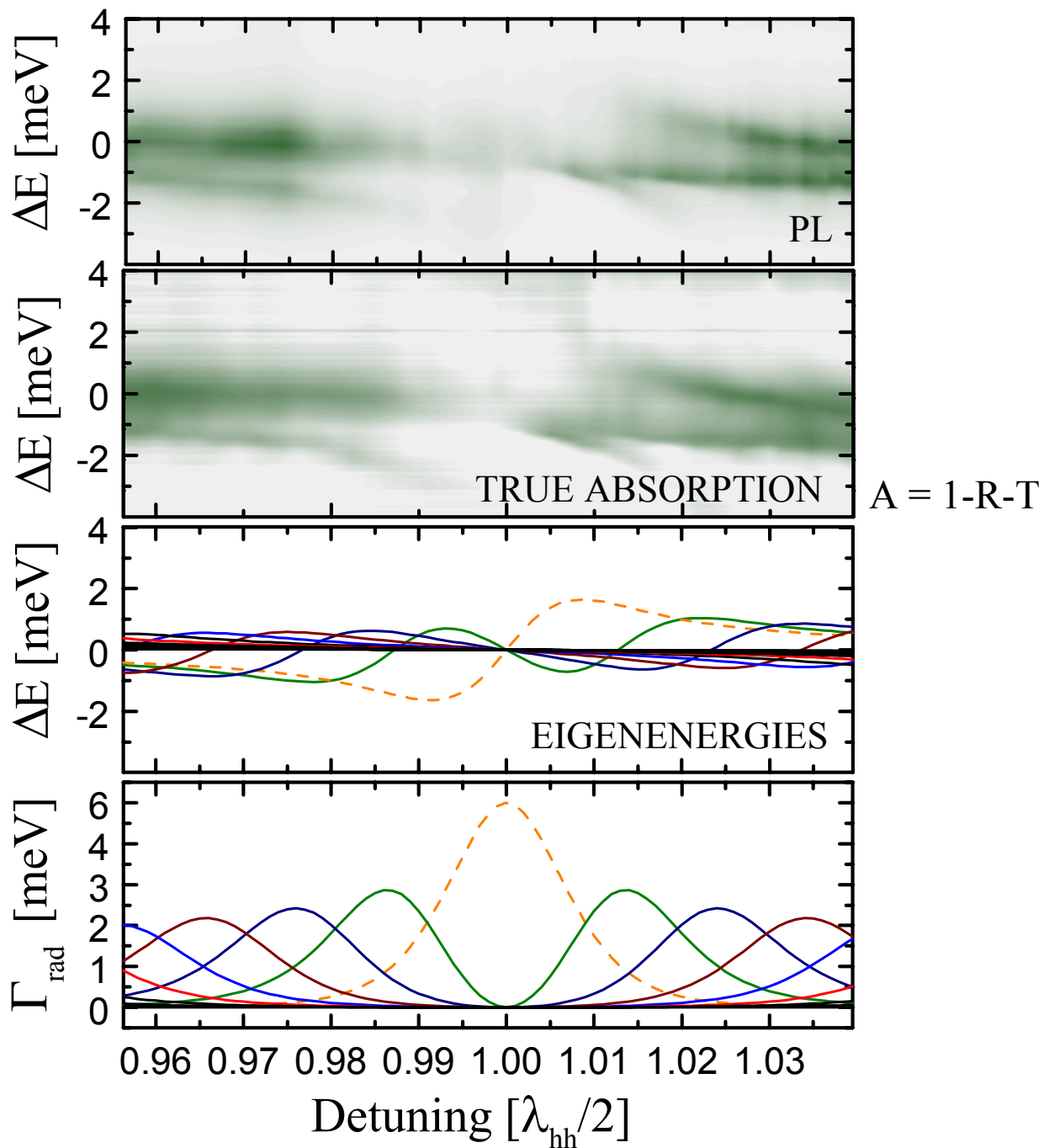


\Rightarrow **EVIDENCE FOR NORMAL MODES**

N eigenmodes – complex poles of the transmission coefficient

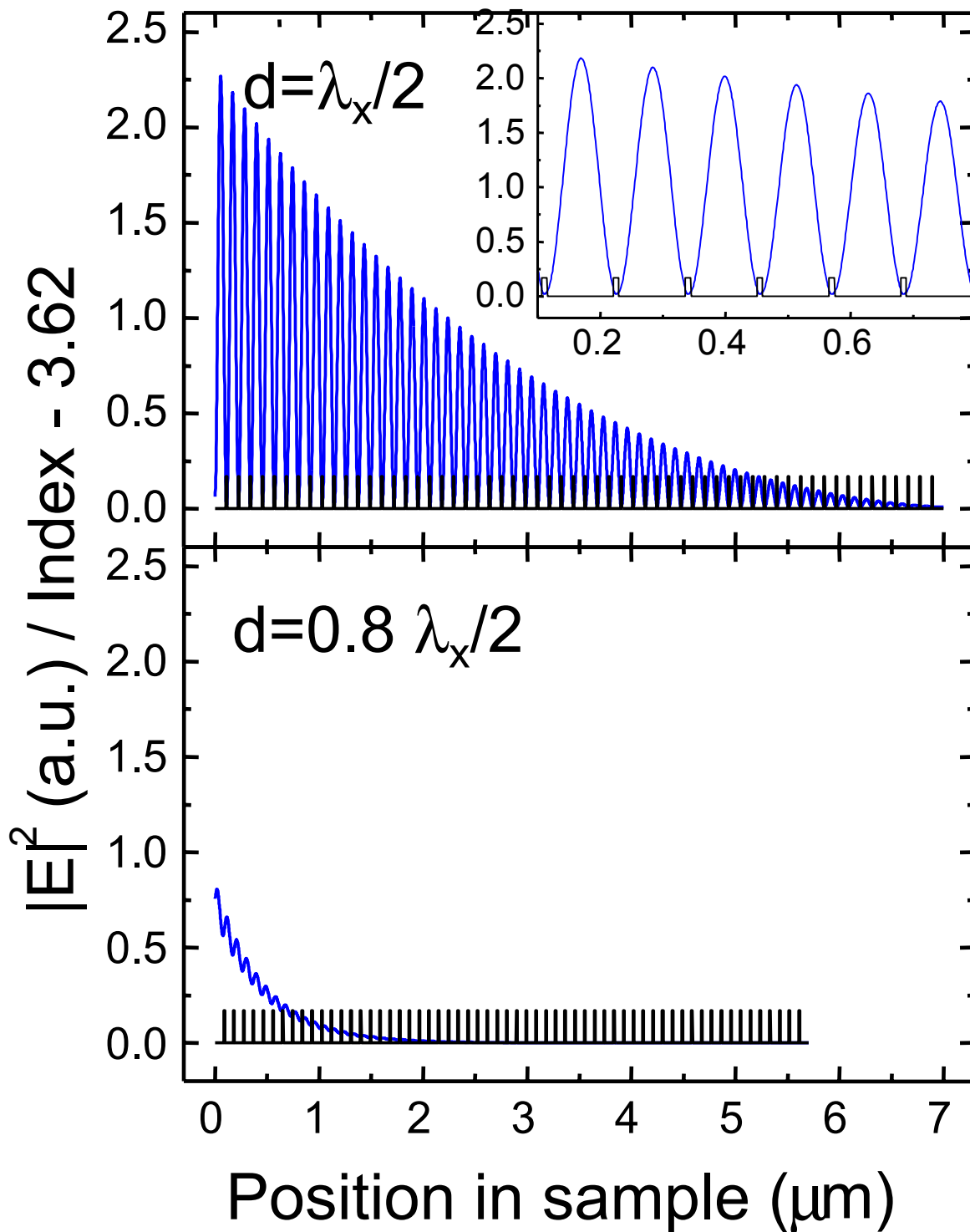
L.C. Andreani, *phys. stat. sol. b* **29**, 188 (1995)

100 Coupled Quantum Wells



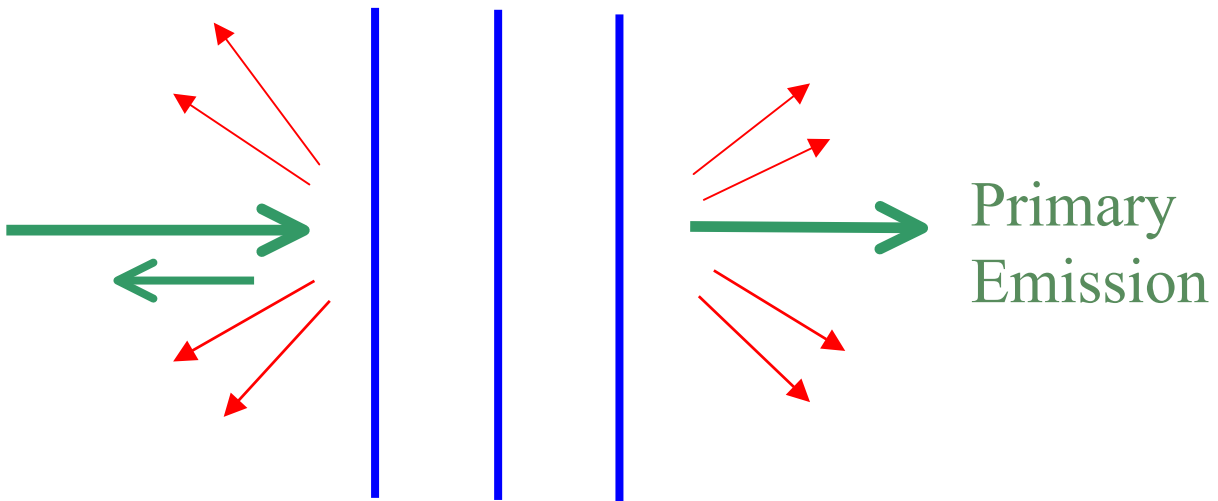
Field Distribution

N=60



Light-Coupling Dominance of Resonant Rayleigh Scattering from Periodic Quantum Wells

Disordered
quantum wells



Secondary emission:

Resonant Rayleigh scattering (RRS)

Resonant photoluminescence (RPL)

Resonance Rayleigh Scattering

Bell Labs

Jagdeep Shah

John Prineas

Spectral Interferometric Technique
(Berkedal & Shah)

10° incidence

Collect in 10° half angle about

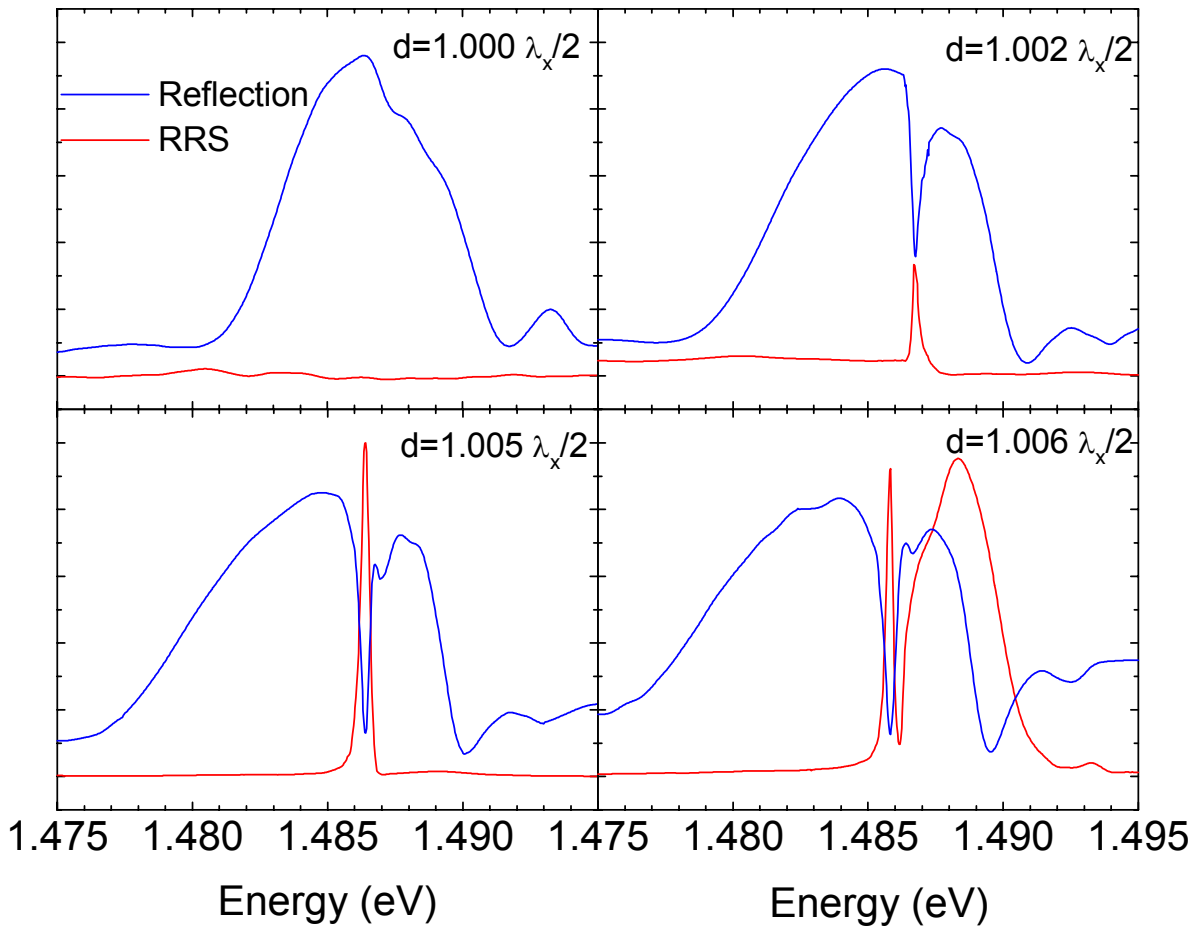
Specularly reflected

Iris to select speckle

Interfere with reference

Speckle appears to be completely coherent

Suppression of Resonant Rayleigh Scattering at Bragg Periodicity

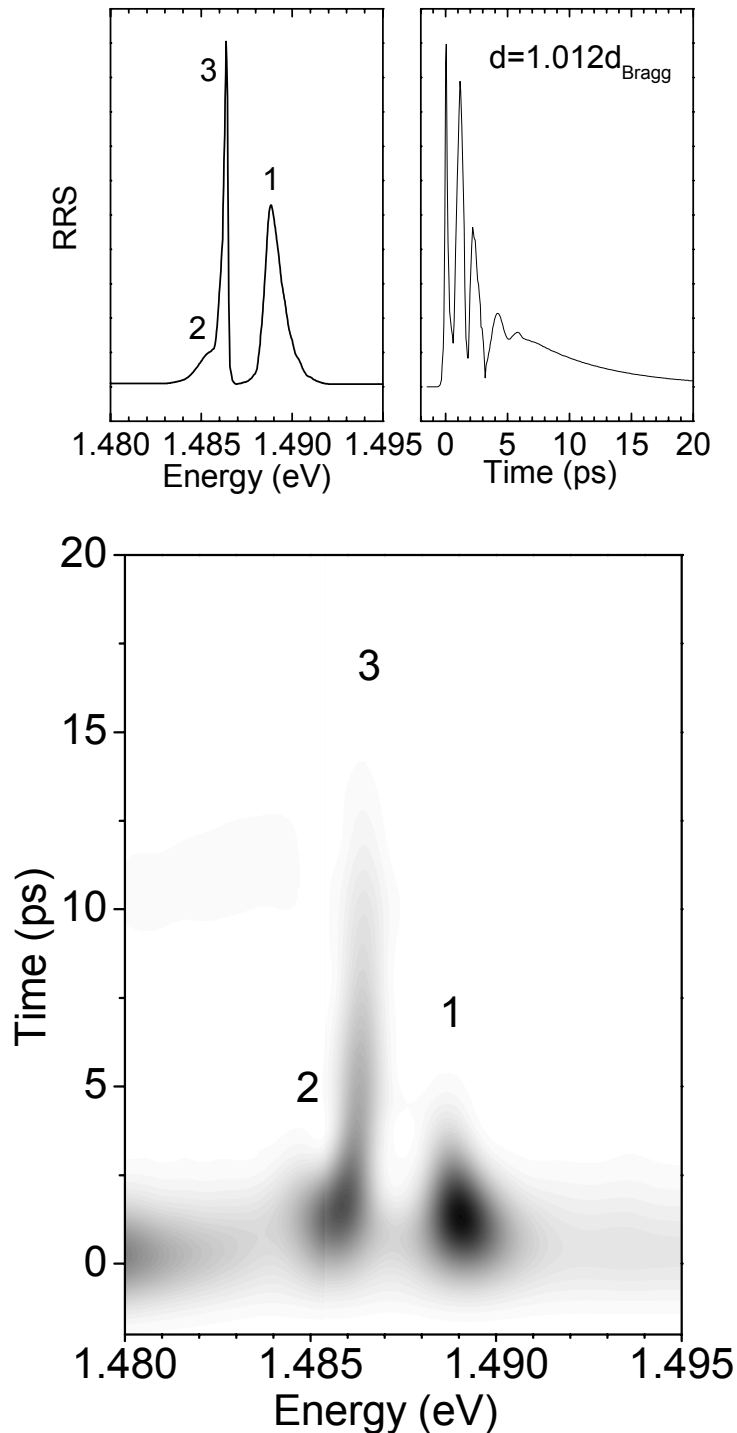


At Bragg, all polarization decays fast (100 fs) in the forward and backward direction

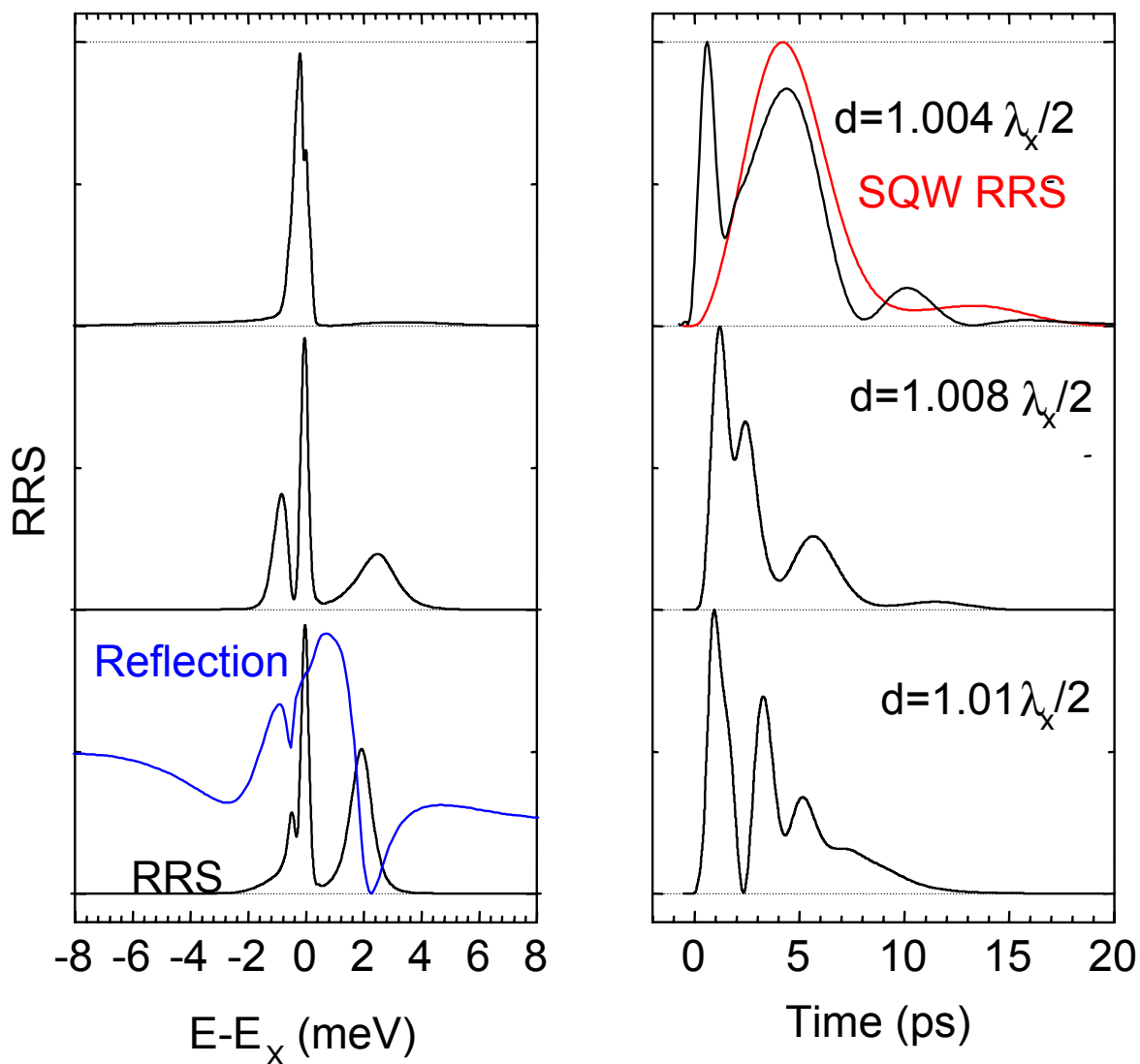
Longer risetime of RRS (pstimescale) means it gets suppressed

Dynamics of Modes in RRS Extracted Using the Pseudo-Wigner Function

$N=100$, $d=1.01 \lambda_{\text{ex}}/2$, $\Delta t=2\text{ps}$, $\Delta E = 1.84 \text{ meV}$



Calculated RRS Signals for a N=100 MQW

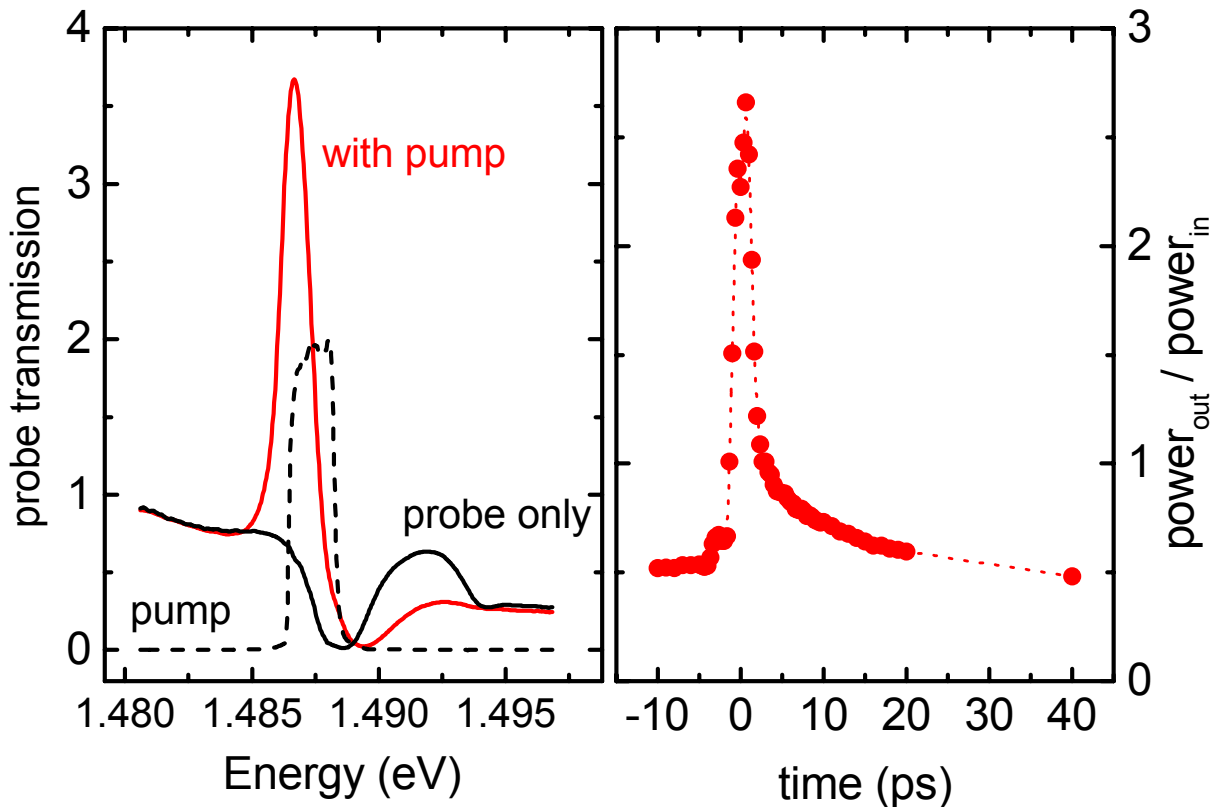


$$\sigma = 0.45 \text{ meV}$$

$$\lambda = 3\alpha_0 \approx 20 \text{ nm}$$

GROTE et al. PRB to be published

Large Optical Gain in Pump-Probe Measurements



- pronounced optical gain
- fast recovery
- possible application
 - ➔ optical switch of a 2.4 ps pulse

References

Light-Coupled Quantum Wells

M. Hübner, J P. Prineas, C. Ell, p. Brick, E.S. Lee, G. Khitrova, H.M. Gibbs, and S. W. Koch, Phys. Rev. Lett. **83**, 2841 (1999).

J.P. Prineas, C. Ell, E S. Lee, G. Khitrova, H.M. Gibbs and S. W. Koch, Phys. Rev. B. **61**, 13863 (2000).

Light-Coupling Effects in Resonant Rayleigh Scattering:

J P. Prineas, J. Shah, B. Grote, H.M. Gibbs, G. Khitrova, and S.W. Koch, Phys. Rev. Lett. 85, 3041 (2000).

B. Grote, E. Ell, H M. Gibbs, G. Khitrova, S.W. Koch, J P. Prineas, and J. Shah, submitted to Phys. Rev. B.