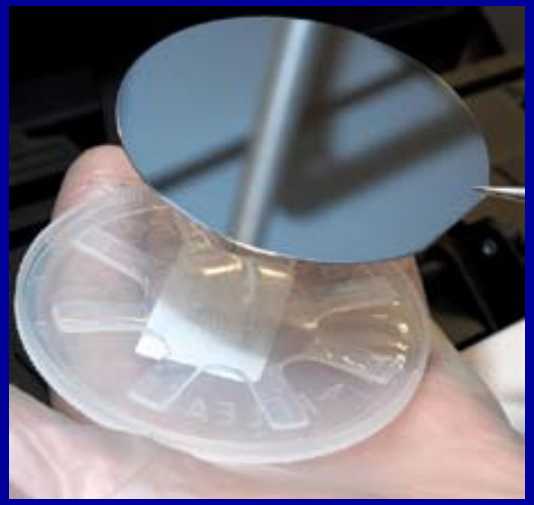
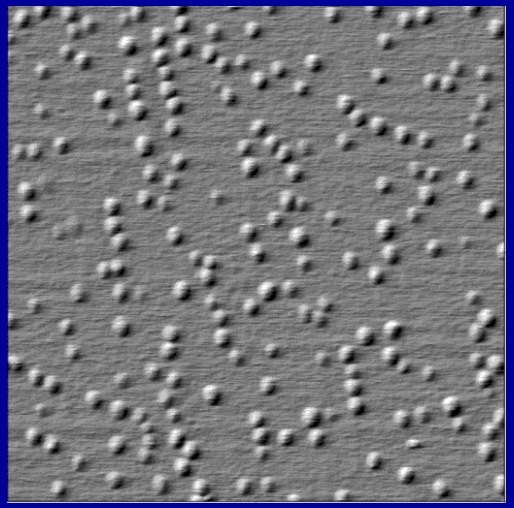
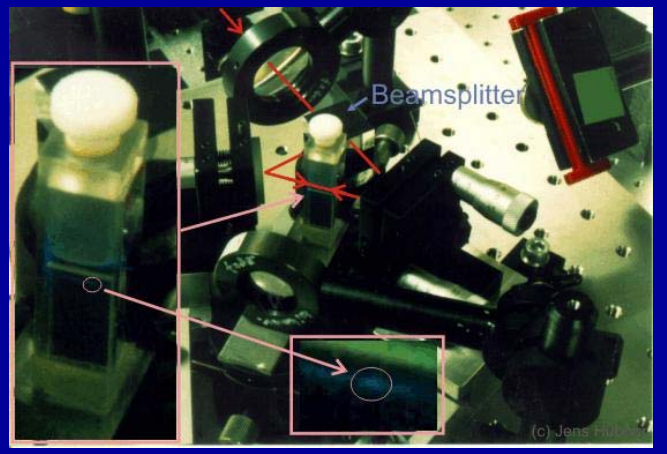
Forschungsschwerpunkte



Halbleiter

Nanostrukturen



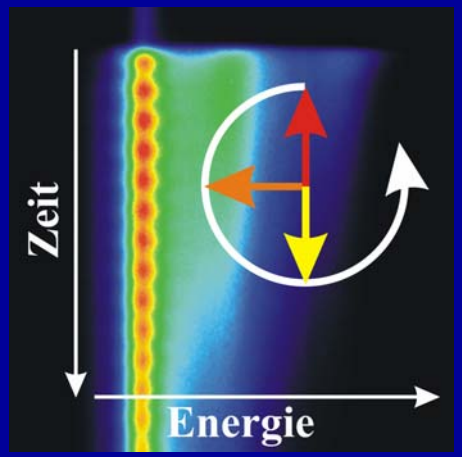


Alles was leuchtet
(Polymere, …)

Optische Spektroskopie und Transport an Nanostrukturen
Ladungsträgerdynamik (z.B. bosonische Exzitonenstreuung), Spin-Elektronik, …

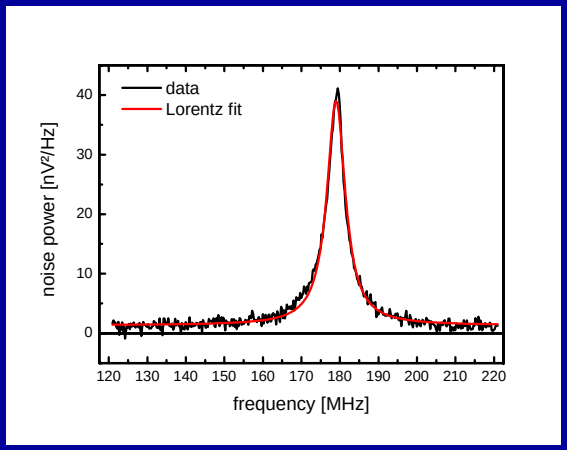
Michael Oestreich, Institute for Solid State Physics, Leibniz University Hannover, Germany

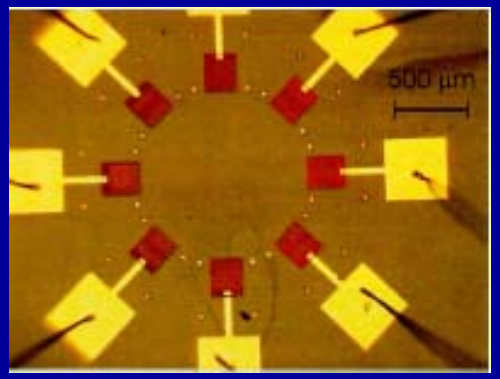
Experimentelle Methoden



Zeitaufgelöste Magnetooptik

Rauschmessung



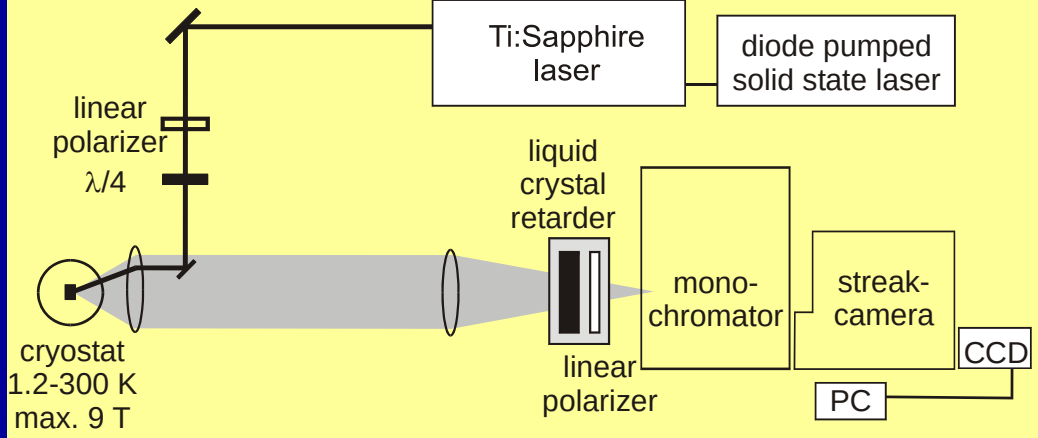


Transport

Michael Oestreich, Institute for Solid State Physics, Leibniz University Hannover, Germany

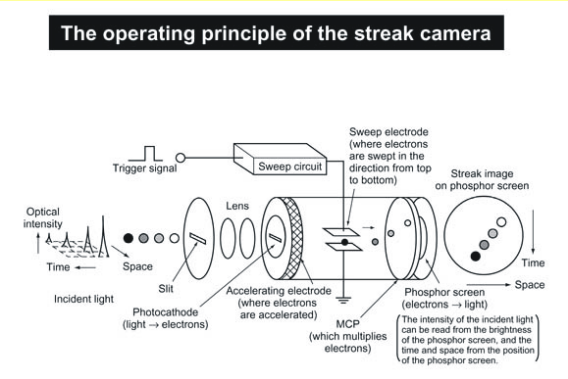
Zeitaufgelöste, Magneto-Photolumineszenz

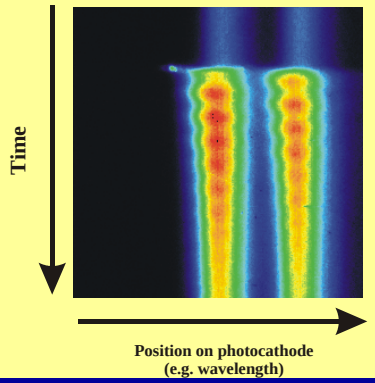
Setup:



+ elektrischer Transport

Principle:





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PRL 95, 216603 (2005) PHYSICAL REVIEW LETTERS week ending 18 NOVEMBER 2005

Spin Noise Spectroscopy in GaAs

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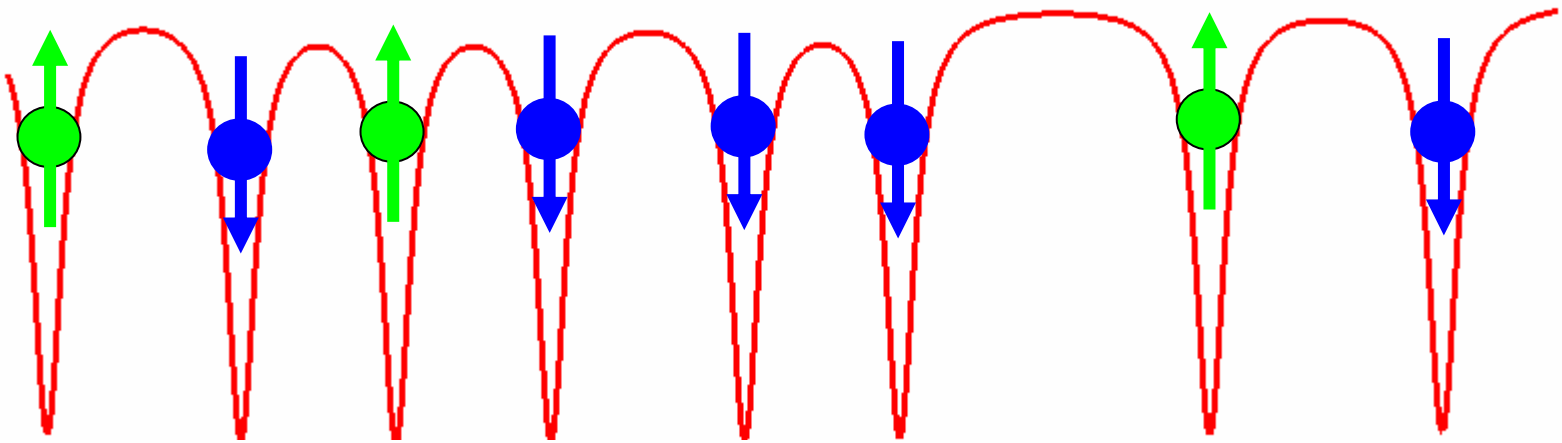
(Received 18 May 2005; published 17 November 2005)

Assumption:

1.) *N* electrons are localized at their donors

2.) Spins of the electrons are in thermal equilibrium

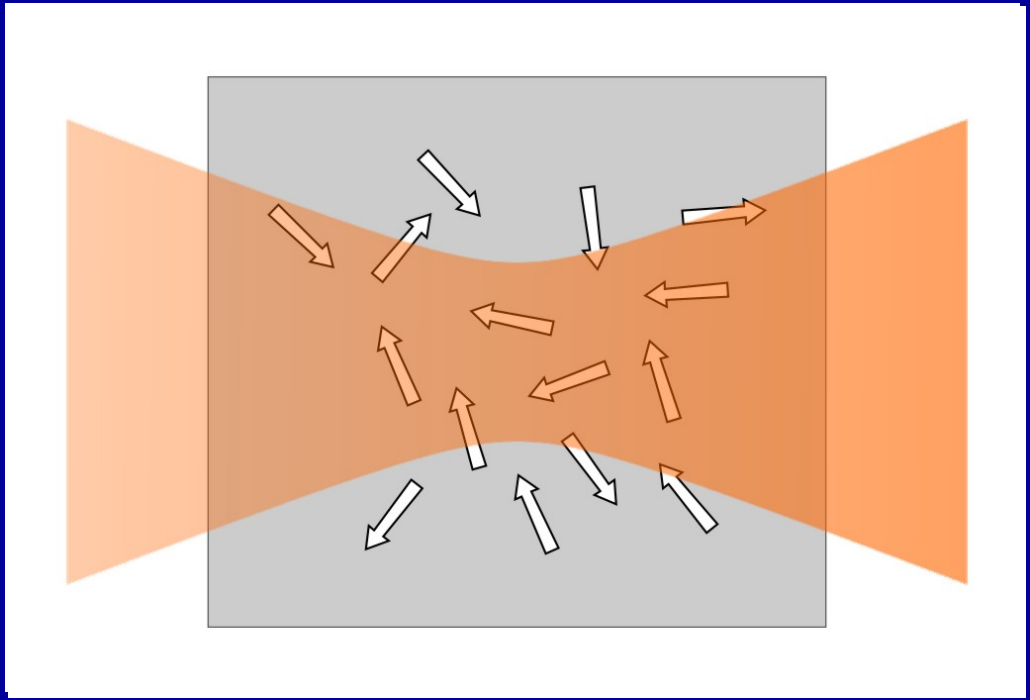
3.) Spins are independent from each other



$\Rightarrow$ in average $\sqrt{N}$ electron spins are spin oriented (Poisson distribution)

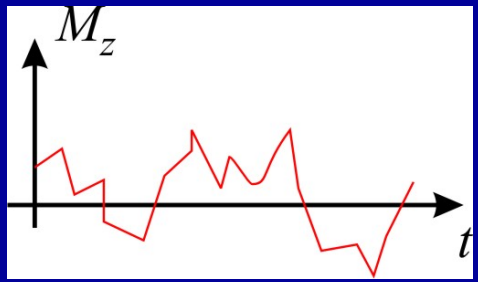
Measurement by Faraday rotation

Linear polarisierter cw Laser



Faraday Rotation

Messbar im transparenten Spektralbereich !



Zufällige „Magnetisierung“ Korrelationszeit = Spinlebensdauer

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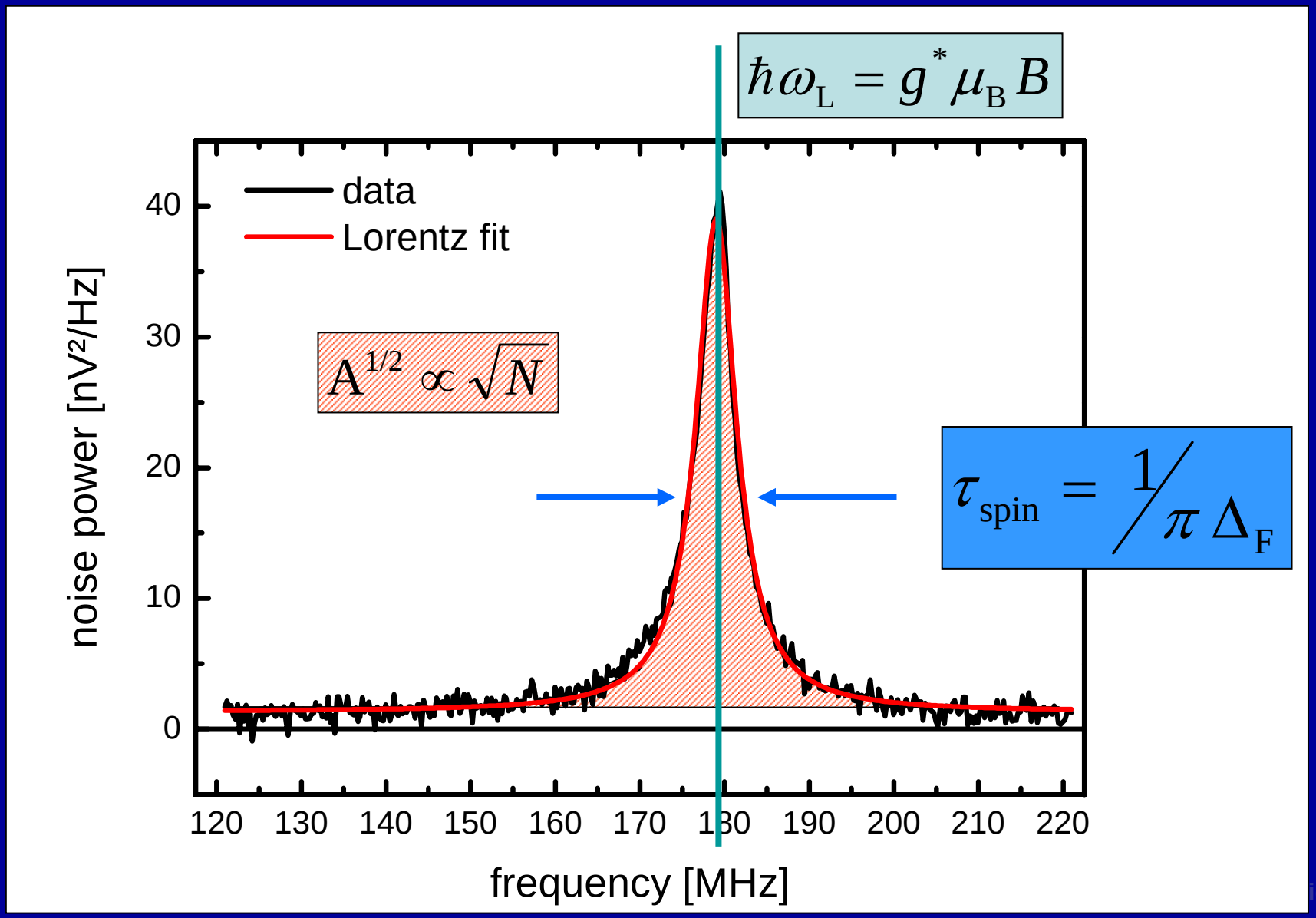
Spin noise spectrum



Spintronik -

die Elektronik der Zukunft ?

S. Döhrmann, M. Römer, S. Oertel, H. Horn, L. Schmidt,
S. Chen, J. Hübner

Michael Oestreich, Institute for Solid State Physics, Leibniz University Hannover, Germany

There's Plenty of Room at the Bottom

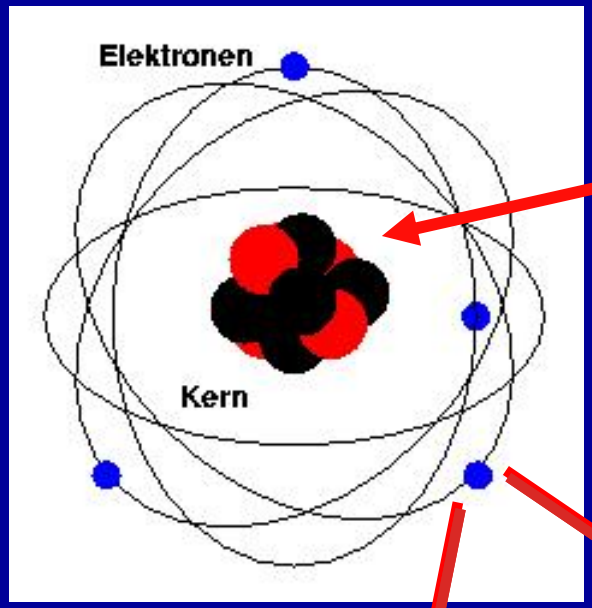
„When we get to the very, very small world … we have … completely new opportunities for design. … We can use, not just circuits, but some system involving … the interactions of quantized spins, etc.“

Richard P. Feynman, APS Meeting, 29.12.1959

There's Plenty of Room at the Bottom

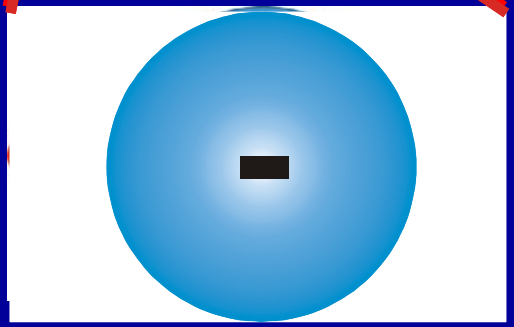
Atom

0,1 nm ~ 1/500.000 Haar



Kern-Spin

Elektron



Spin:

„Rotation“ des Elektrons

Motivation

today‘s electronics

- semiconductors, not metals
- electron‘s charge

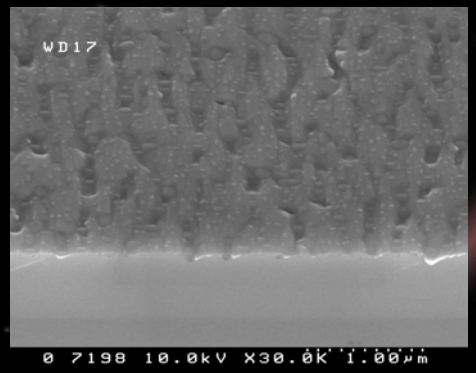
spintronics

- spintronics = semiconductor electronics + spin $\Rightarrow$ new functionality
- advantage : spin is a robust quantum mechanical system !!!

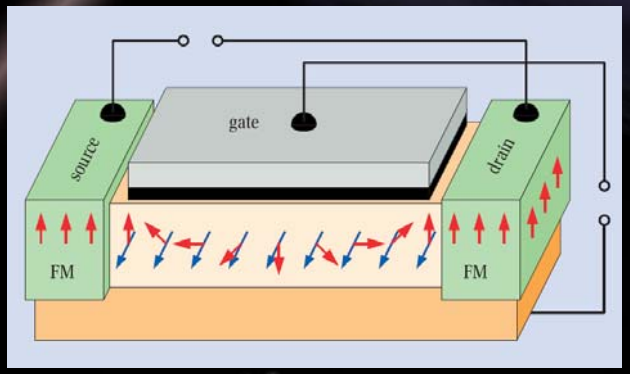
Fundamentals of

Semiconductor Spintronics

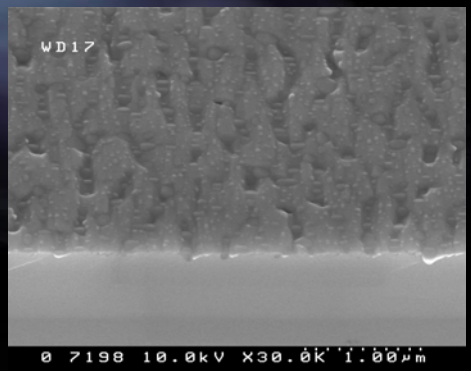
1.
Injection of
spin polarized carriers



2.
Manipulation of
spin polarized carriers



3.
Detection of
spin polarized carriers



Advantages of

Semiconductor Spintronics

- Quantum mechanically stable
  - electron spin
  - localized hole spin
  - nuclei spin
- New functionality
- Lower energy consumption /less heating ?
- … ???
- Exciting New Physics !!!

“Disadvantages” of

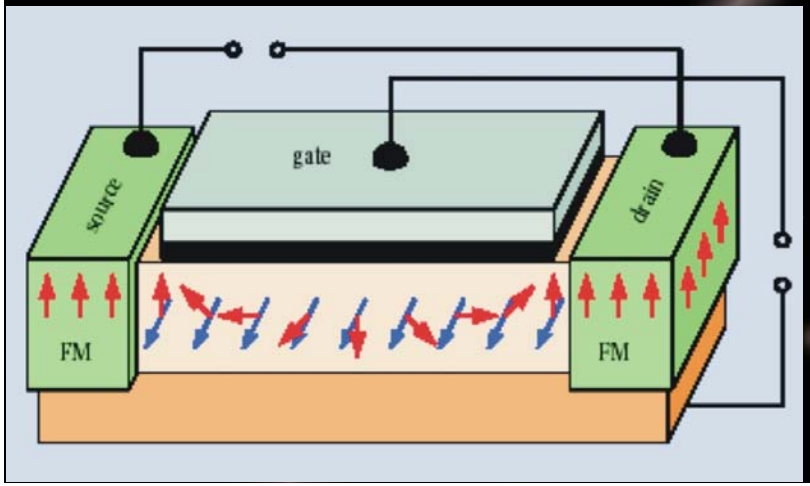
Semiconductor Spintronics

- Spins not in thermal equilibrium
  (in contrast to magneto electronics)
- Electron spin not conserved
  (in contrast to electronic charge)
- Spin orbit interaction used for spin control
  but leads to spin relaxation
- …

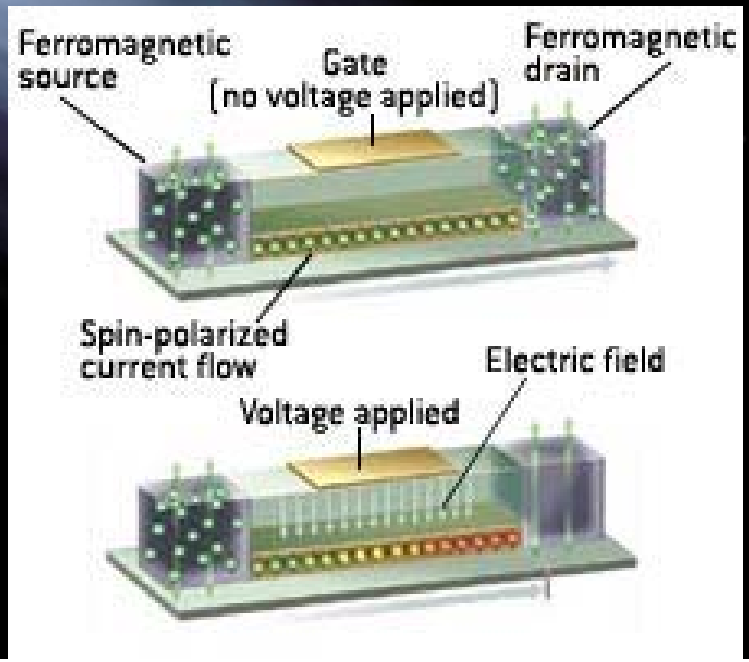
- Exciting New Physics required for future devices

Prospective Spintronic Devices

Spin transistor

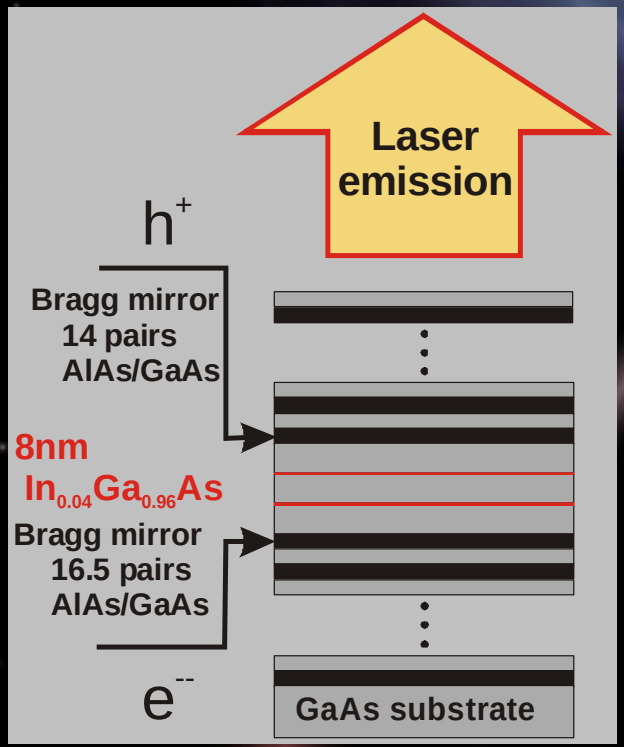


Spin FET
Reprogrammable Logic

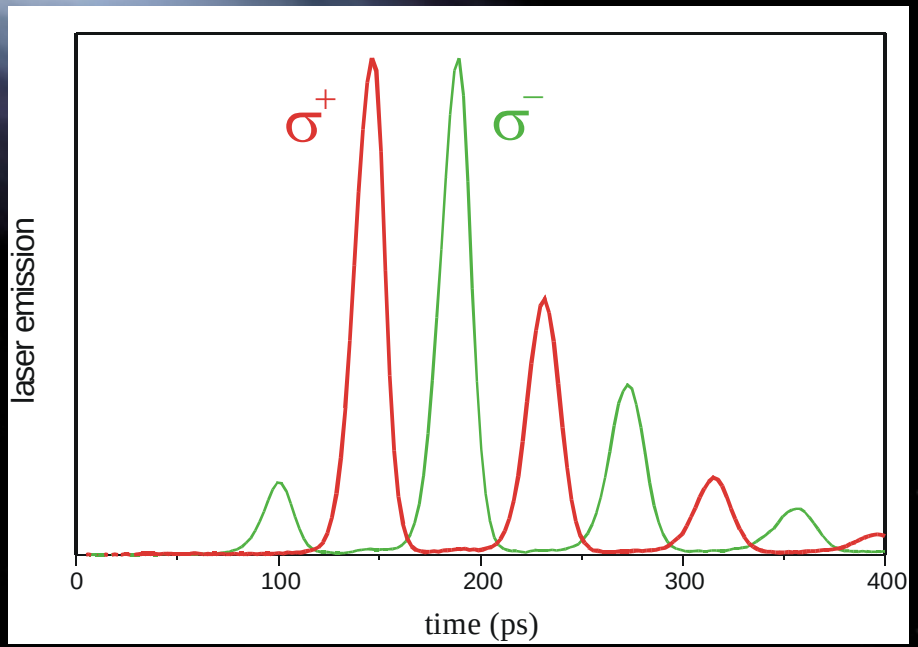


Prospective Spintronic Devices

Spin VCSEL



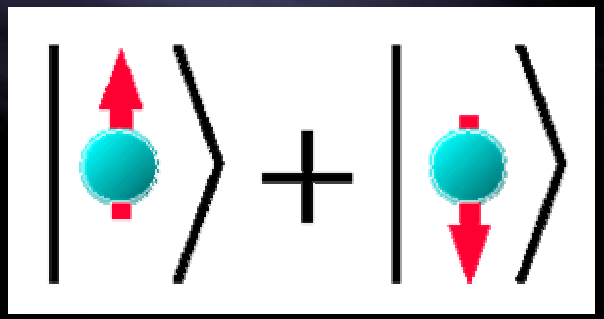
VCSEL intensity modulation by spin modulation

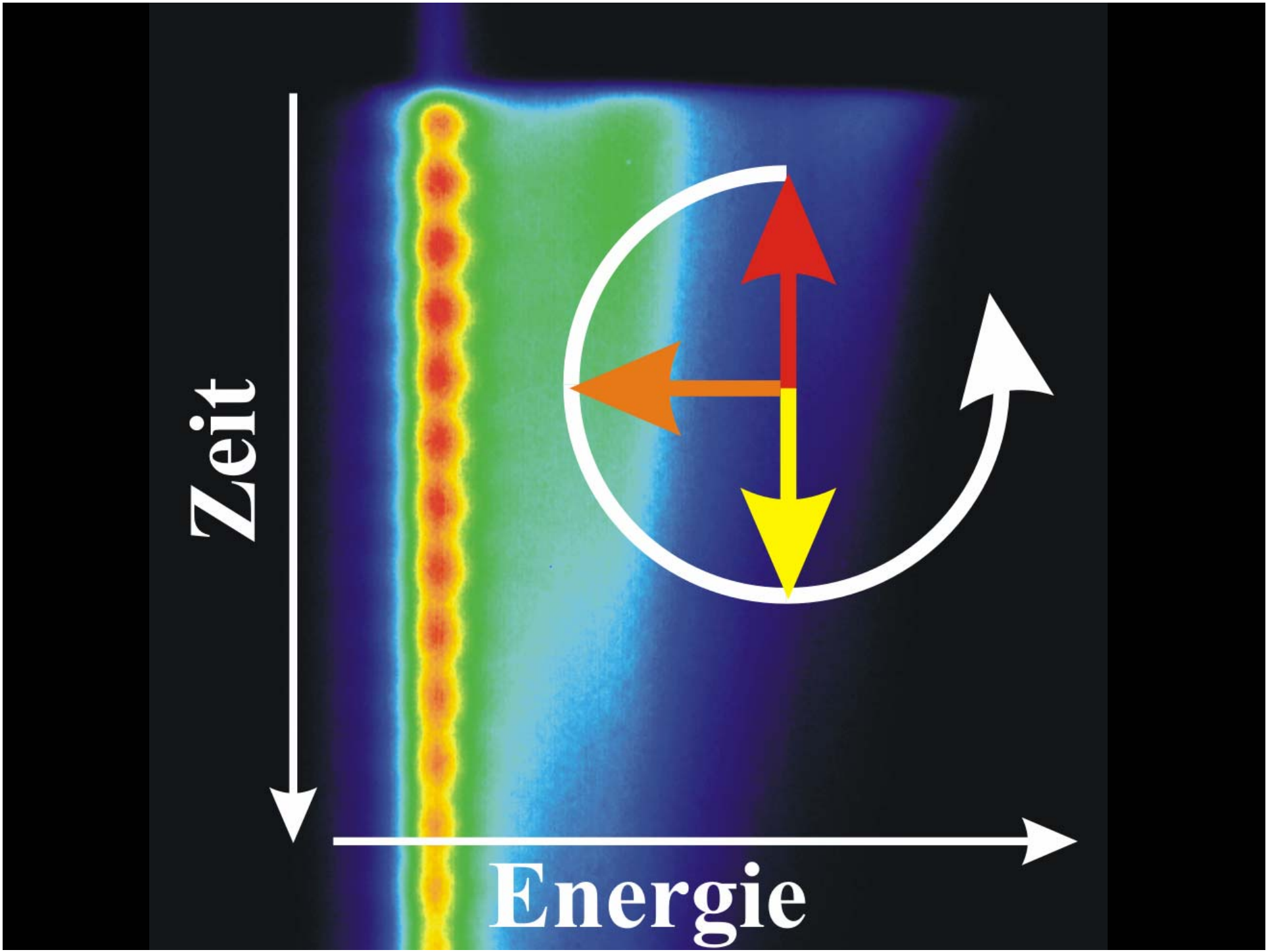


Prospective Spintronic Devices

$$|\psi\rangle = a_y |yes\rangle + a_n |no\rangle$$

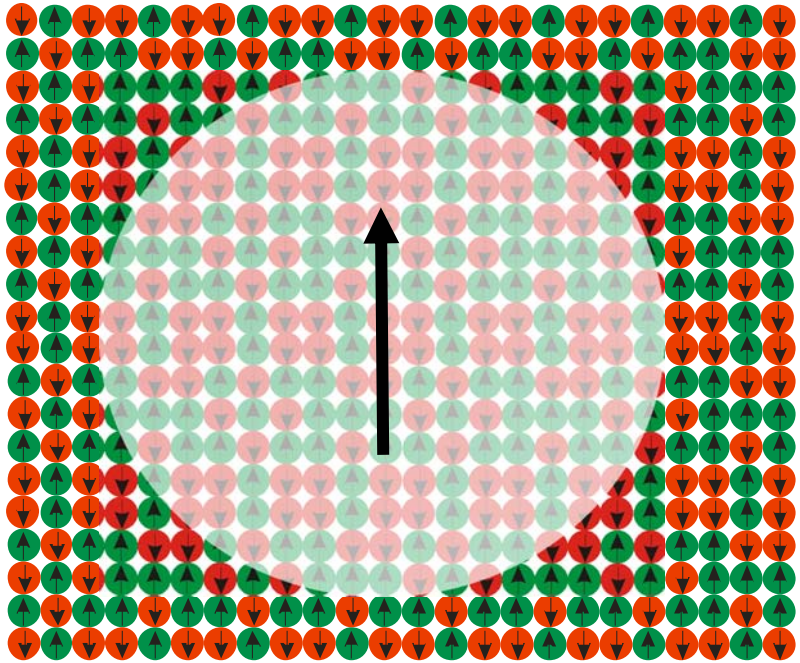
Spin
Quantum Computer



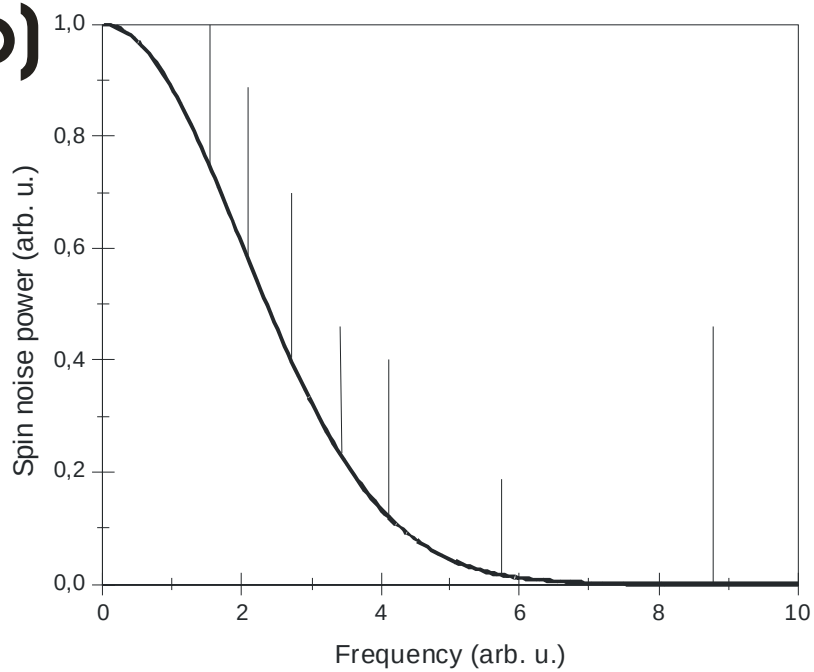

Zeit
Energie

Single spin dynamics

a)



b)



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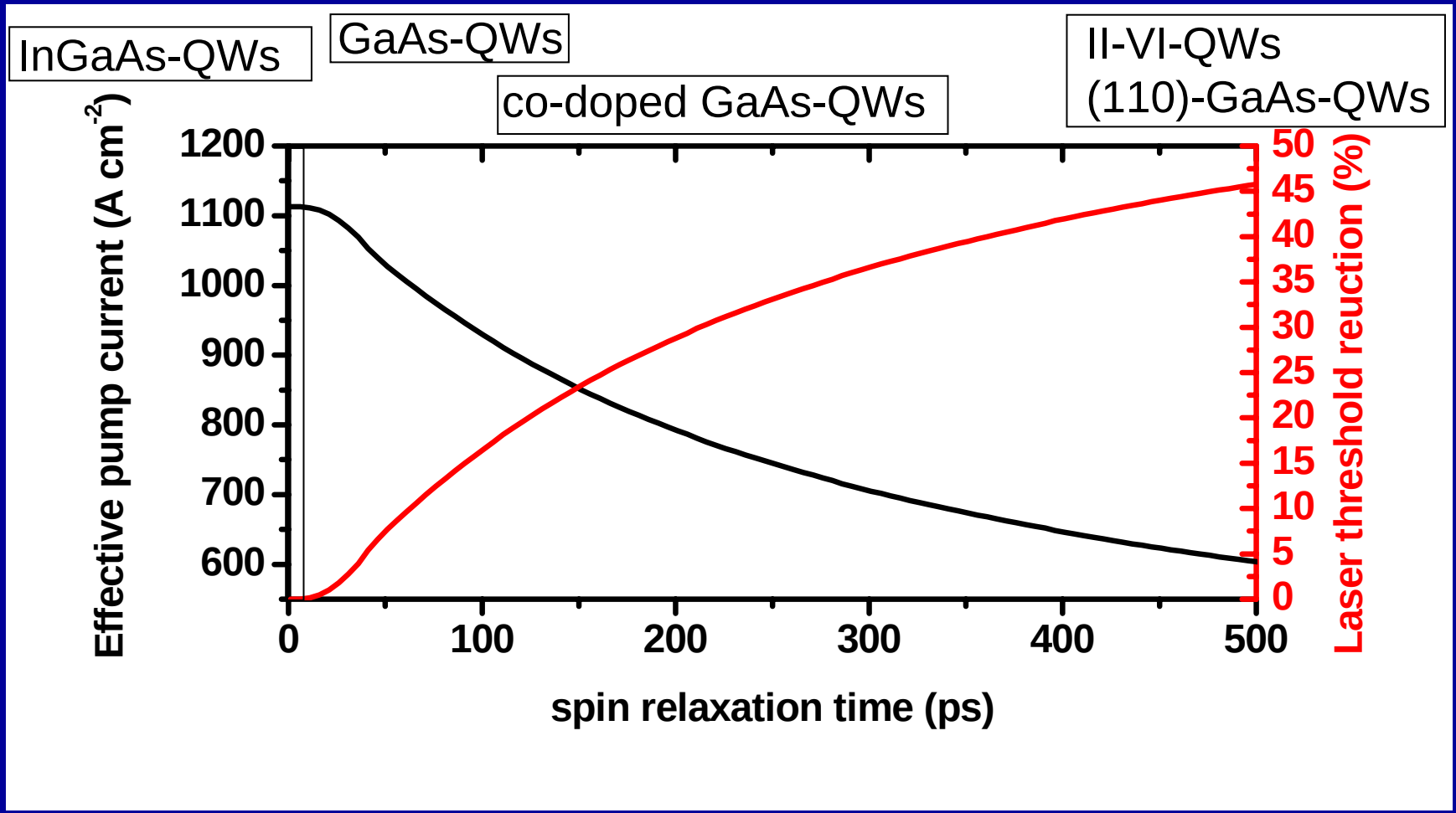
Room temperature spin dynamics



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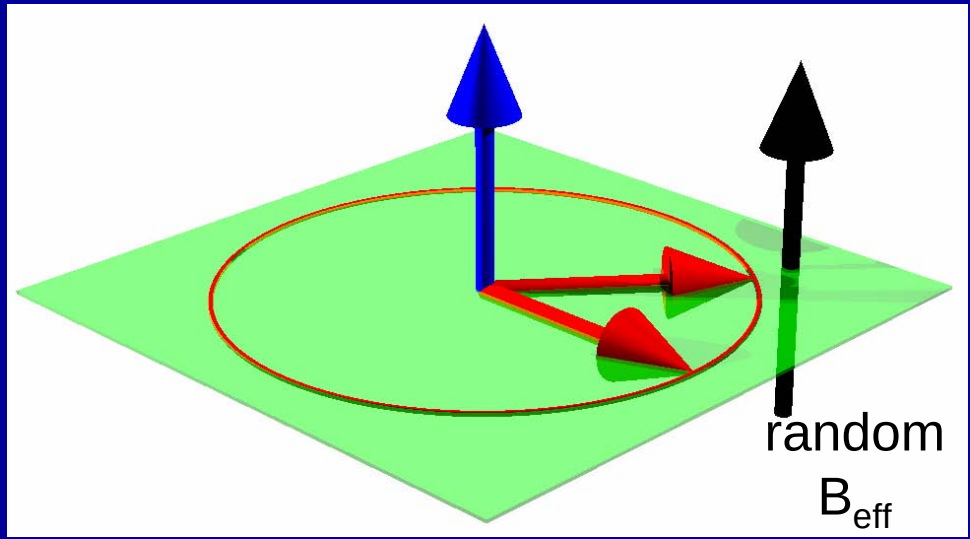
Spin relaxation in (110) GaAs QWs

Dresselhaus
lowest subband

$$\mathcal{H}_{110} = -\frac{1}{2}\Gamma\sigma_z k_x \left[\langle k_z^2\rangle - k_x^2 + 2k_y^2\right]$$



spin relaxation depends on spin orientation. $\gamma_z < \gamma_x$

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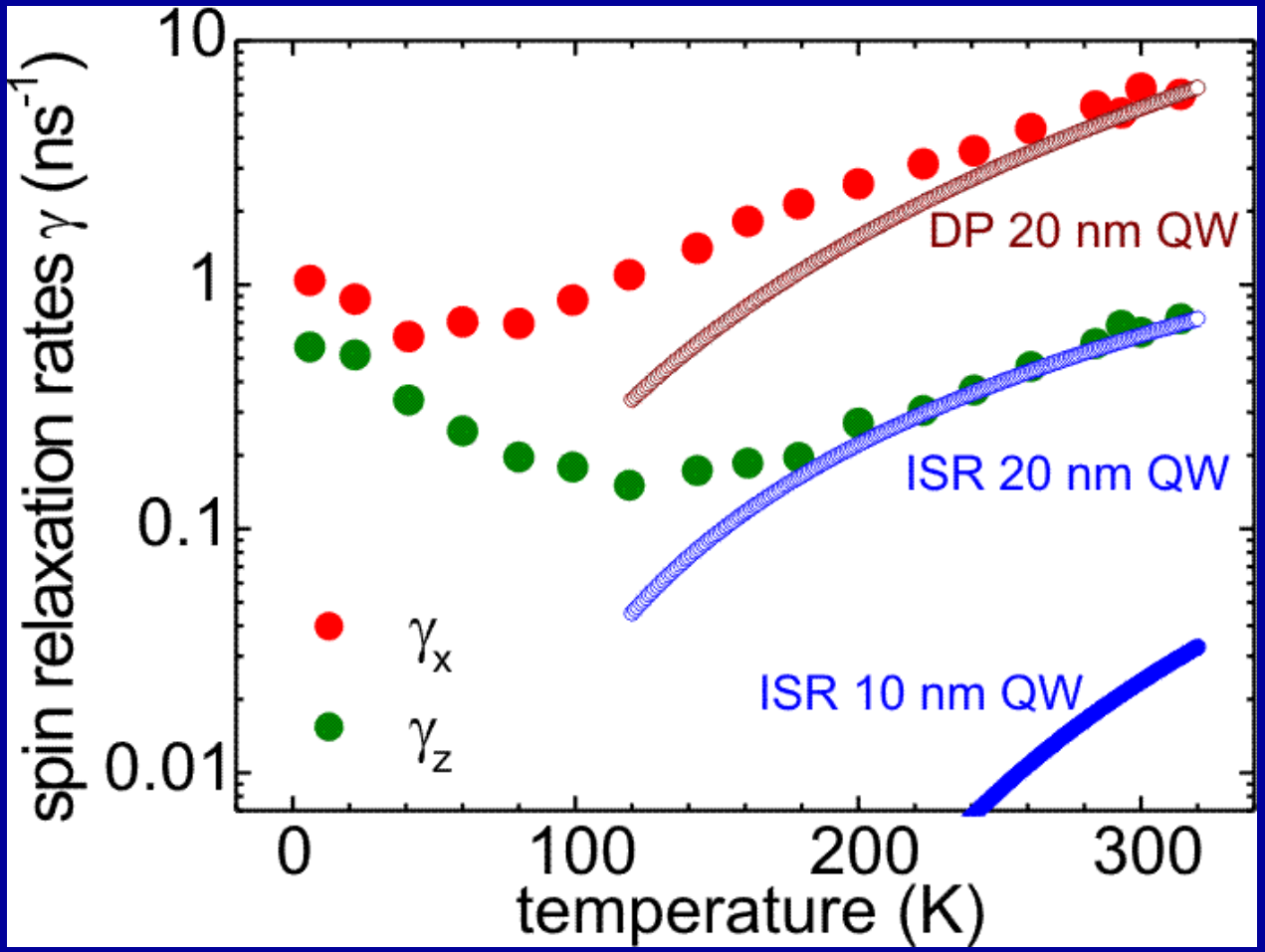
Intersubband Spin Relaxation (ISR)

Spin relaxation in (110) GaAs QWs



γ_p = 70 fs

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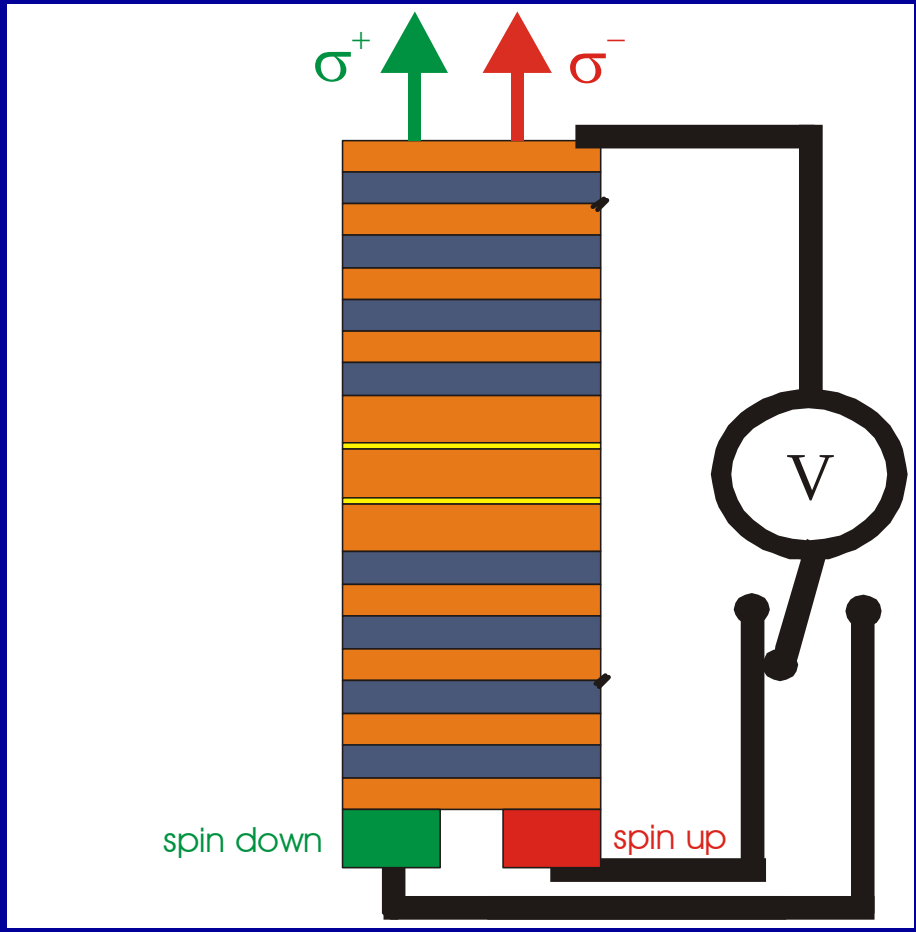
Spin-Optoelektronik

Spin

VCSEL



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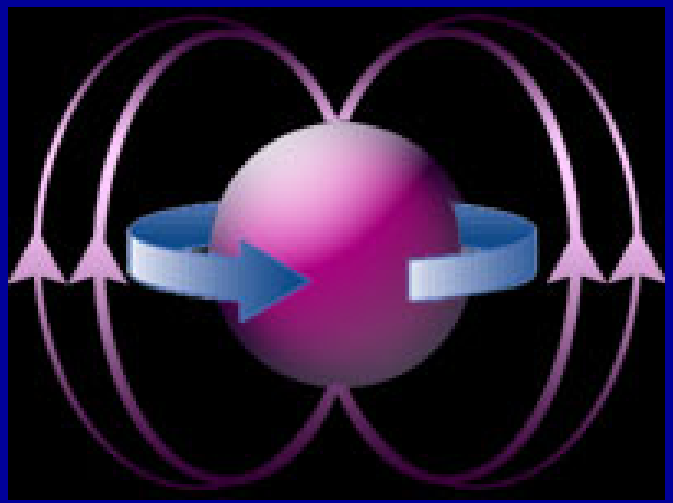
Spintronik -

die Elektronik der Zukunft ?

Von der Spin-Dynamik

zu

potentiellen Spin-Bauelementen



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