Revolution in der Festplatte - der Supermagnetwiderstand

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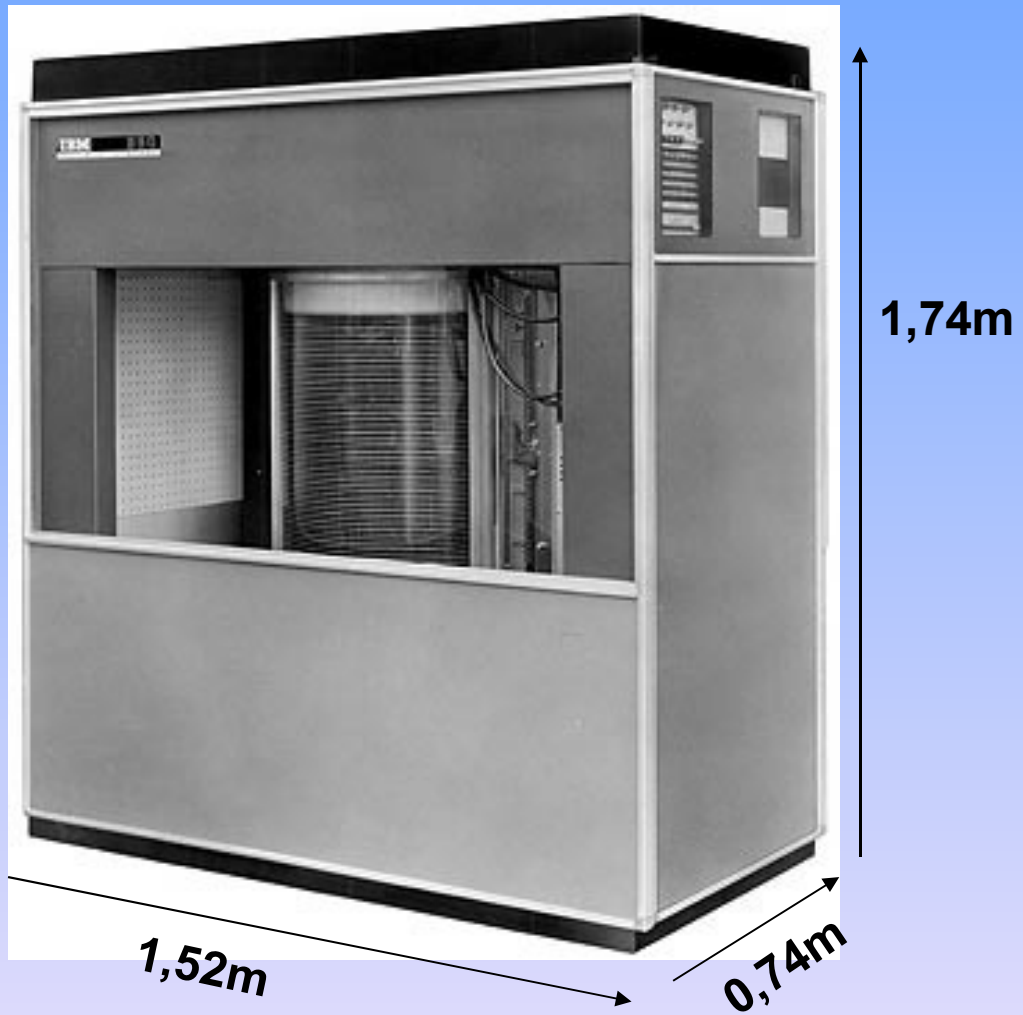
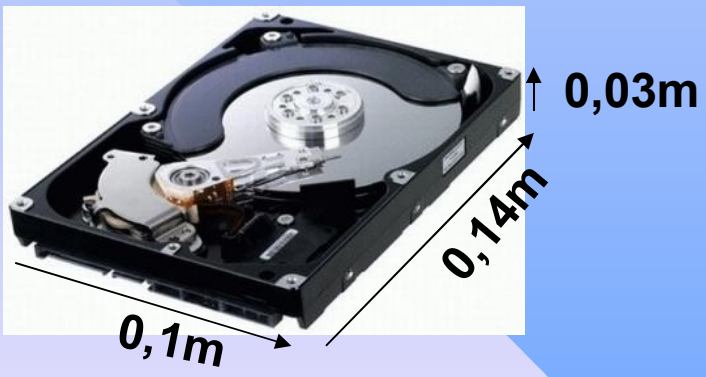
Festplatten: gestern und heute



IBM 350 (1956)



2010

Festplatten: 1956 vs. 2010

Kapazität	5 MegaByte	2 TeraByte
A4-Seiten	1 500	600 000 000
Umdrehungen	1200 Upm	5400 Upm
Zugriffszeit	600 ms	9 ms
Masse	1000 kg	0,7 kg
Maße	1,72 x 1,52 x 0,74 m	0,15 x 0,10 x 0,03 m

Festplatten: 1956 vs. 2010

2010

= 3x

1956

Festplatte

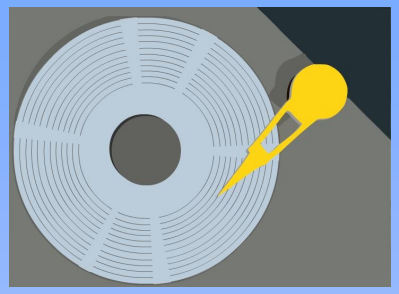
2 TByte

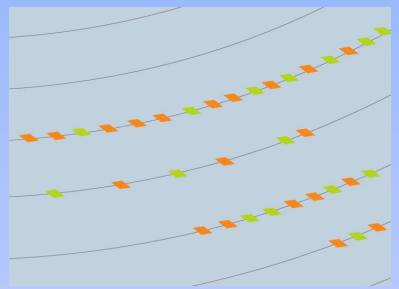
0.7kg

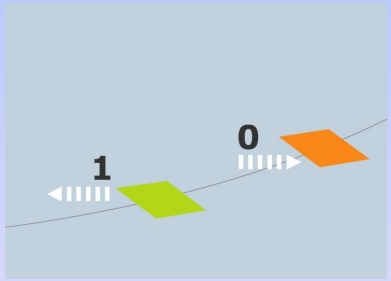
Queen Mary 2 wiegt 151.400 Tonnen

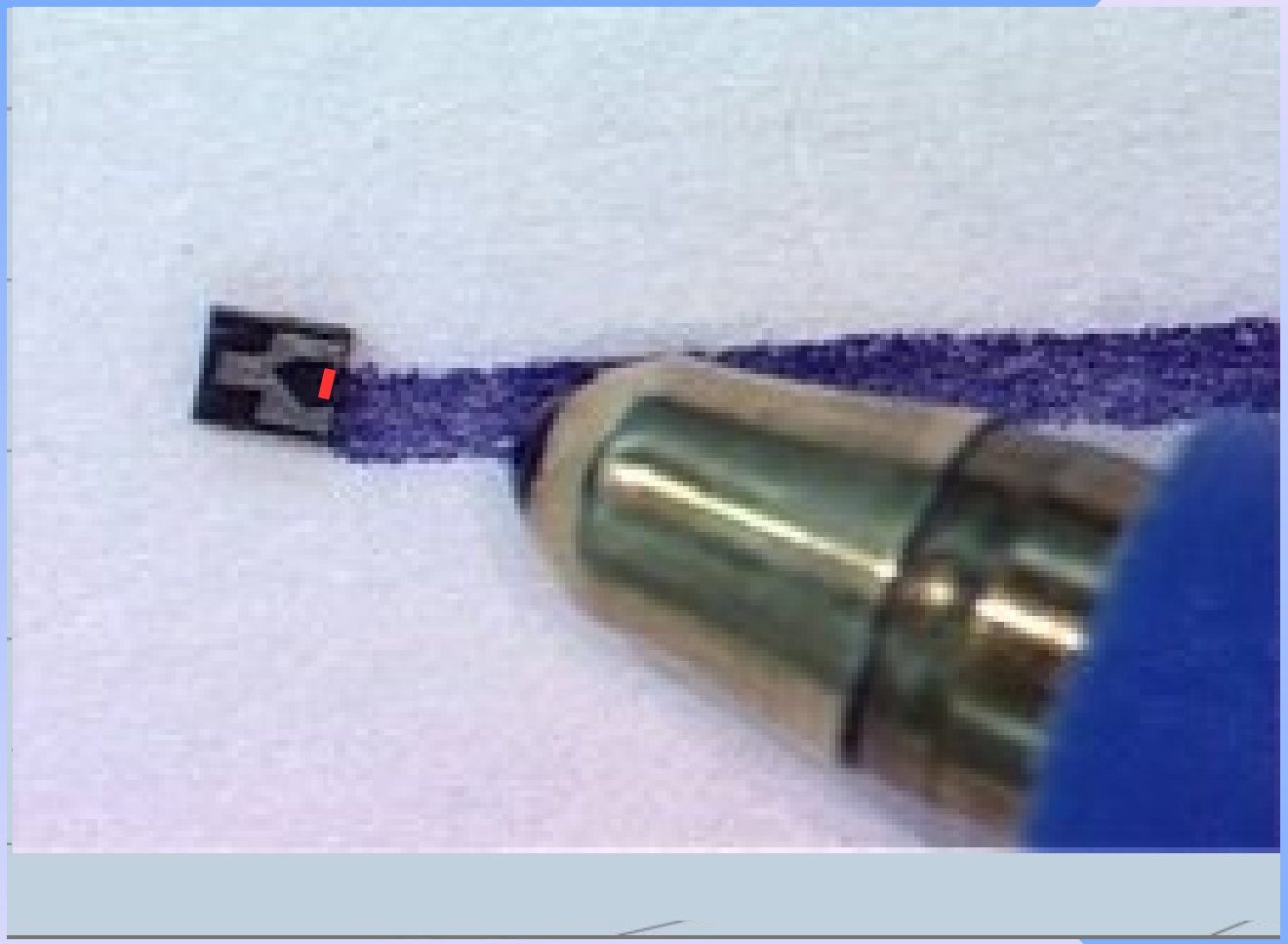
Wie funktioniert eine Festplatte?

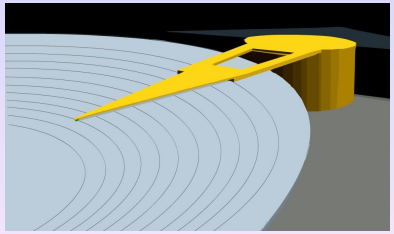
JÜLICH FORSCHUNGSZENTRUM

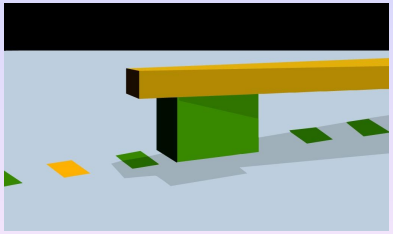


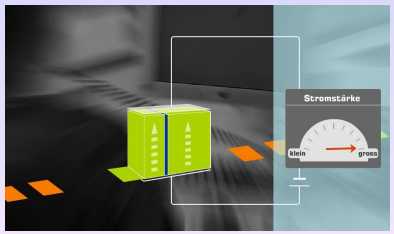


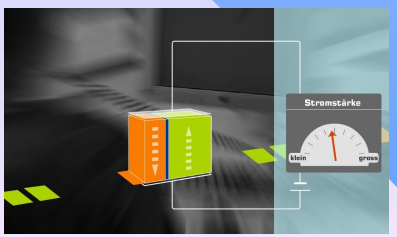












Der Supermagnetwiderstand: Physikalische Grundlagen

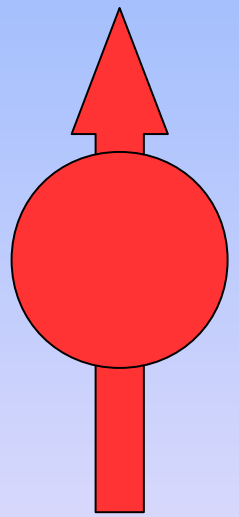
Der Spin des Elektrons und Magnetismus

Magnetische Zwischenlagenkopplung

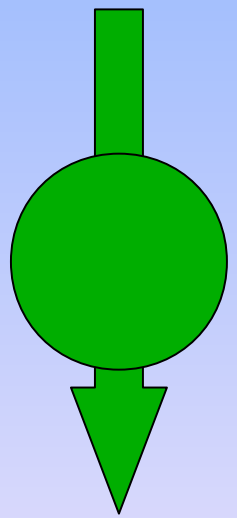
Spinabhängiger Widerstand – Magnetwiderstand

Der Elektronenspin

Spin = ½
Eigendrehimpuls



$m_S = 1/2$



$m_S = -1/2$

1925

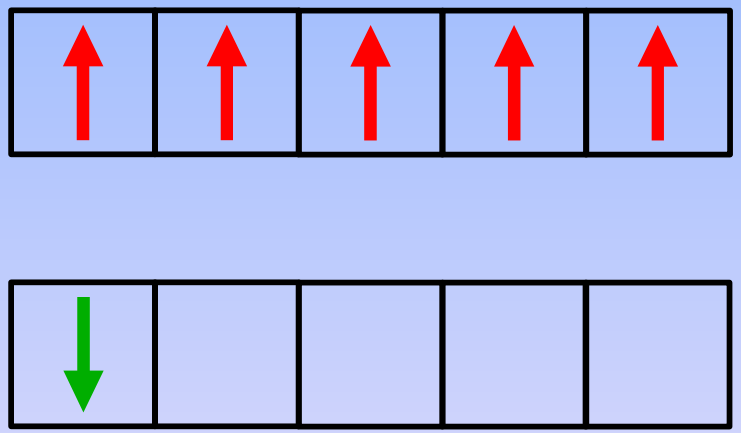
Wolfgang Pauli (1900-1958)

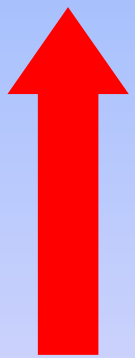
Nobelpreis 1945

Magnetismus: Hundsche Regel

Gesamtspin S maximal

Fe Z=26 1s 2s 2p 3s 3p 3d 4s Eisen





$\mu_{Atom} = 4$

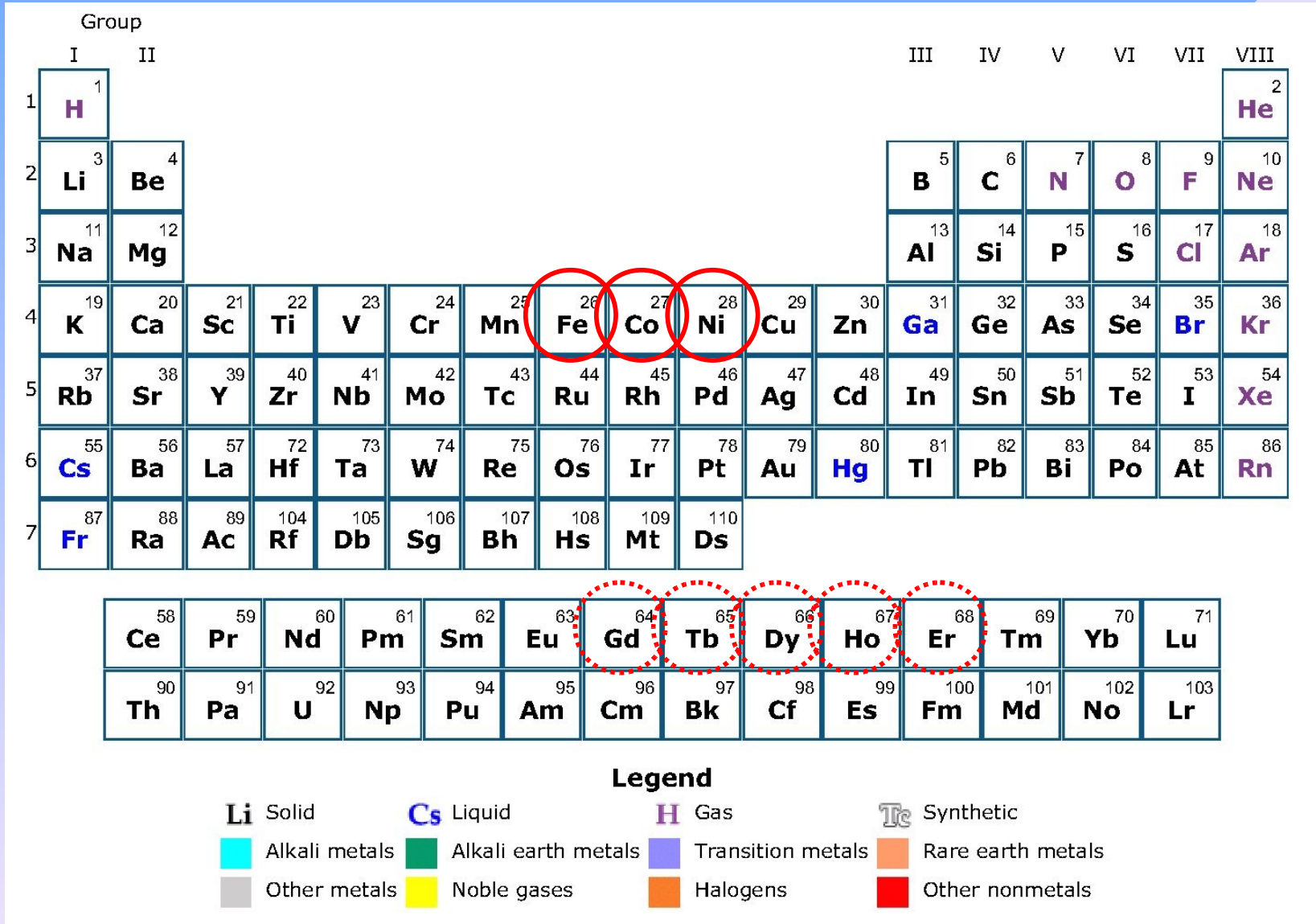
1925

Festkörper

$\mu = 2.1 \mu_B$

Friedrich Hund 1896-1997

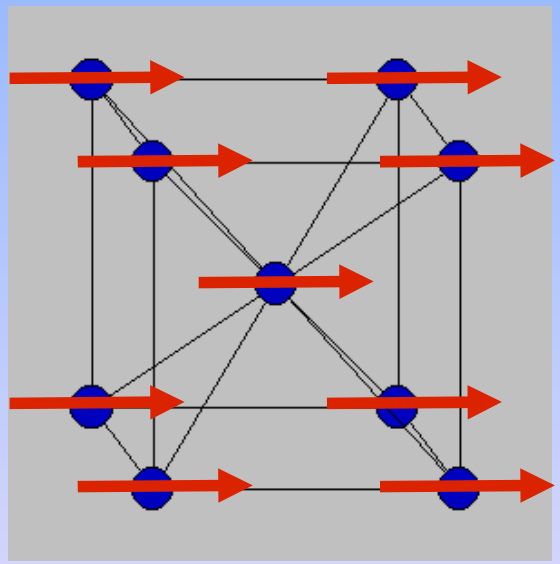
Magnetische Elemente



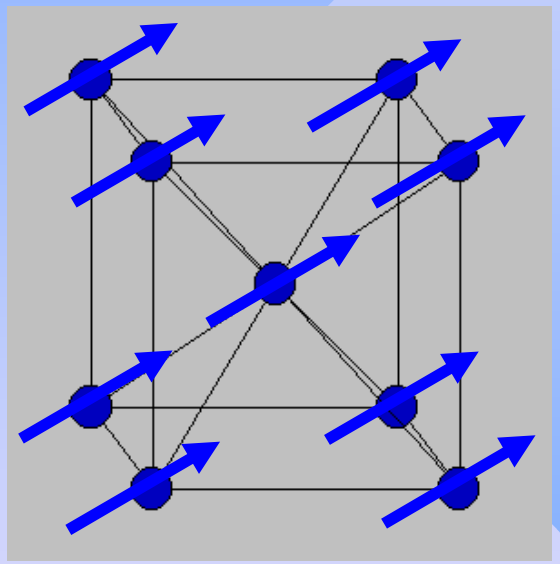
www.chemicool.com

Magnetisch leichte und schwere Achsen

Eisen-Kristall-Gitter: kubisch-raumzentriert



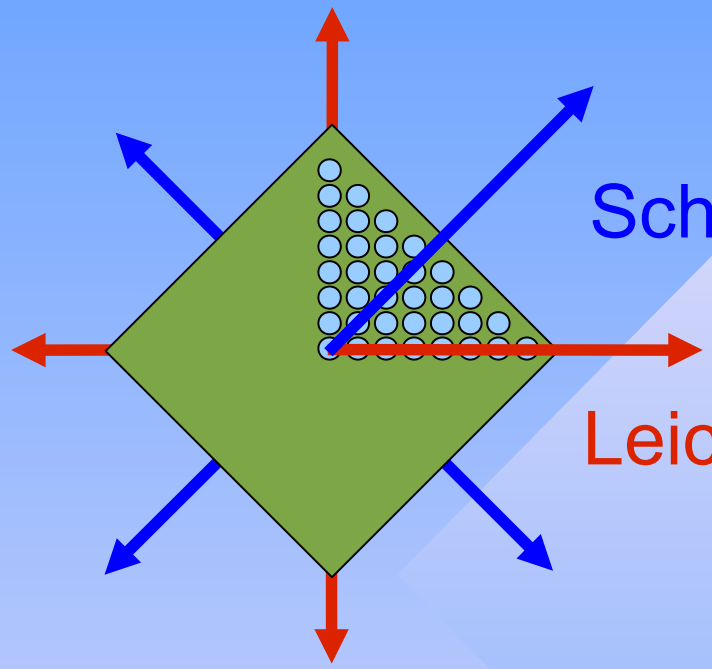
Leichte Achse
[100]

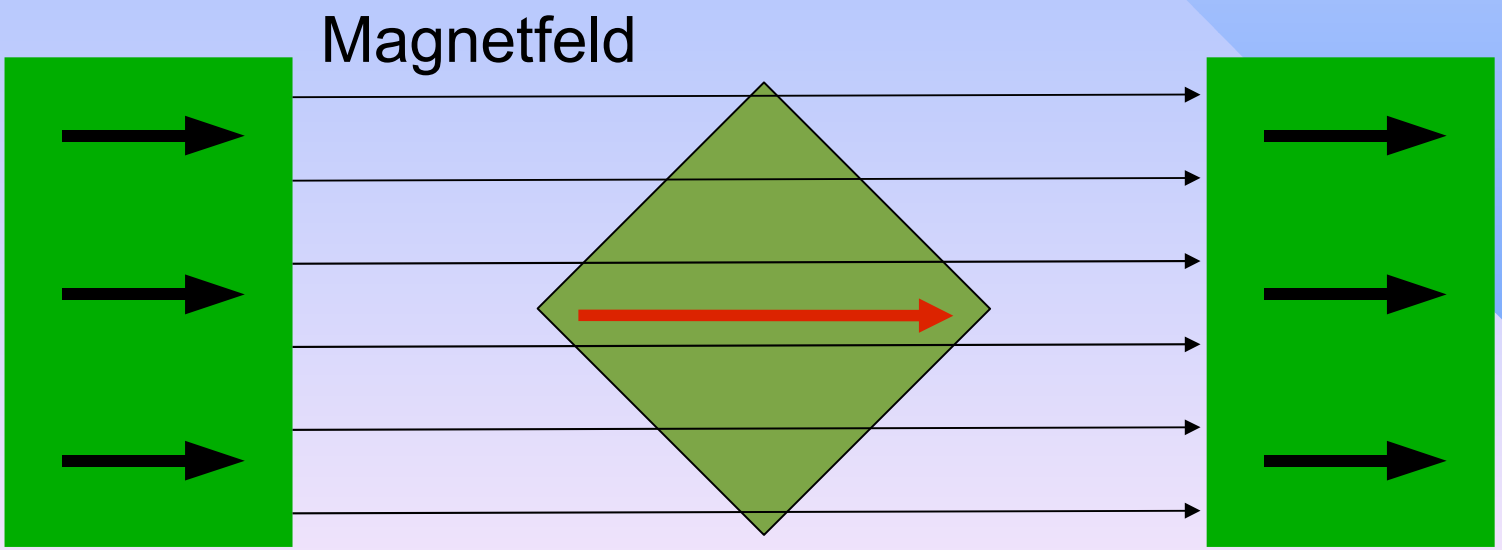


Schwere Achse
[110]

Der normale Kompass (D. Bürgler, FZ Jülich)

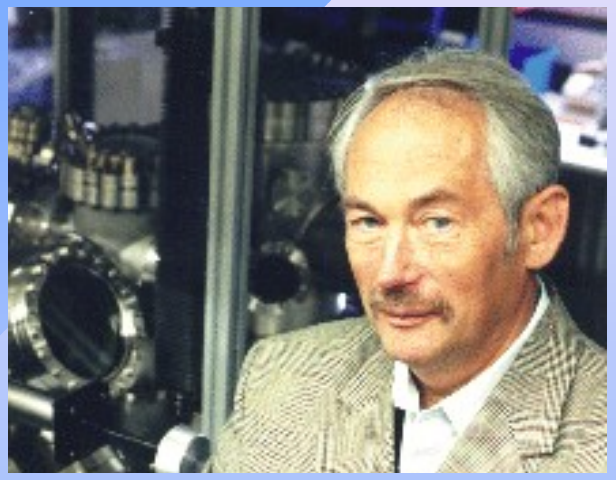
Einkristalline Eisen-Schicht
wenige nm dick
auf Silizium-Substrat





Schichtsysteme: Magnetische Zwischenlagenkopplung 1986

Peter Grünberg, Forschungszentrum Jülich

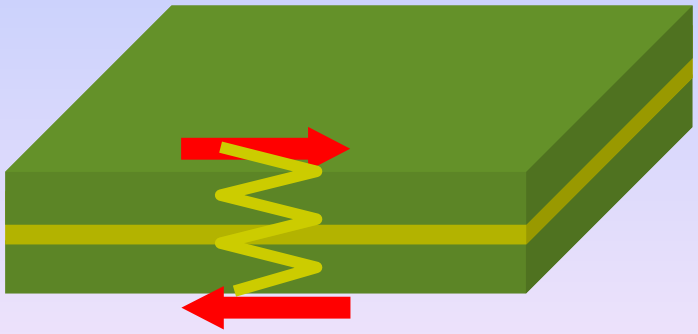


parallel ?

NEIN (:-(

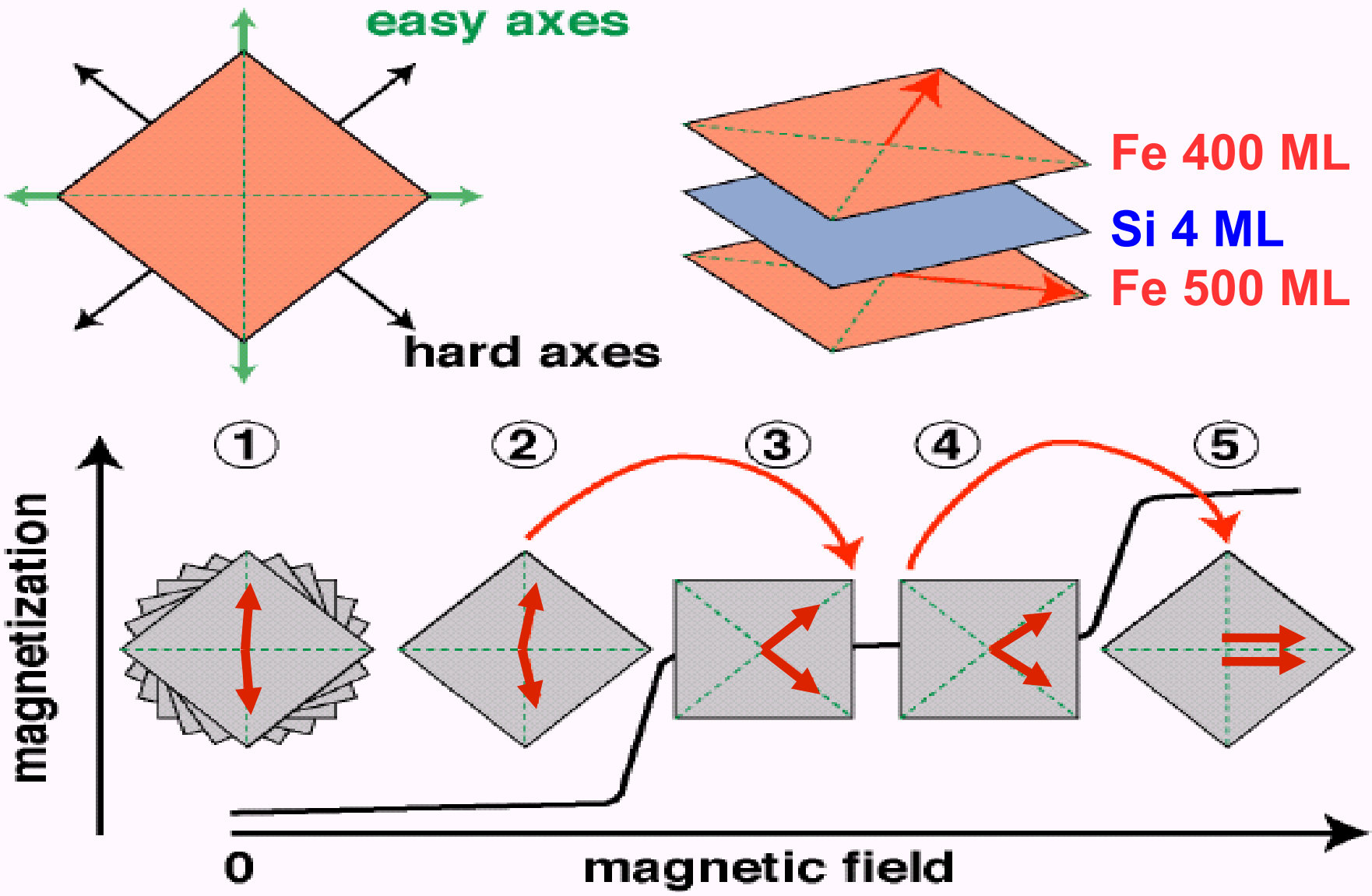
antiparallel ?

JA (:-)



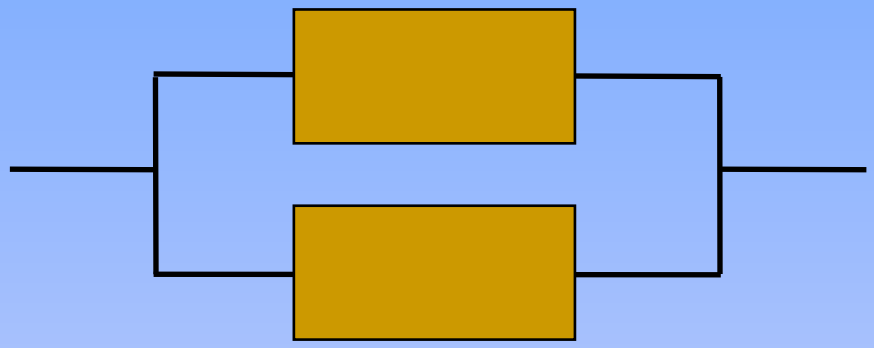
500 Atomlagen Fe
4 Atomlagen Si
400 Atomlagen Fe

“Der verrückte Kompass” (D. Bürgler, FZ Jülich)



Spinabhängiger Widerstand

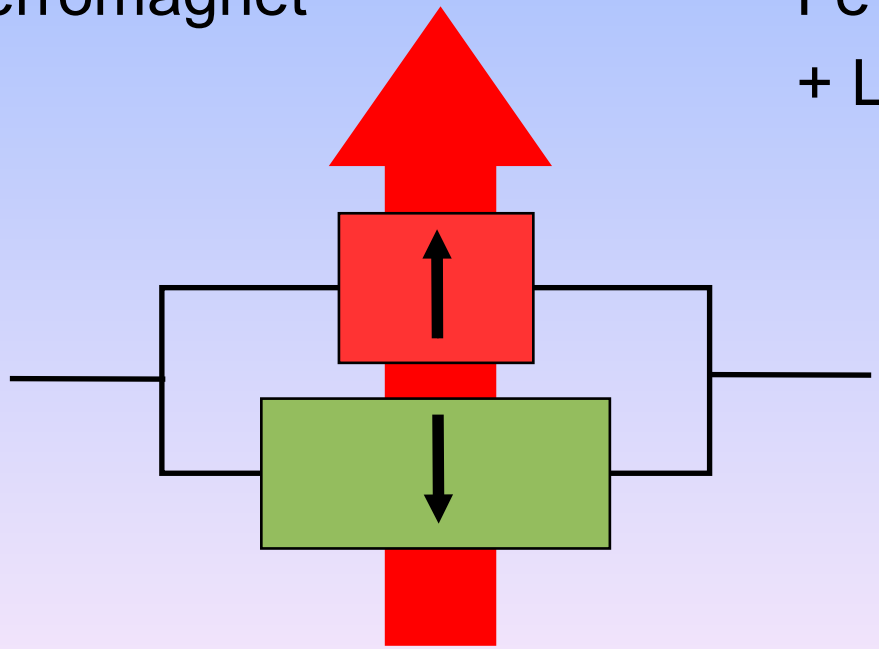
Nichtmagnetisch Metalle Al Cr Cu Ru Pt



1826

Georg Simon Ohm 1789-1854

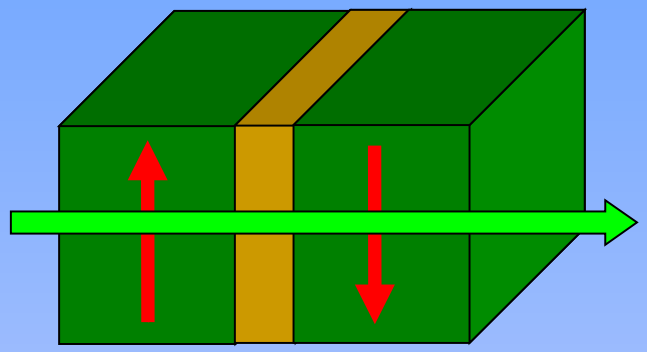
Ferromagnet Fe Co Ni
+ Legierungen

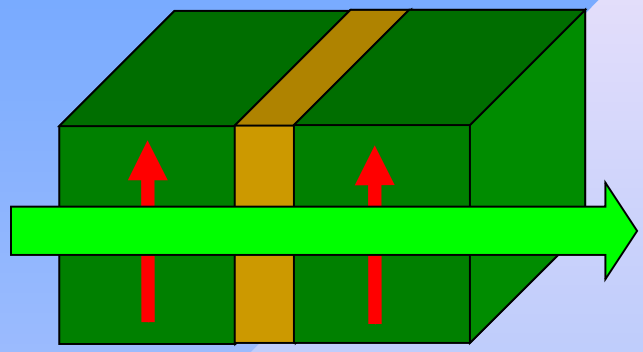


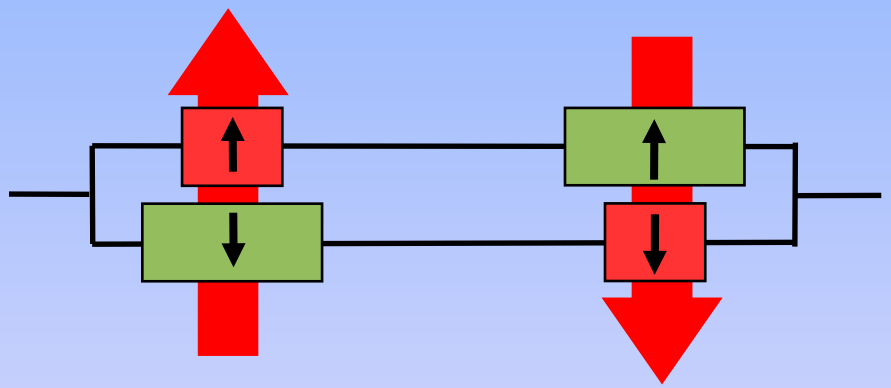
1936

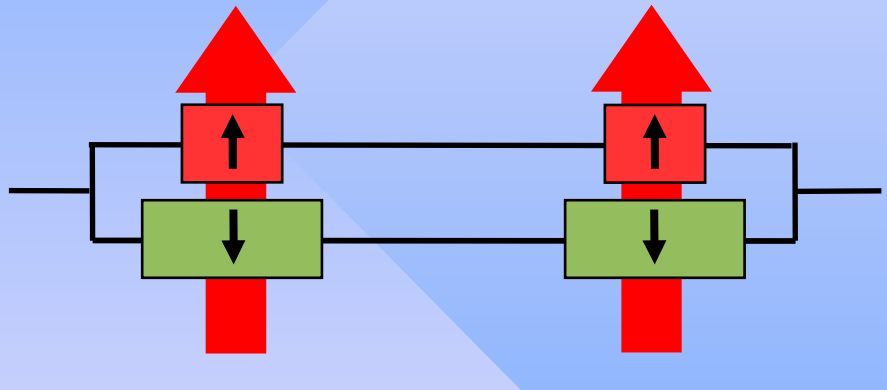
Sir Nevill F. Mott 1905-1996

Supermagnetwiderstand







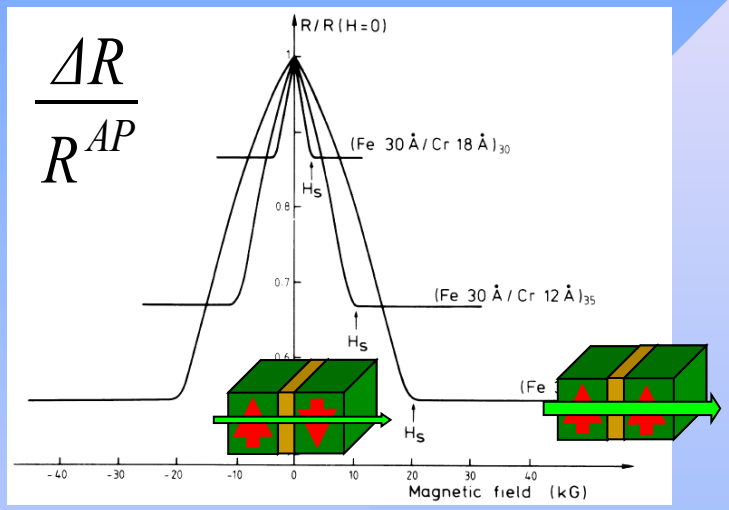


R^{AP} > R^{P}

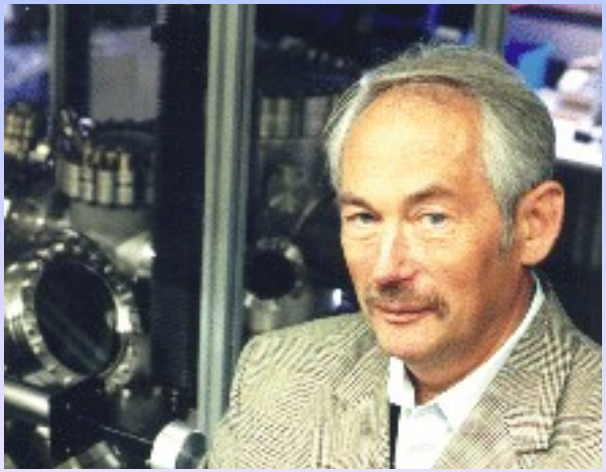
Unterschied bis Faktor 2

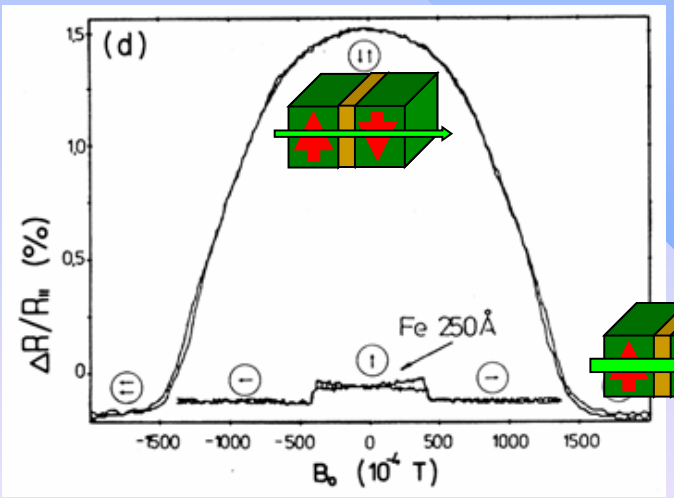
Supermagnetwiderstand GiantMagnetoResistance (GMR) 1988

Albert Fert, Paris



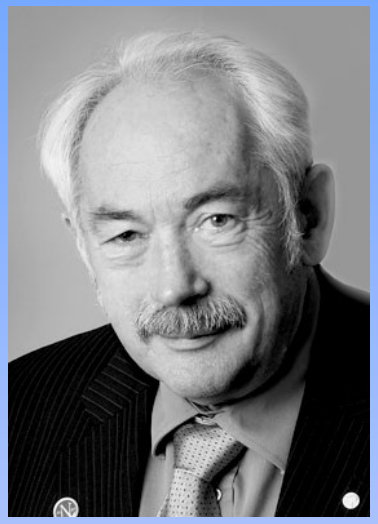
Peter Grünberg, Jülich



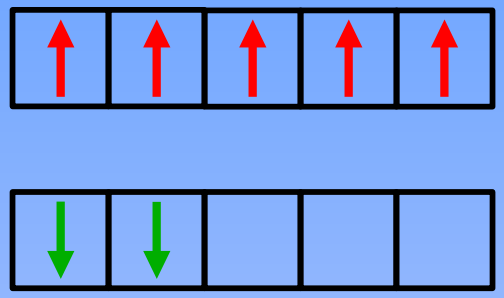


A. Fert et al., Phys. Rev. Lett. **61**, 472 (1988), P. Grünberg et al., Phys. Rev. B **39**, 4828 (1989)

Die Nobelpreise in Physik 2007



Zusammenfassung

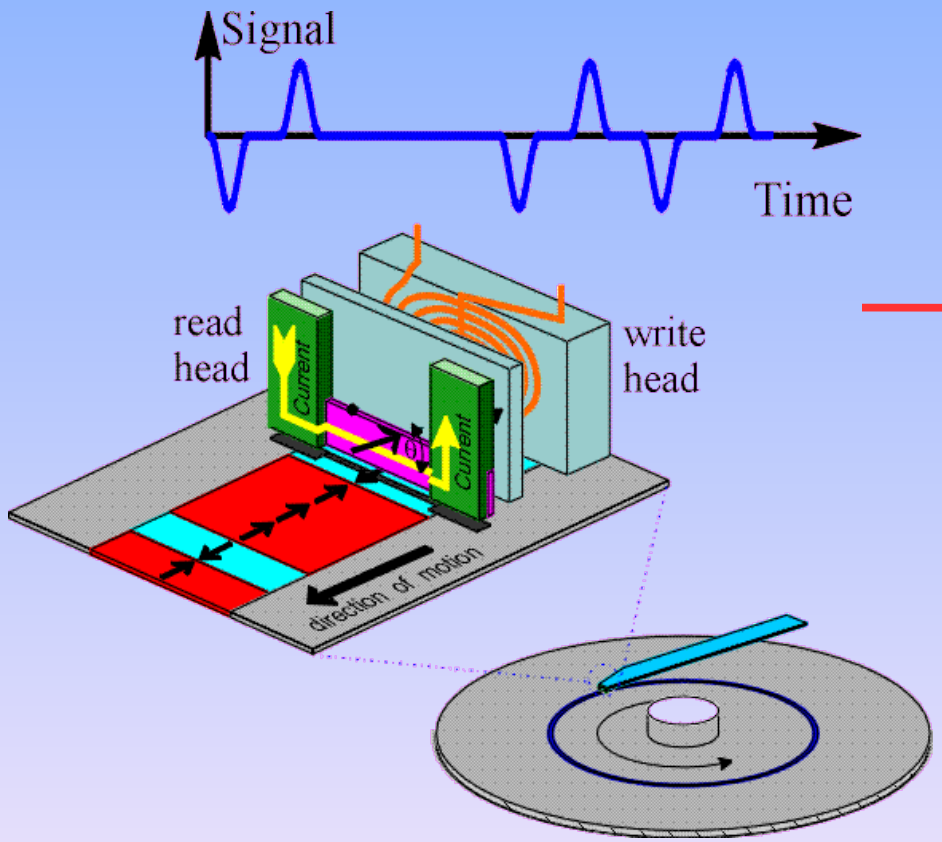


- Magnetismus wird durch die Ausrichtung der Spins der Elektronen verursacht.

- In magnetischen Nanostrukturen treten neue Phänomene auf, z.B. Zwischenlagenkopplung und Supermagnetwiderstand (GMR).

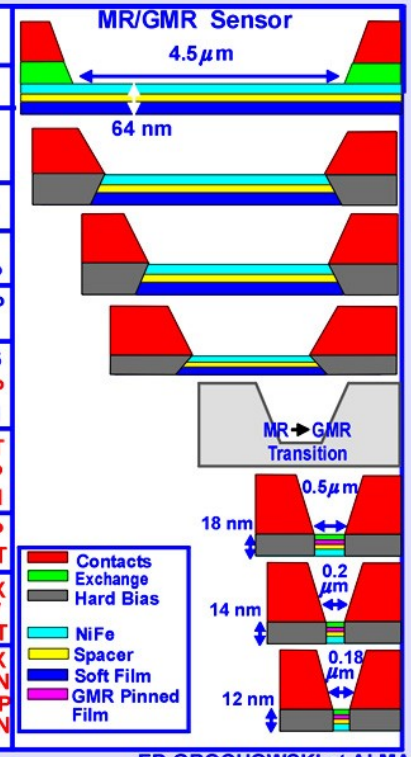
- Neue GMR-Technologie macht Festplatten
  leistungsfähiger und
  kleiner.

Anwendung von GMR-Elementen in Festplatten-Leseköpfen



IBM MR/GMR Read Head Evolution

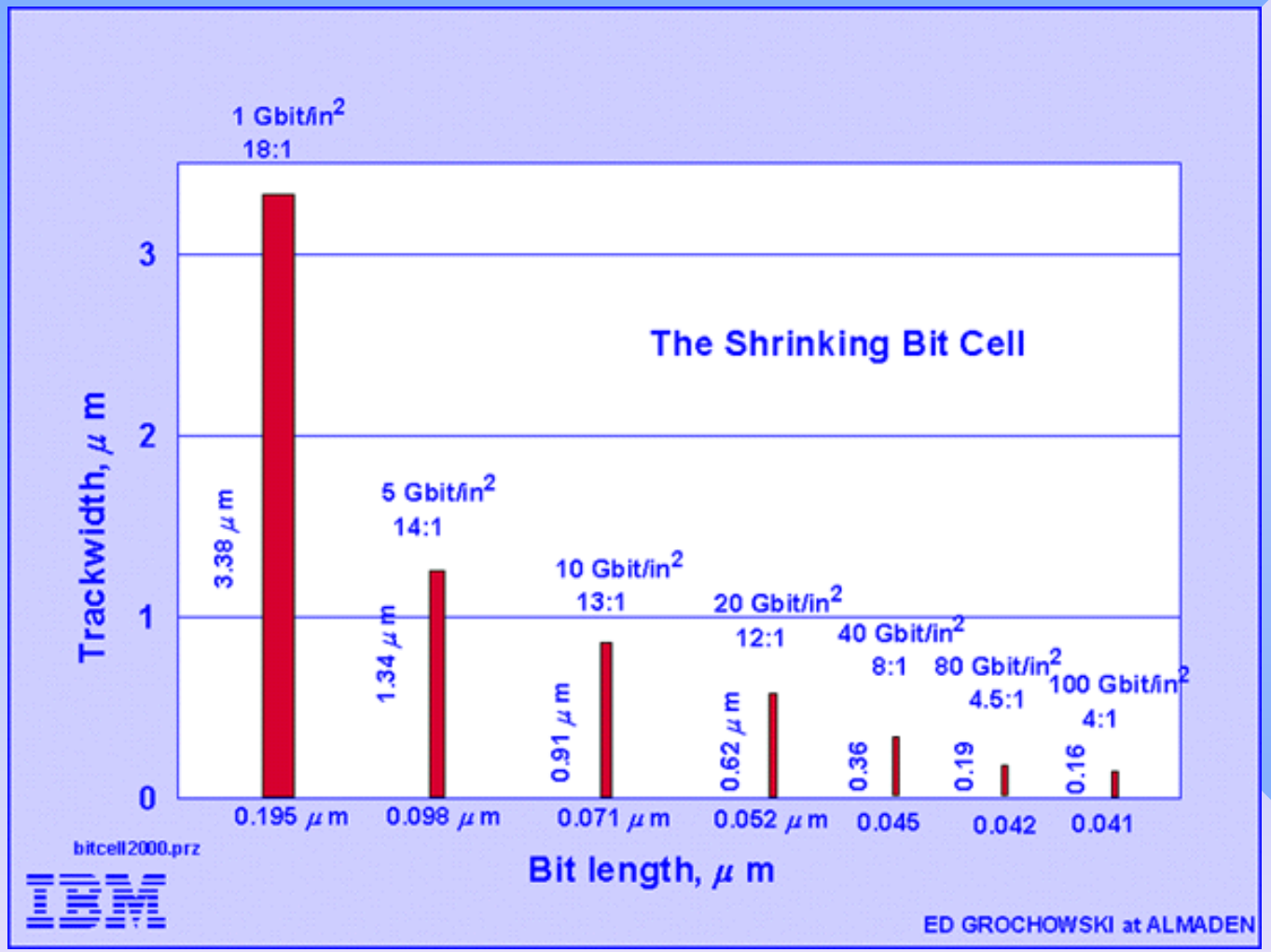
Year	Areal Density Gbits/in²	Product
1991	0.132	Corsair
1992	0.260	Allicat
1993	0.354	Spitfire
1994	0.578	Ultrastar XP
1995	0.829	Ultrastar 2XP
	0.923	Travelstar 2LP
1996	1.32	Travelstar 2XP
	1.45	Travelstar VP
1997	2.64	Travelstar 5GS
	2.68	Deskstar 16GP
	3.12	Travelstar 8GN
1998	3.74	Travelstar 6GT
	4.1	Deskstar 25GP
	5.7	Travelstar 6GN
1999	5.3	Deskstar 37GP
	10.1	Travelstar 18GT
2000	7.04	Ultrastar 36LZX
	14.5	Deskstar 40GV
	17.1	Travelstar 30GT
2001	13.2	Ultrastar 73LZX
	25.7	Travelstar 30GN
	29.7	Deskstar120GXP
	34	Travelstar 40GN



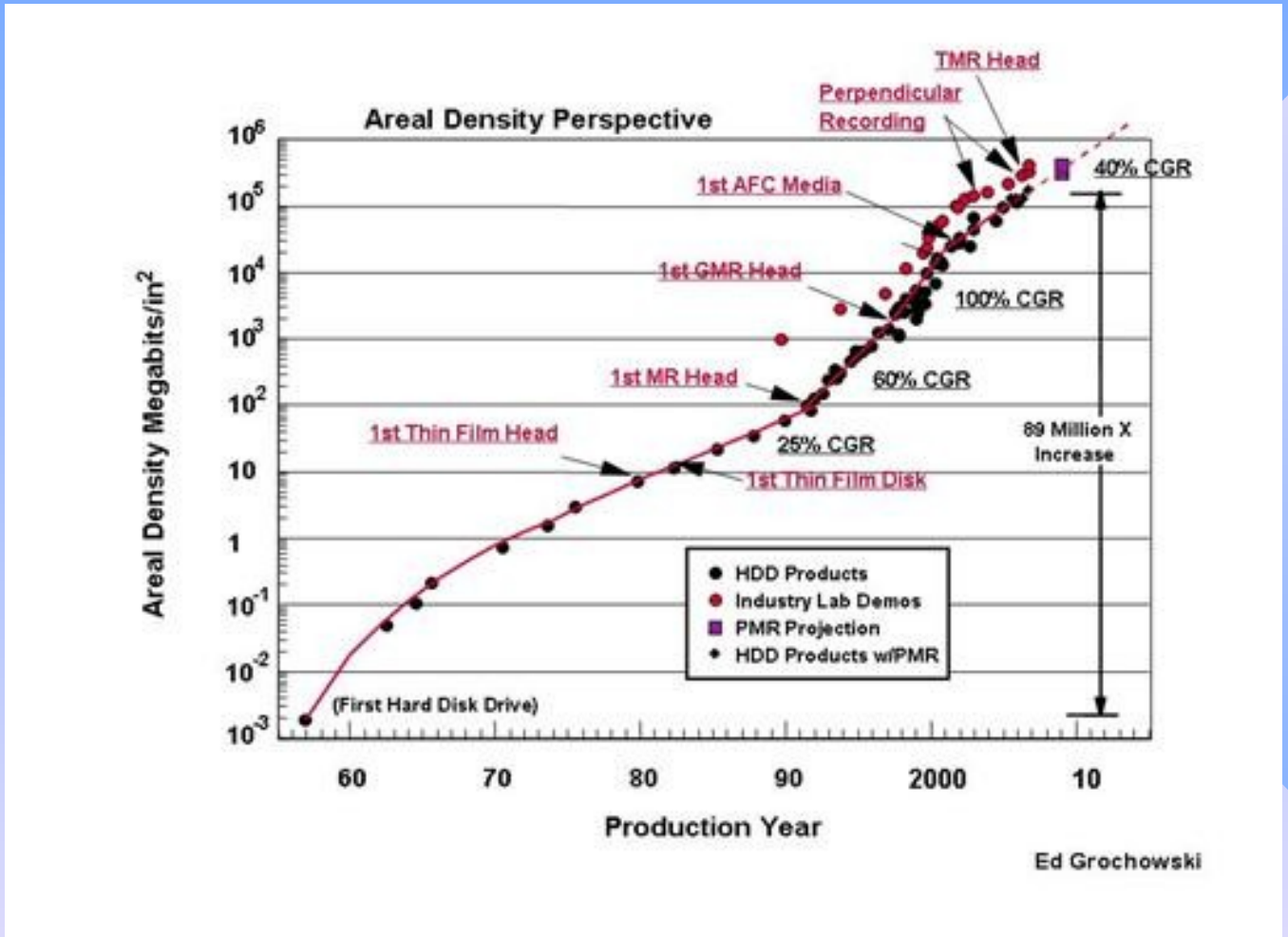
Super2001aa.cdr

ED GROCHOWSKI at ALMADEN

Entwicklung der Bit-Größe



Entwicklung der Speicherdichte



2010: 500 Gbit/in2