Subnanometer Magnetic Storage Bits: a Prediction

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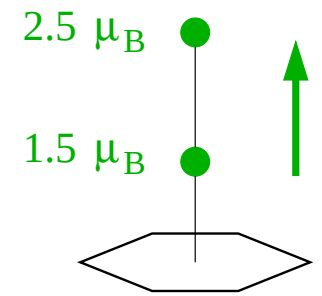
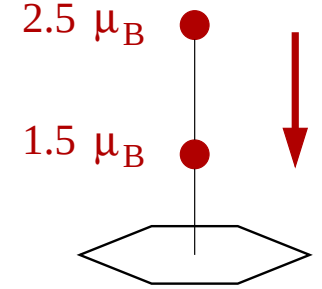


- Motivation
- Geometry and spin state of $Co_2C_6H_6$
- Electronic structure and magnetic anisotropy
- How can the bits be switched?

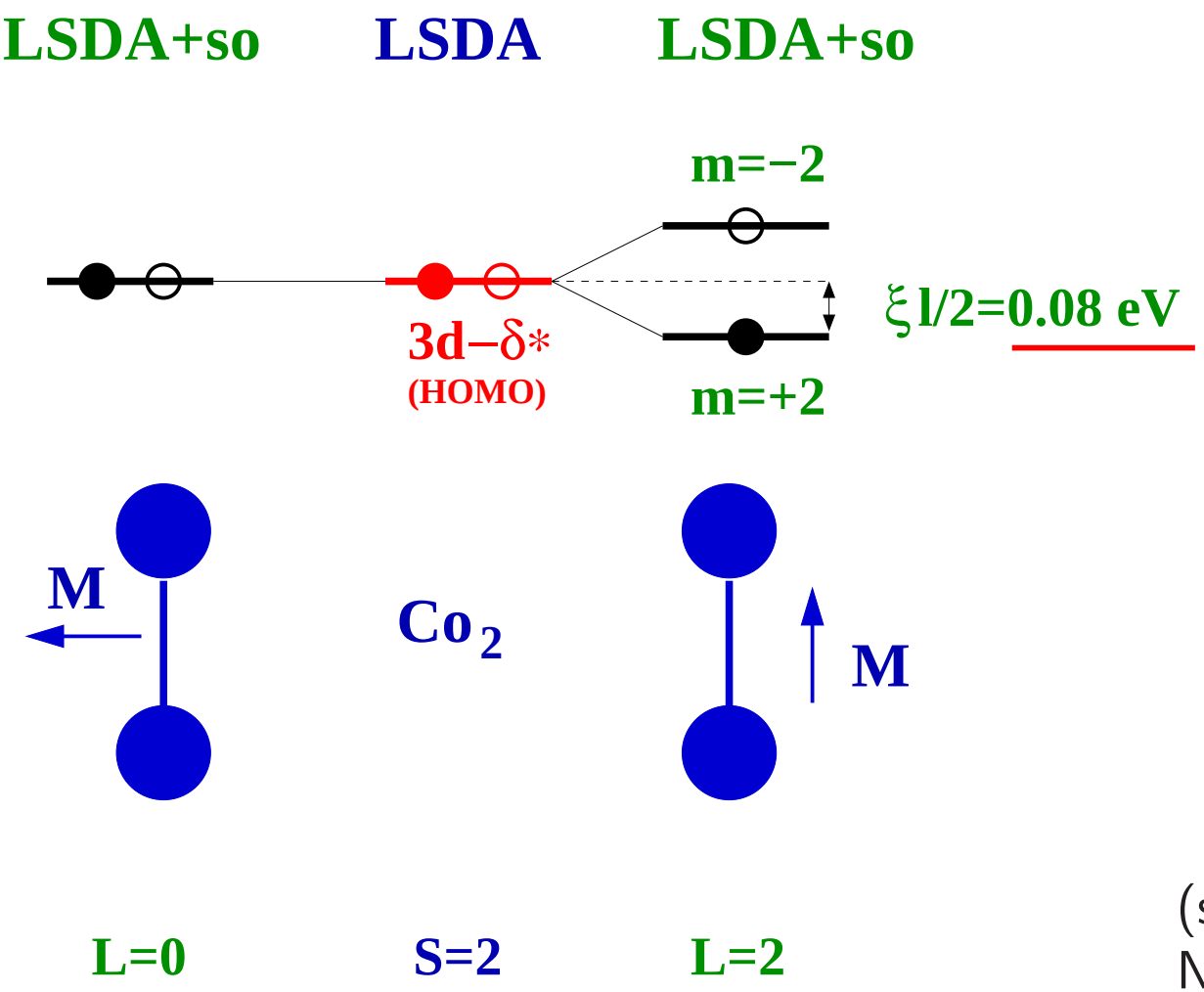


Co-based magnetic storage materials

(MAE: magnetic anisotropy energy, $\geq 40\ kT$ required)

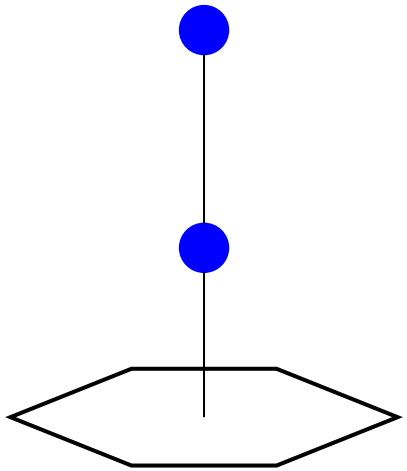
material	MAE per atom	atoms/bit	comments
Co(Cr,Pt)	≈ 0.05 meV	400,000	current bit size about 5,000 nm^3
hcp Co	0.065 meV	15,000	
$L1_0$ CoPt	1 meV	1,000	15 nm^3 per bit seems possible, but such small clusters do not order (Gruner 08)
Co on Pt(111)	9 meV (Gambardella 03)	1 at 3 K?	MAE per atom $\sim 1/$number of Co atoms
predictions for free Co_2	14 meV (Strandberg 07, 08)	2 at 9 K?	(lower estimate) Does bonding reduce the MAE?
	95 meV (Fritsch 08)	2 at 60 K?	(upper estimate)

Huge magnetic anisotropy due to a singly occupied doublet



(see Strandberg *et al.*, Nature Materials 2007)

Idea: a hexagonal symmetry ...



... would not break the degeneracy of (non-relativistic) δ-states!

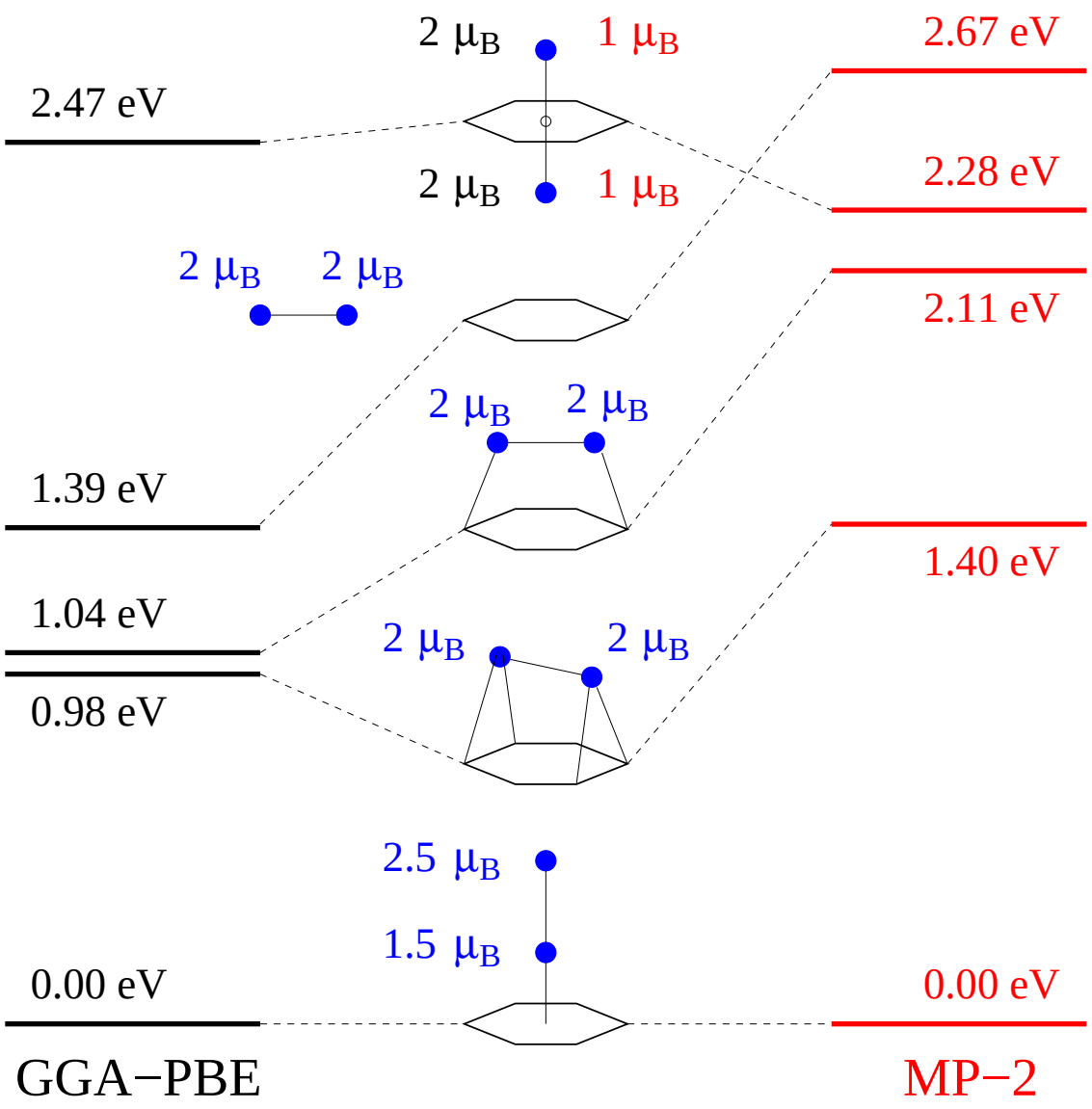
Will the bonding be strong enough?

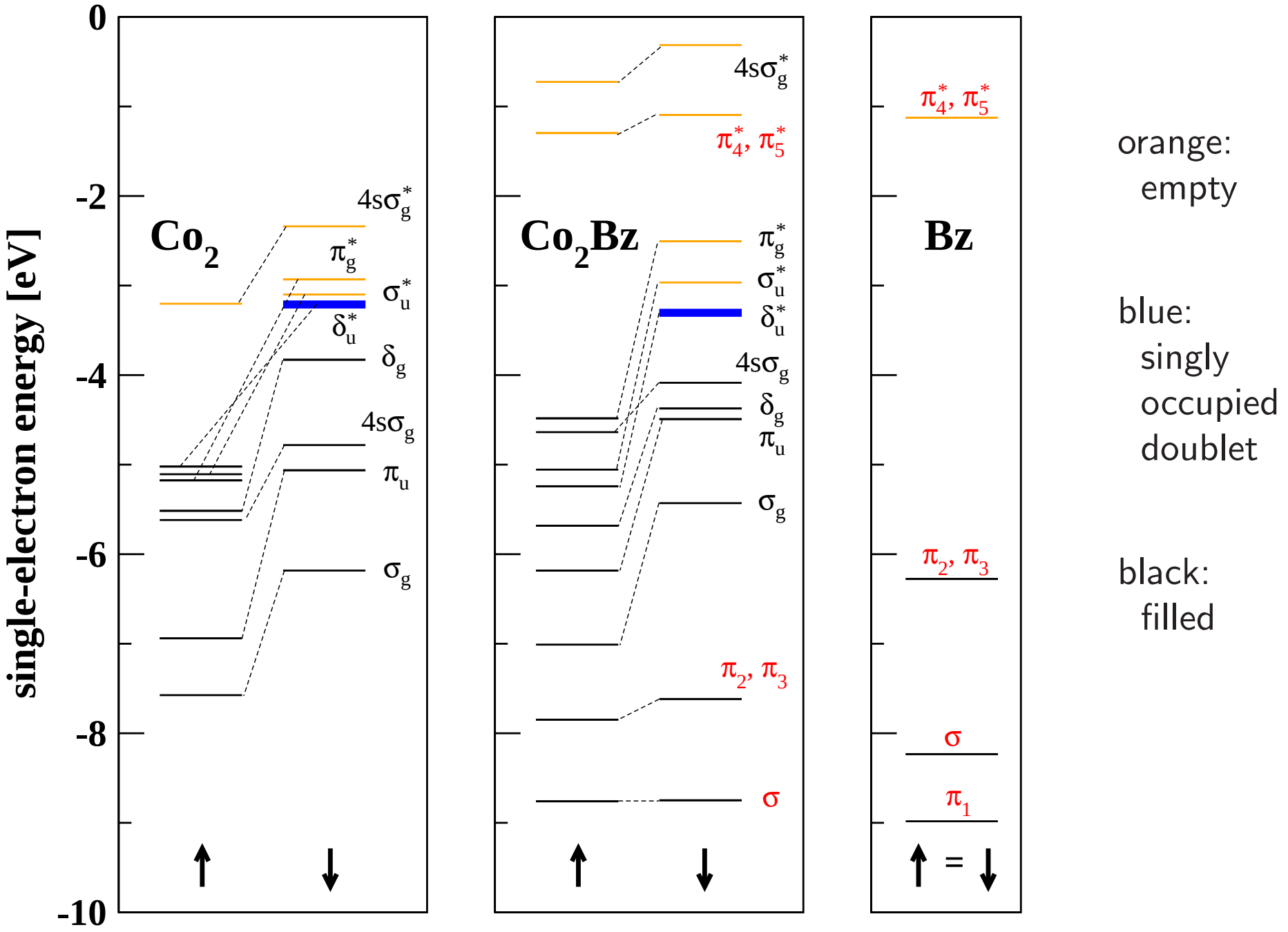
Will magnetism survive?

Check Co_2-benzene as a model for Co_2 on graphene or on graphite!

Co_2-benzene: structures and spin states

Perpendicular
Pd_2-benzene
and Pt_2-benzene:
Lüttgens 01



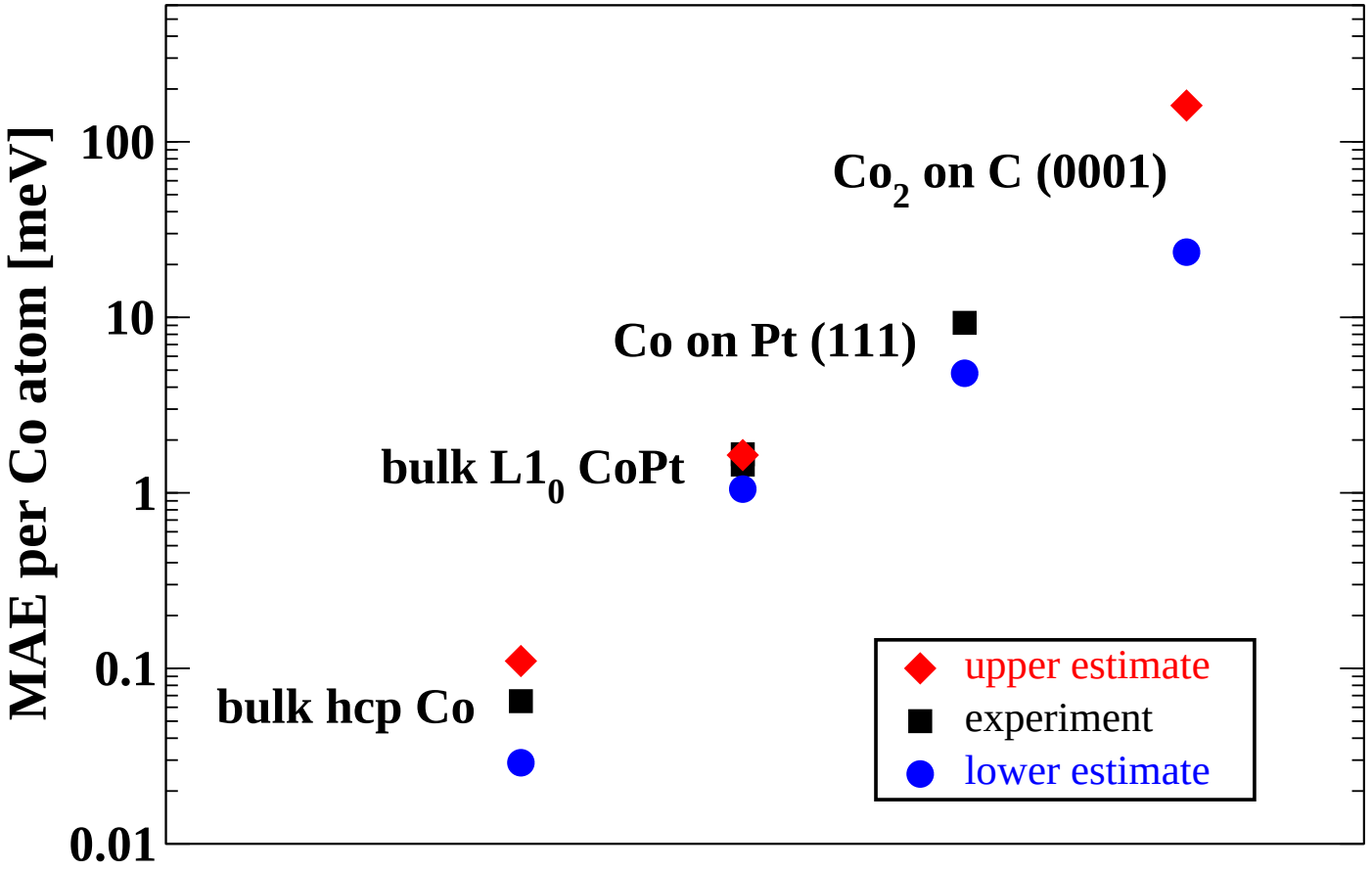

single-electron energy [eV]
0
-2
-4
-6
-8
-10
Co2
4sσg*
πg*
σu*
δu*
δg
4sσg
πu
σg
Co2Bz
4sσg*
π4*, π5*
πg*
σu*
δu*
4sσg
δg
πu
σg
π2, π3
σ
Bz
π4*, π5*
π2, π3
σ
π1
=
orange:
empty
blue:
singly
occupied
doublet
black:
filled

MAE of Co_2 on benzene and on graphene

system	lower estimate [meV/Co] (LSDA+so)	upper estimate [meV/Co] (LSDA+so+OPC)
Co_2-benzene	25	165
Co_2-graphene(0001)	24	160

A (3×3) arrangement was considered for Co_2-graphene(0001).
OPC: orbital polarization corrections.

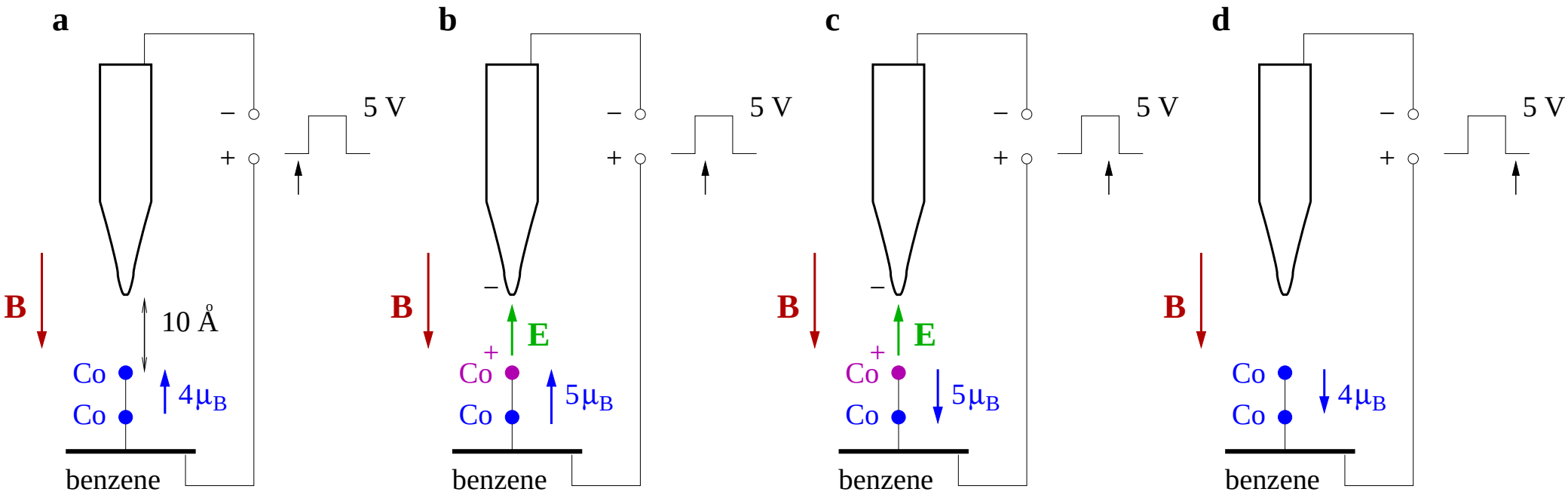
MAE of Co in different systems: heavy metals are not needed



Open problems

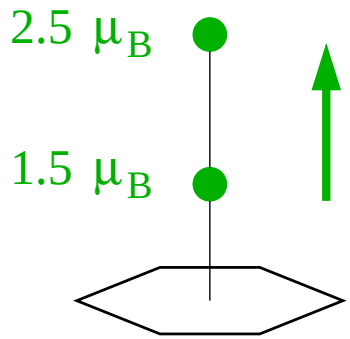
- Cheap production of large regular arrays?
- Protection against oxidation without reducing the anisotropy?
- Appropriate read/write technology? arXiv.org/abs/0906.4645

How can the Co_2-bits be written?



Combination of a moderate B-field with a strong pulse E-field

Take-home message ...



This lecture occupies $100\ \mu$m $\times$ $100\ \mu$m hard disc area.

Using Co_2-bits, it could be squeezed to $3\ \mu$m $\times$ $3\ \mu$m.

method: http://www.fplo.de/

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