Magnetocrystalline anisotropy and the magnetocaloric effect in Fe_2P

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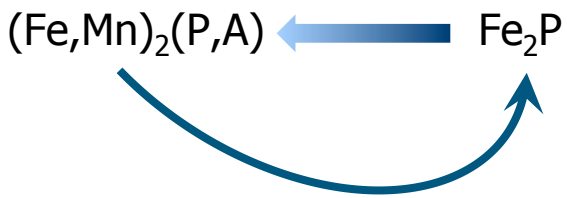
TU Delft

Outline

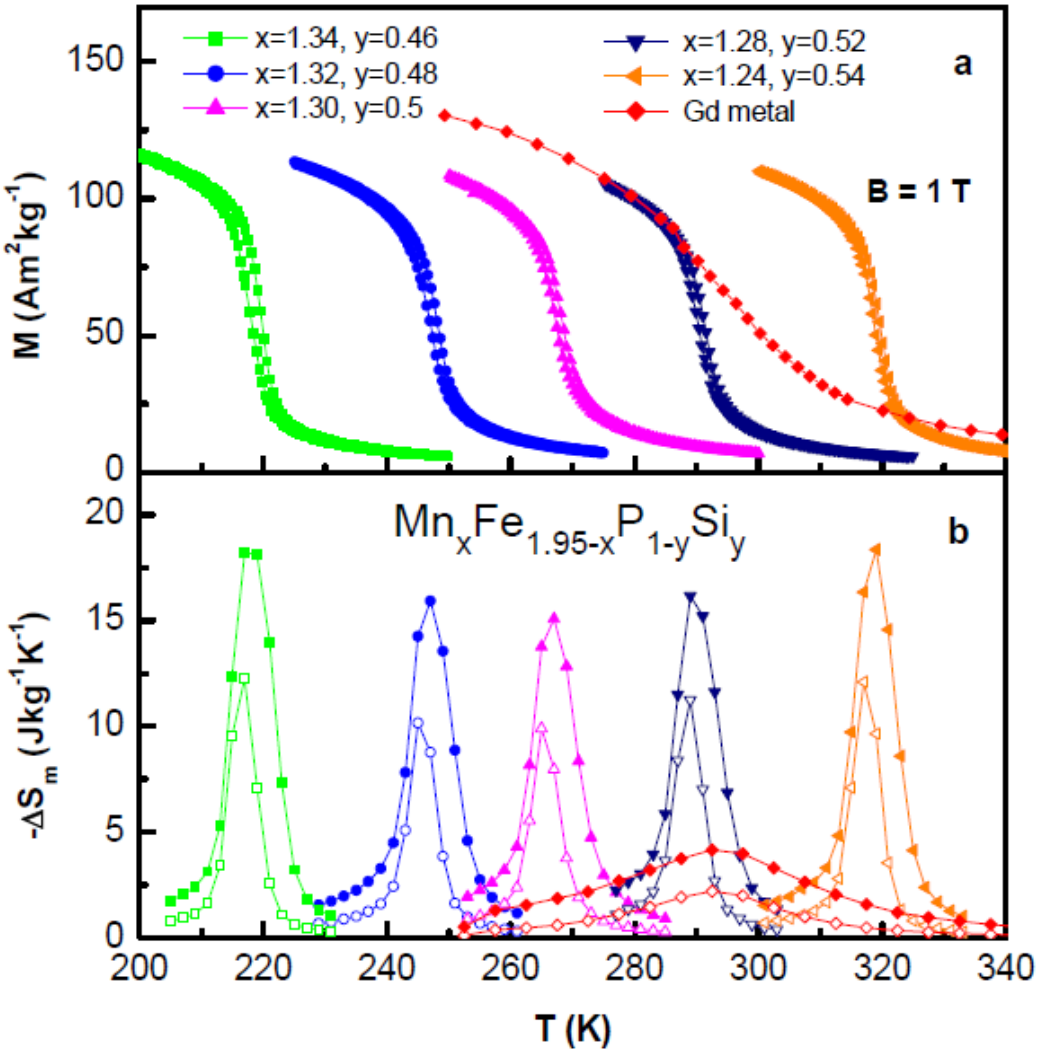
- Why go back to Fe_2P?



- Fe_2P
  - structure
  - what is in literature
  - polycrystal
  - single-crystal
    - *anisotropy & MCE intermezzo*
  - anisotropy & the nature of Fe_2P's magnetic moments

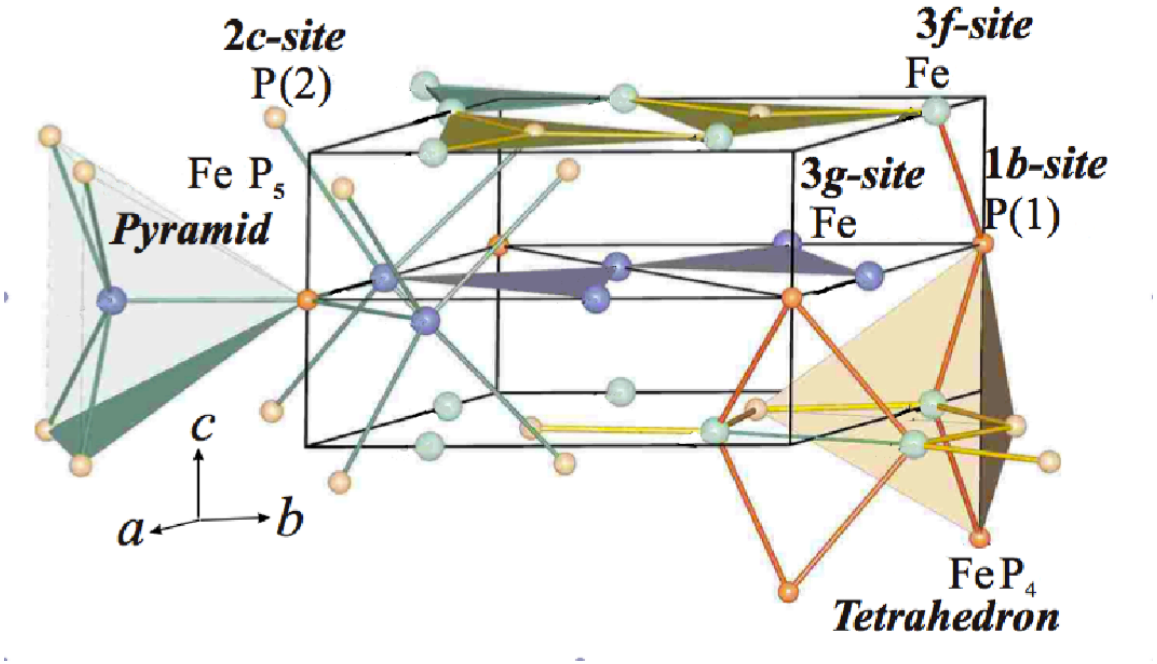
- Conclusions

$(Mn,Fe)_{2-\delta}(P,X)$

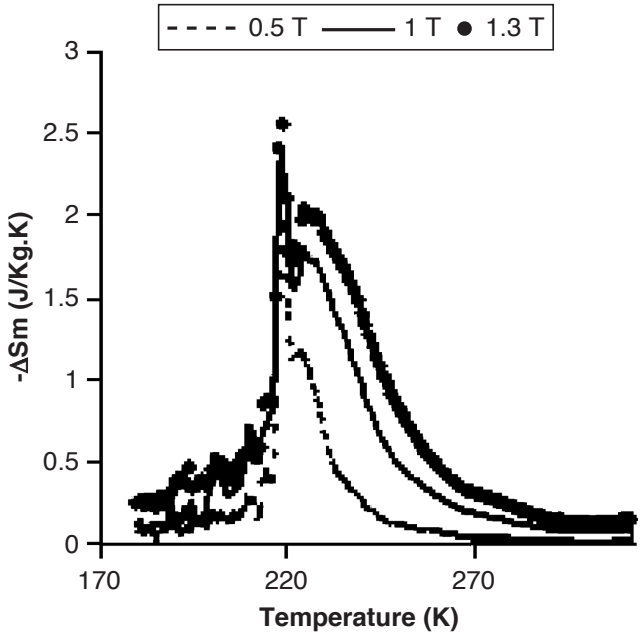


Fe_2P

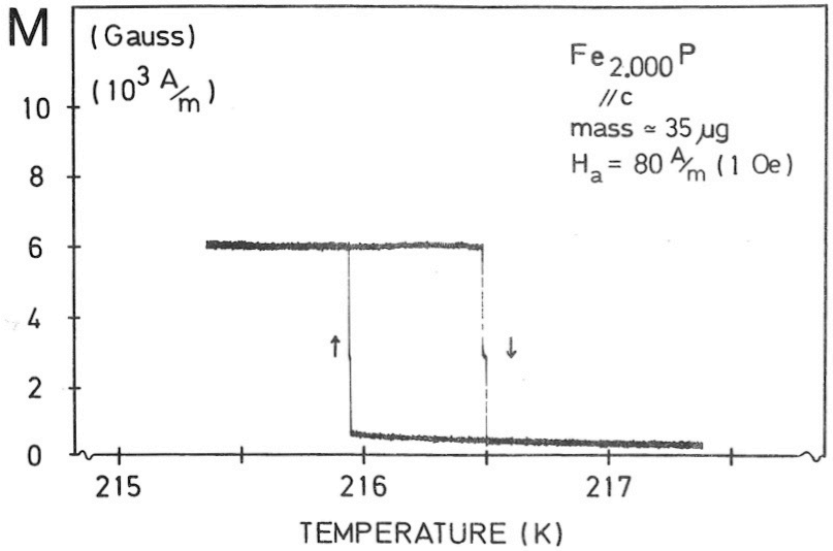
easy magnetization axis



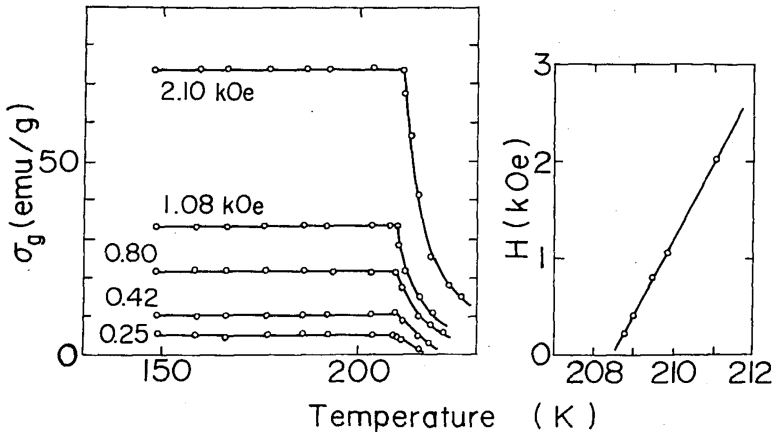
Fe_2P



D. Fruchart et al. / Physica A 358 (2005) 123–135

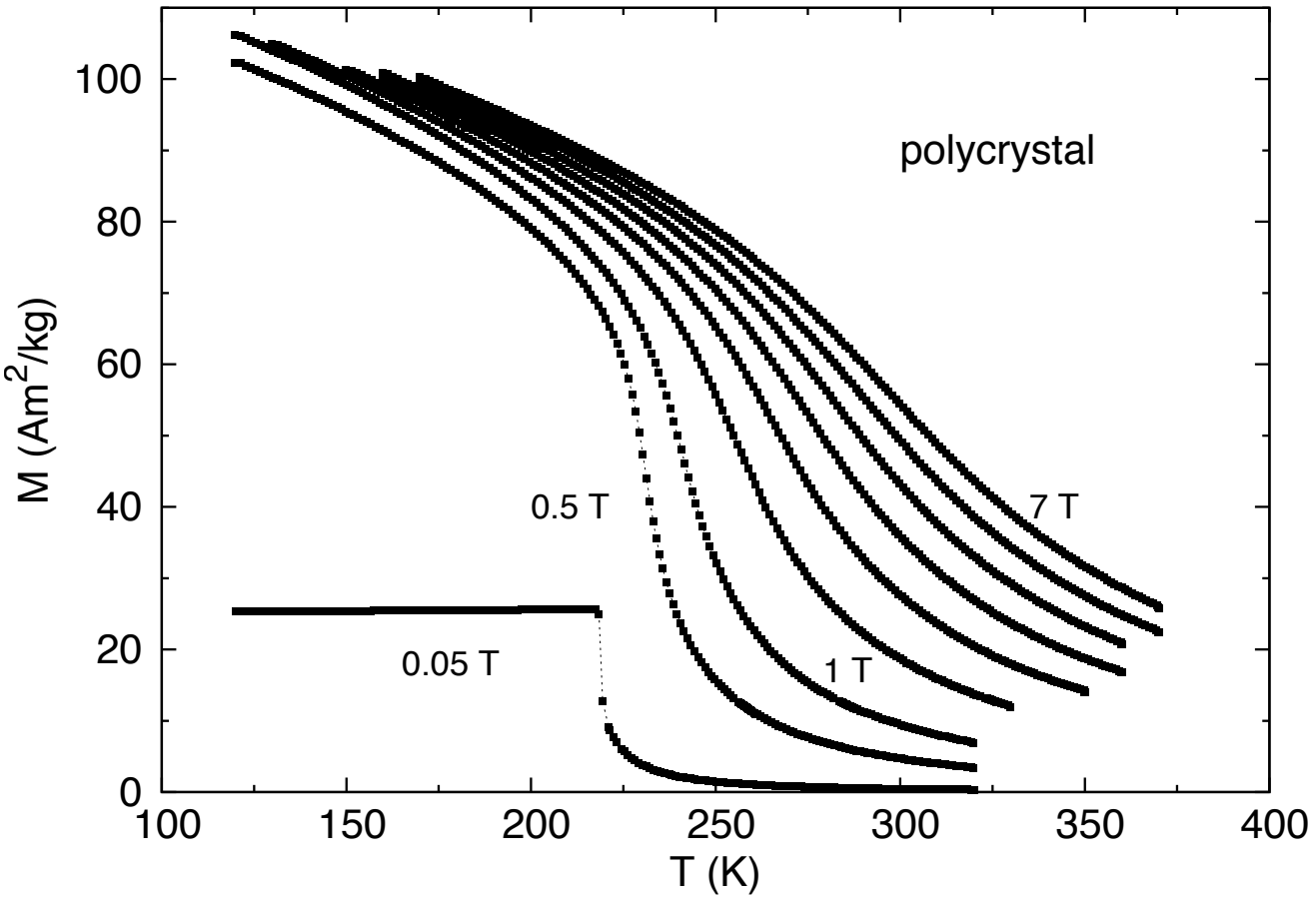


Per Nordblad, PhD thesis Uppsala University 1982

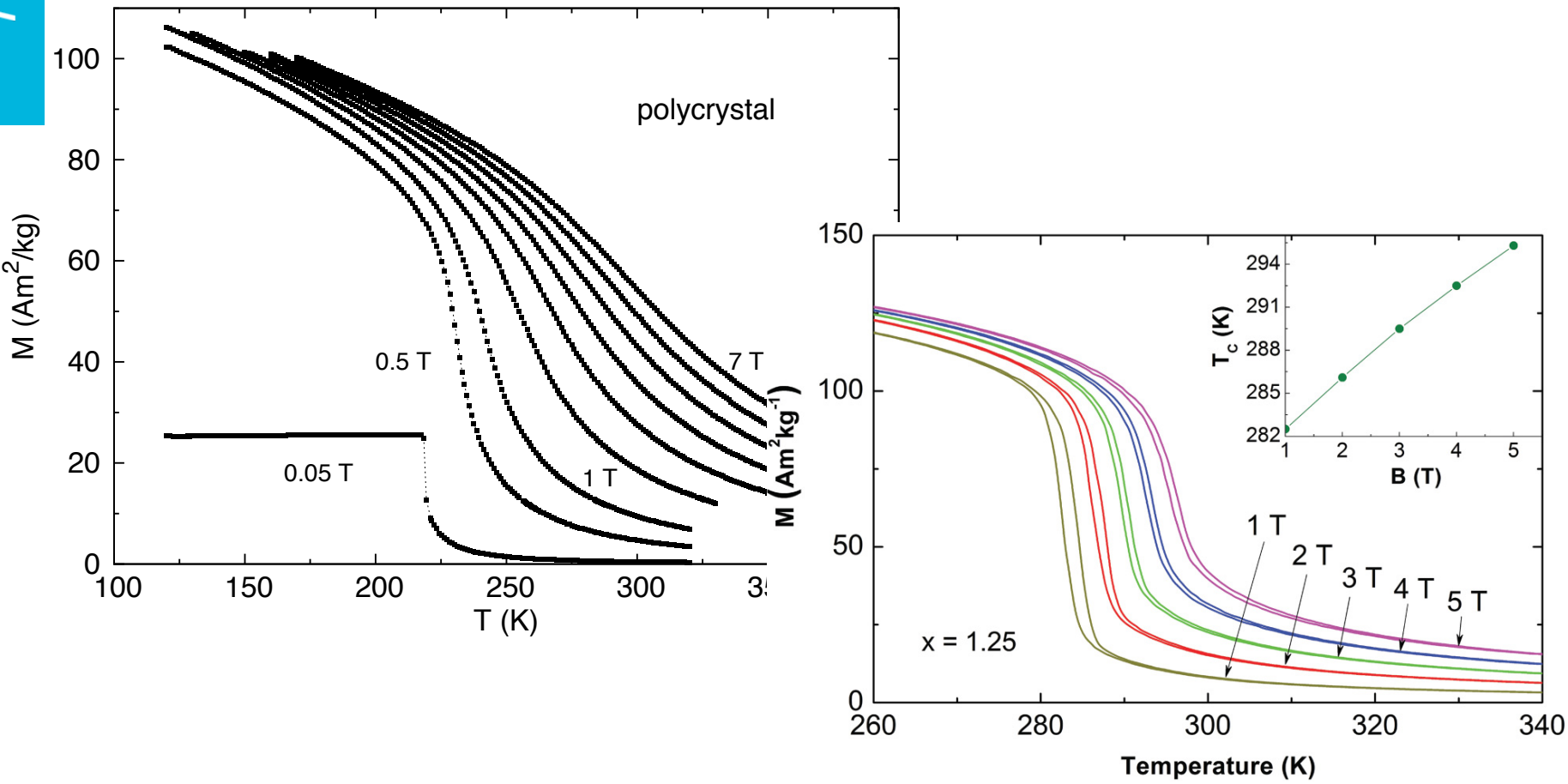


Fujii et al. JPSJ 43, 41 (1977)

Polycrystalline Fe_2P

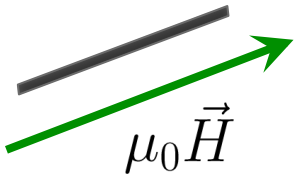


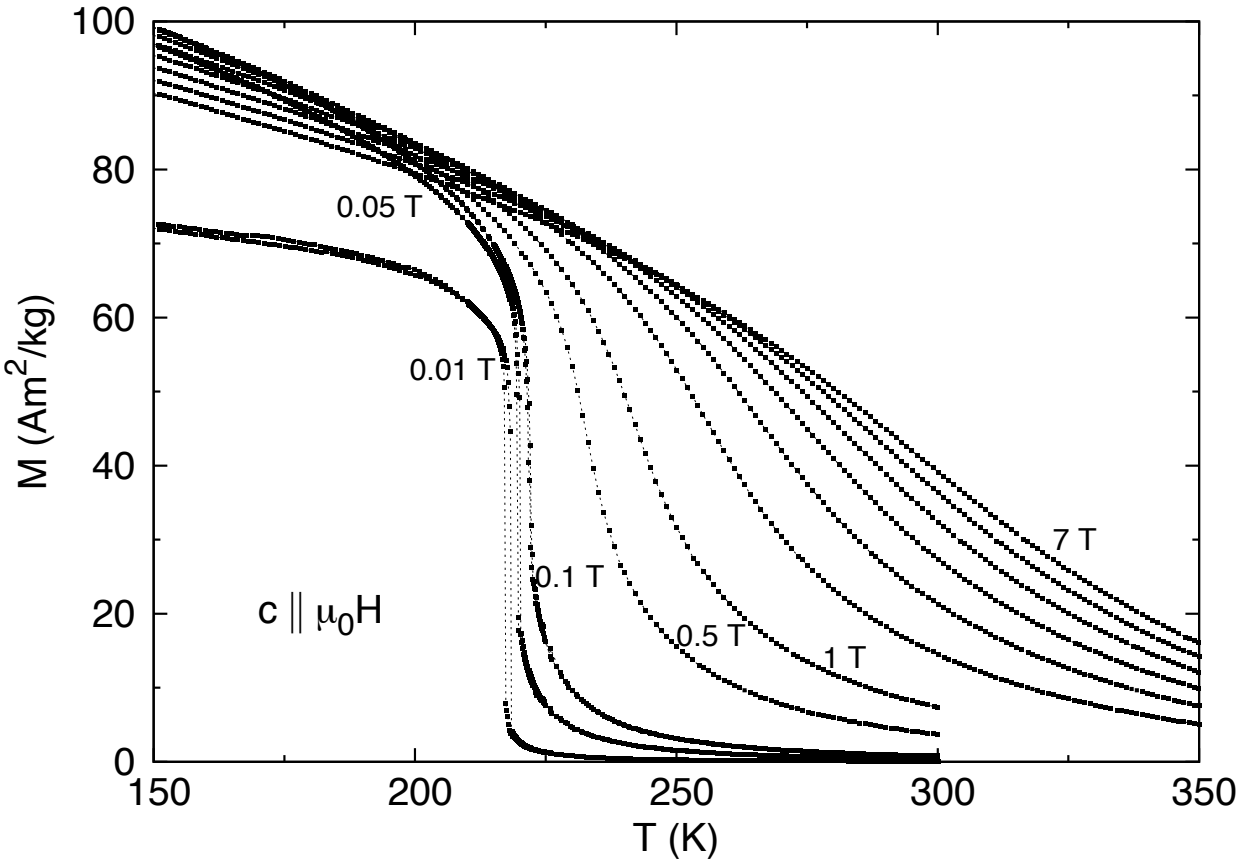
Polycrystalline Fe_2P



Dung et al. *PRB* **86,** 045134 (2012)

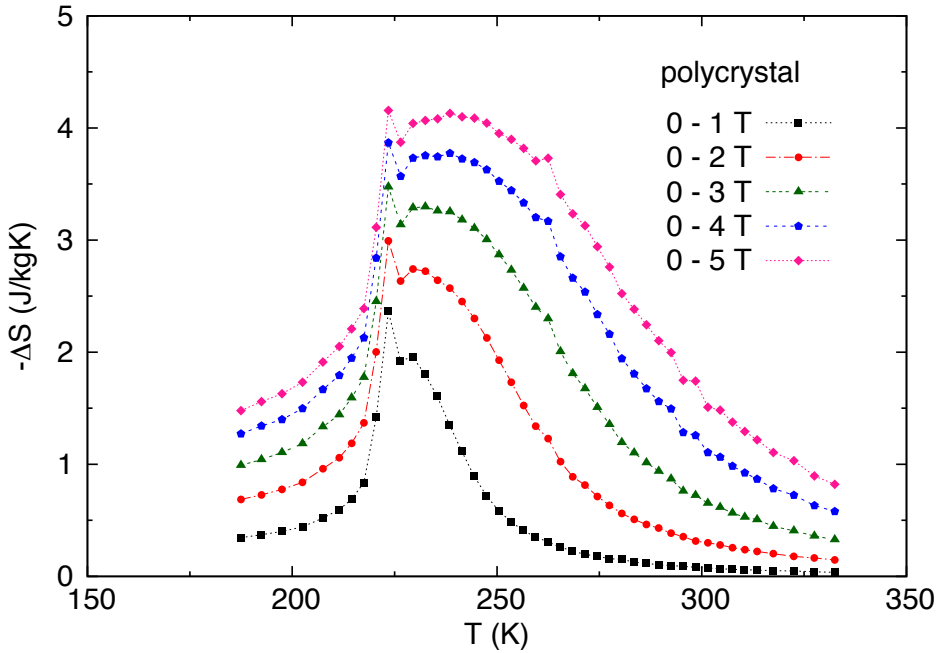
Single-crystalline Fe_2P
c-direction

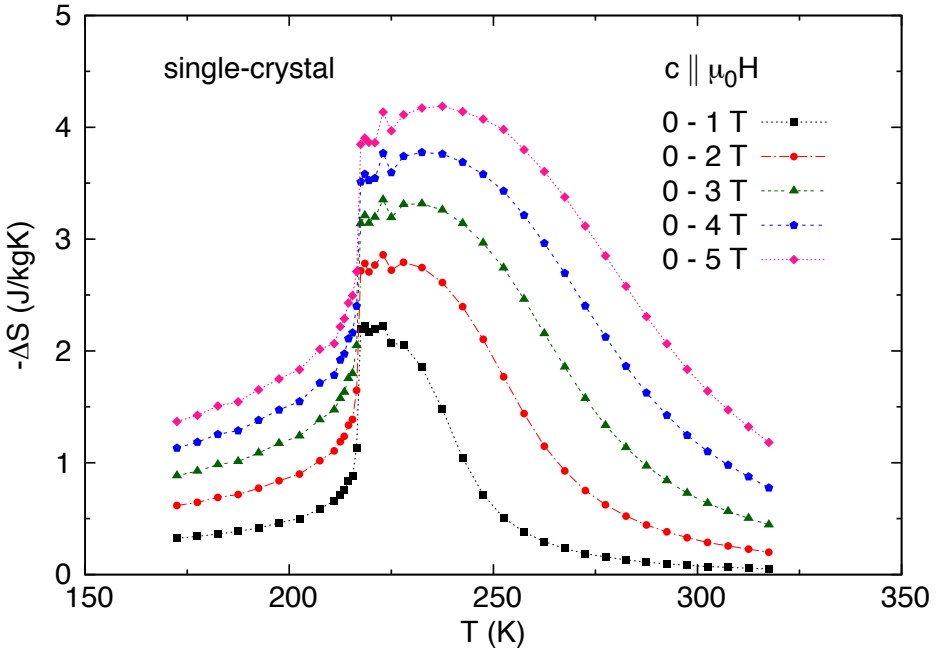




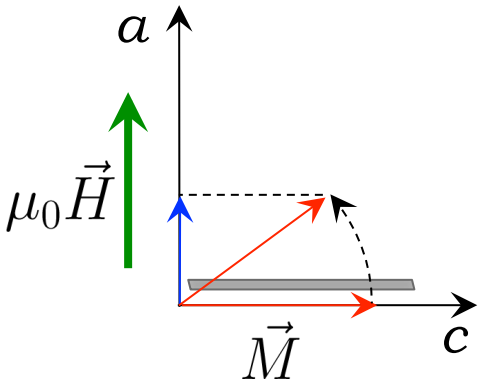
Fe_2P

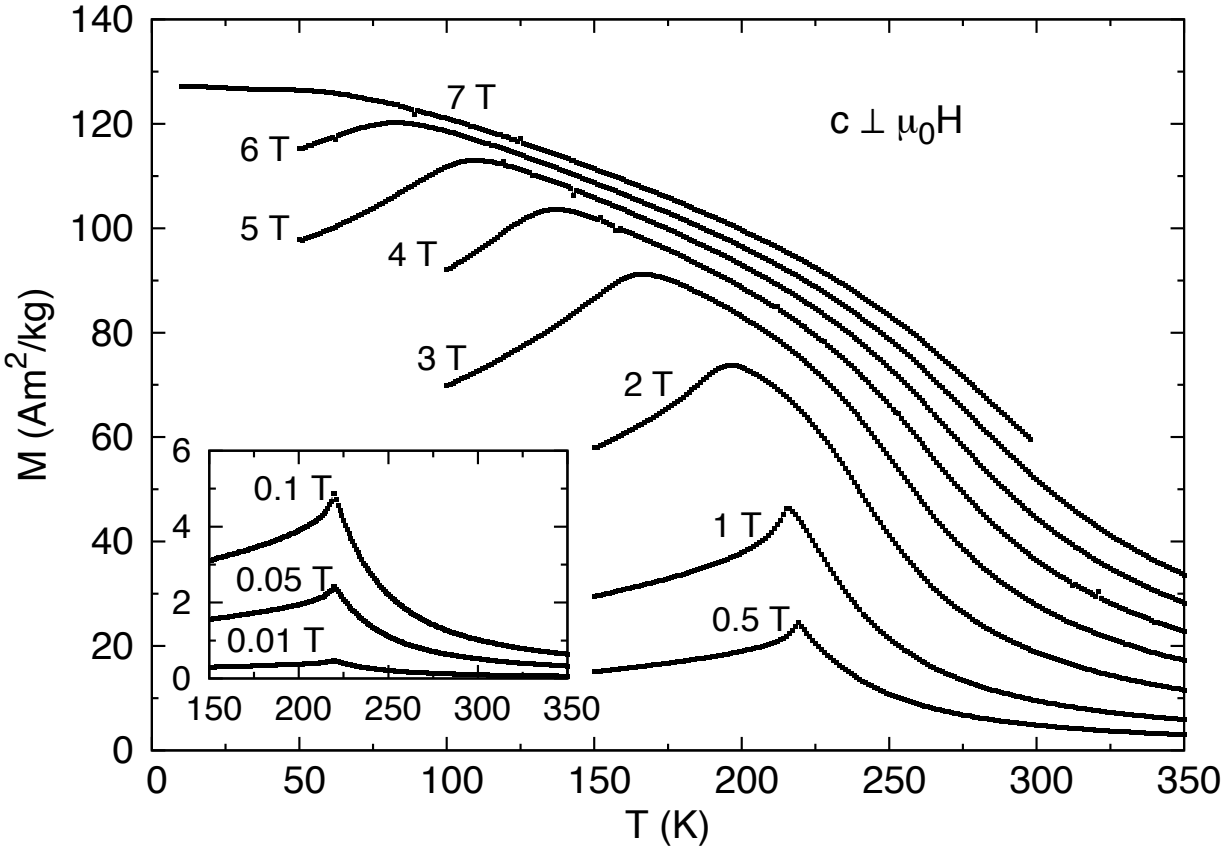
Entropy changes



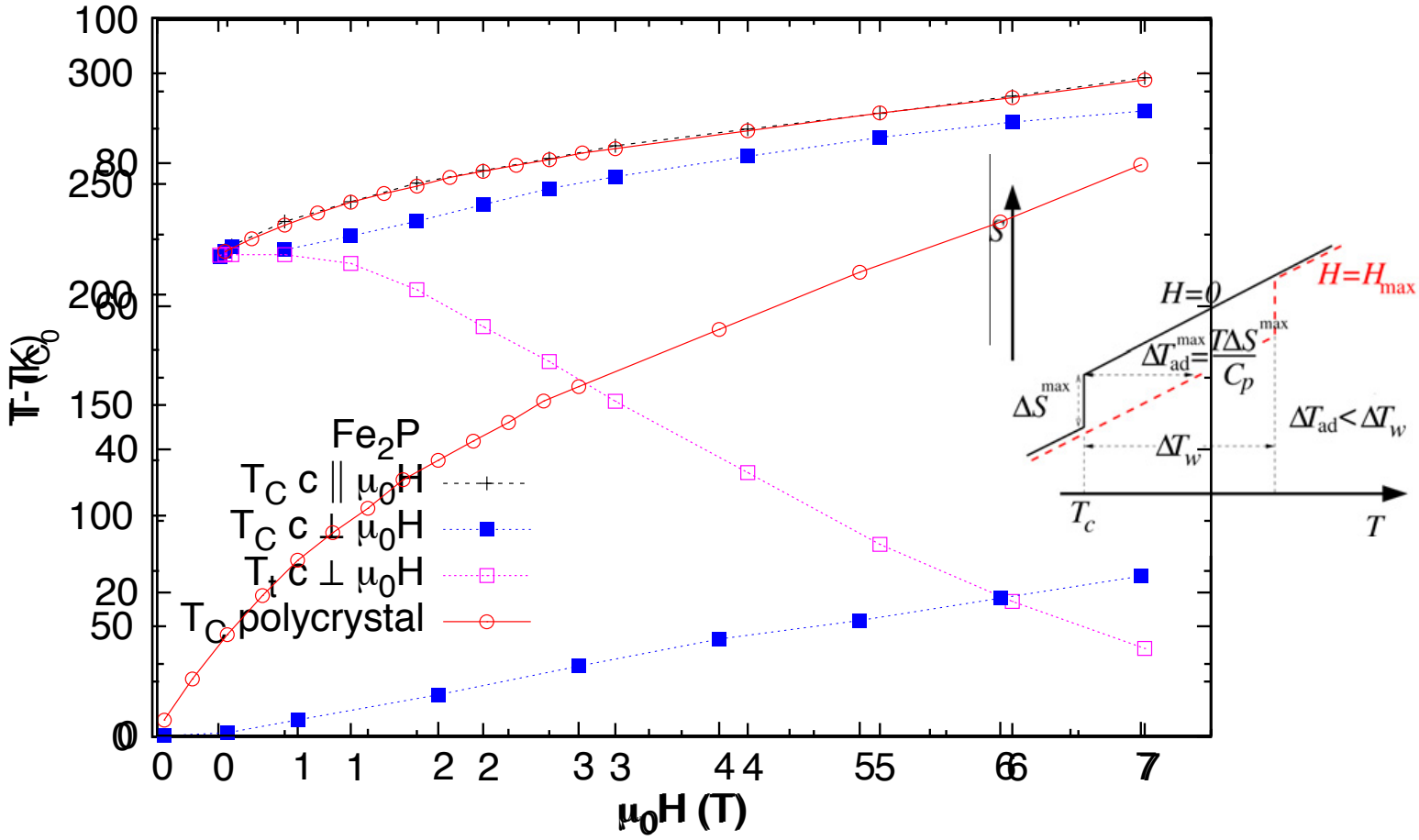


Single-crystalline Fe_2P
a-direction



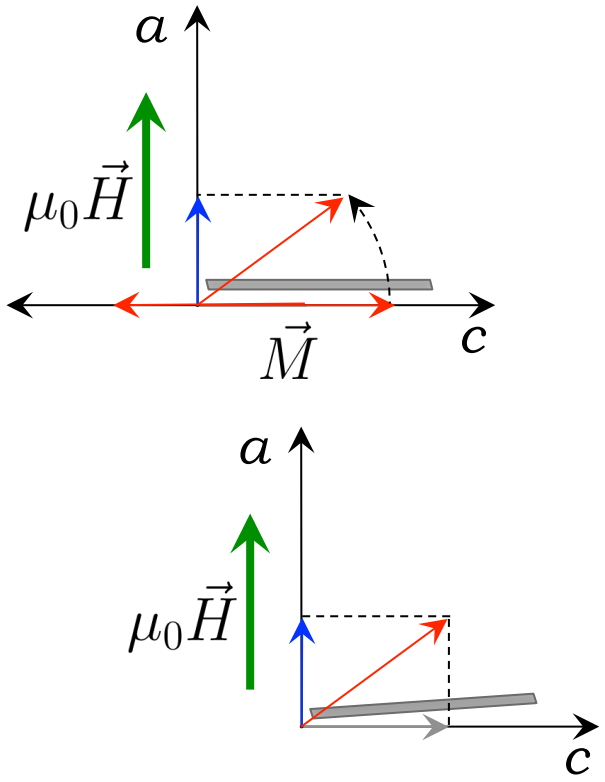


Field dependence of T_C



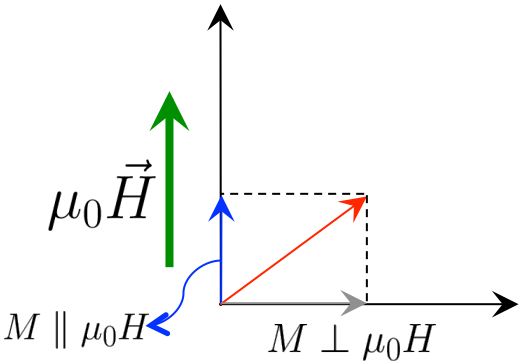
Sandeman *Scripta Materialia* **67**, 566 (2012)

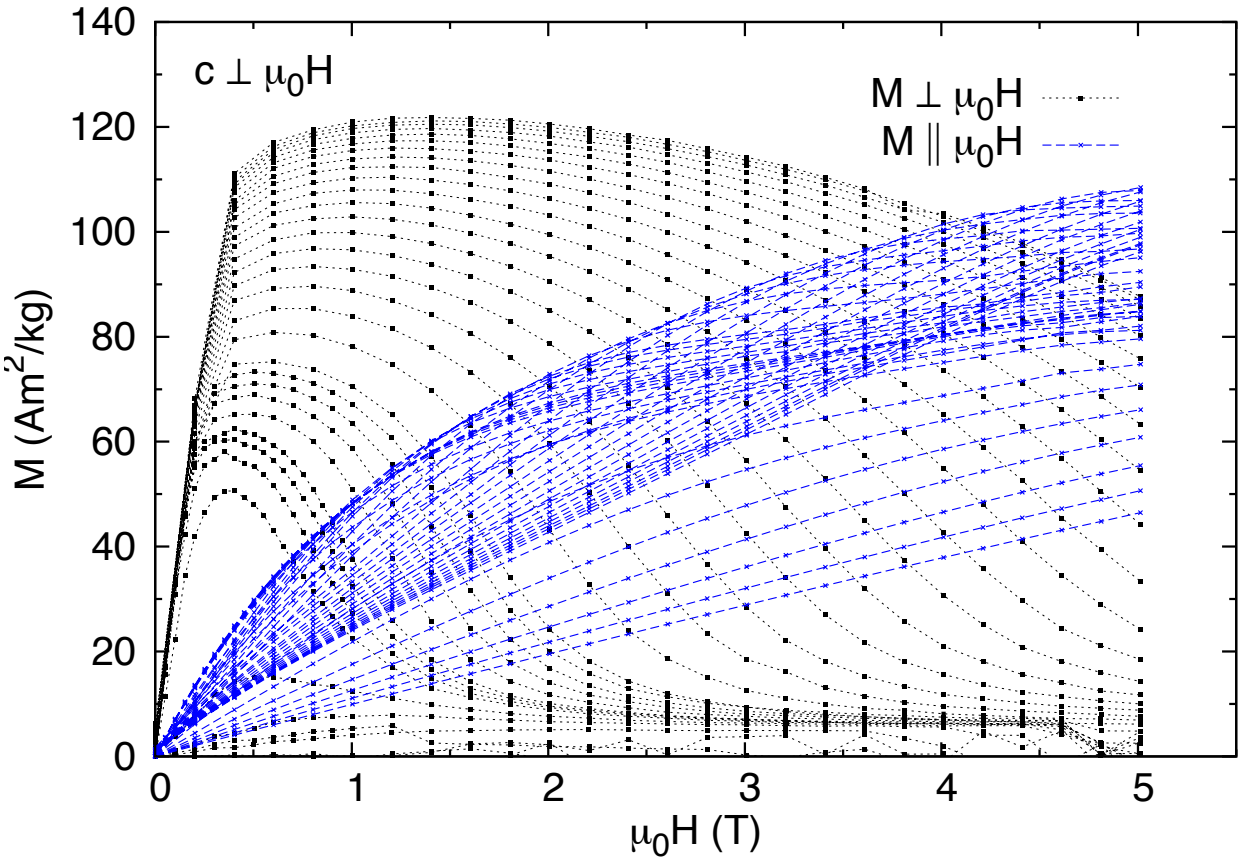
However…



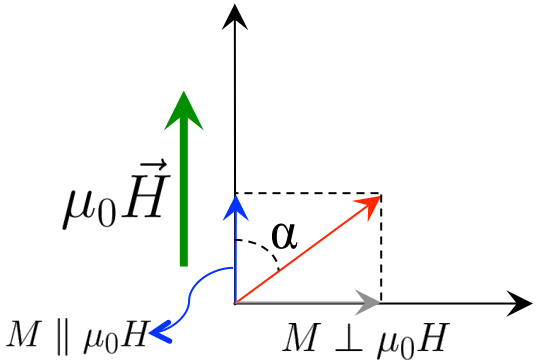
- Crystals are not flawless
  impurities, asymmetries…
- External magnetic fields are not 100% homogeneous over the sample volume
  and
- Alignment is rarely perfect

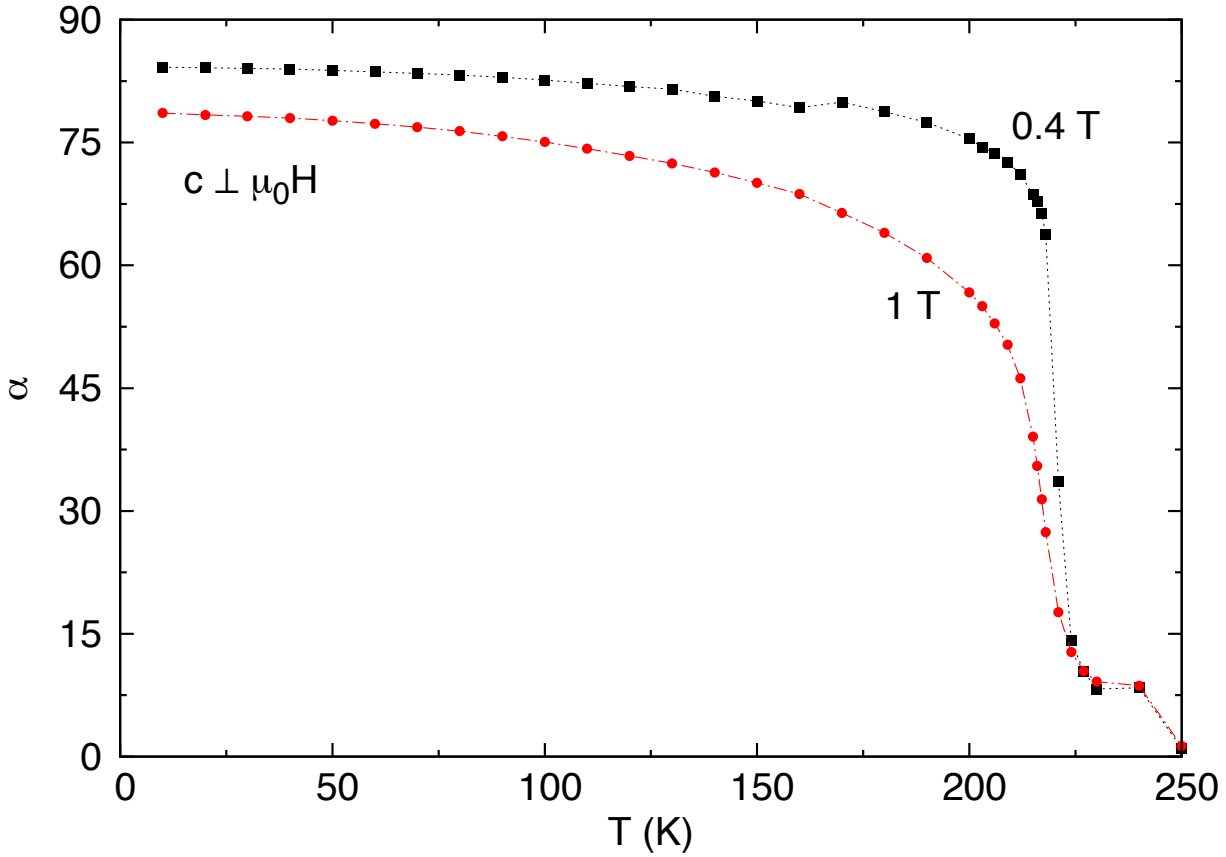
The magnetization in all directions needs to be measured.





Track the rotation of the magnetization…





PHYSIQUE. — *Sur un nouveau phénomene magnétocalorique*. Note de MM. **Pierre Weiss** et **Auguste Piccard**, présentée par M. Paul Painlevé.

. . .

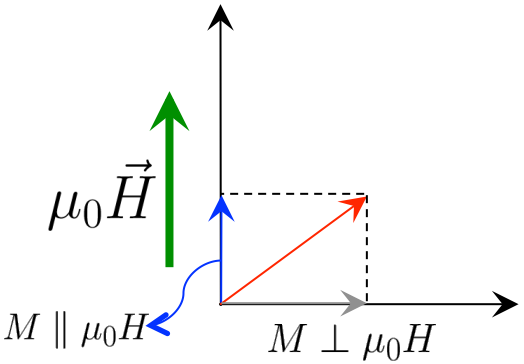
II. Ce phénomène est, comme la discontinuité de la chaleur spécifique au point de Curie, une conséquence du champ moléculaire. La chaleur élémentaire communiquée à l'unité est

$$dQ = C_\sigma dt - (H + H_m) d\sigma,$$

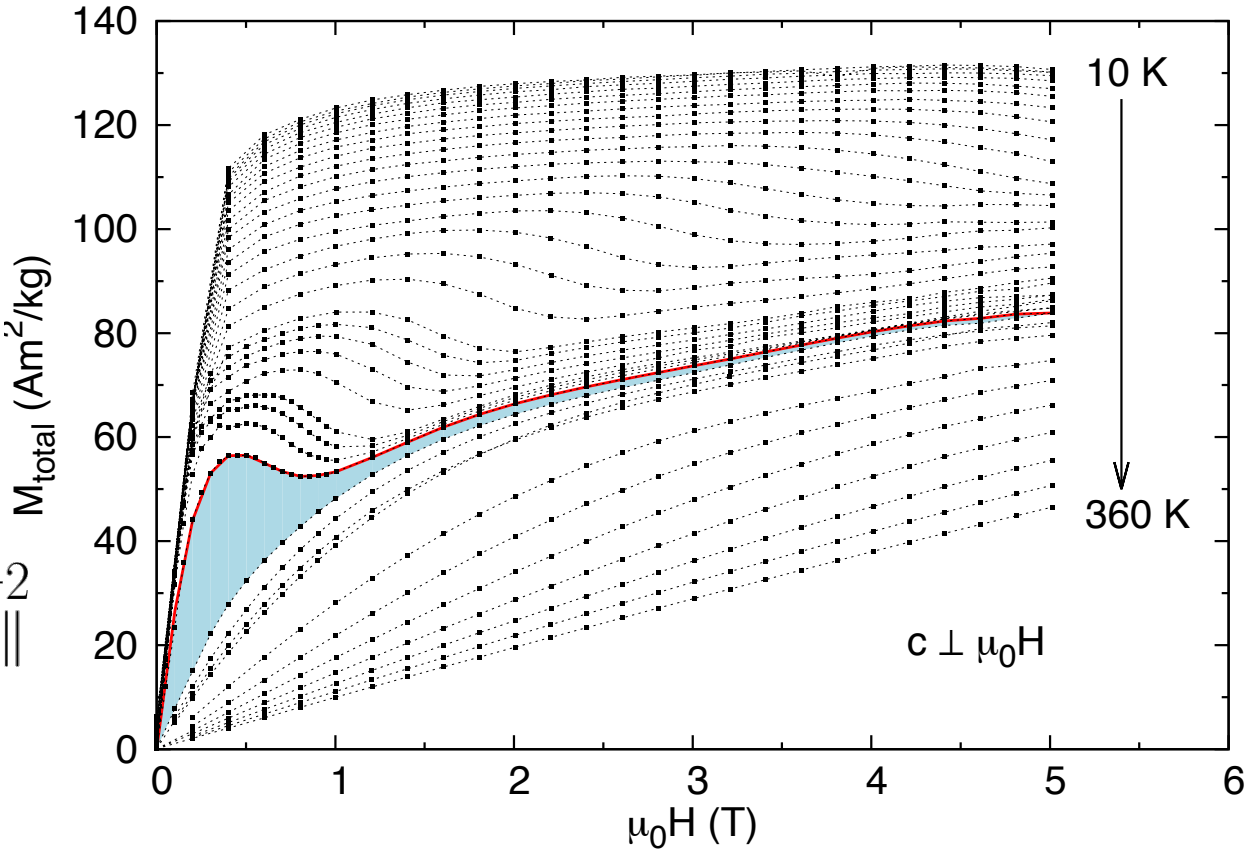
où σ est l'aimantation spécifique,
C_σ la chaleur spécifique à aimantation constante,
H le champ extérieur,
H_m le champ moléculaire.

Comptes rendus hebdomadaires des séances de l'Académie des sciences 1918

The magnetization in all directions needs to be measured.

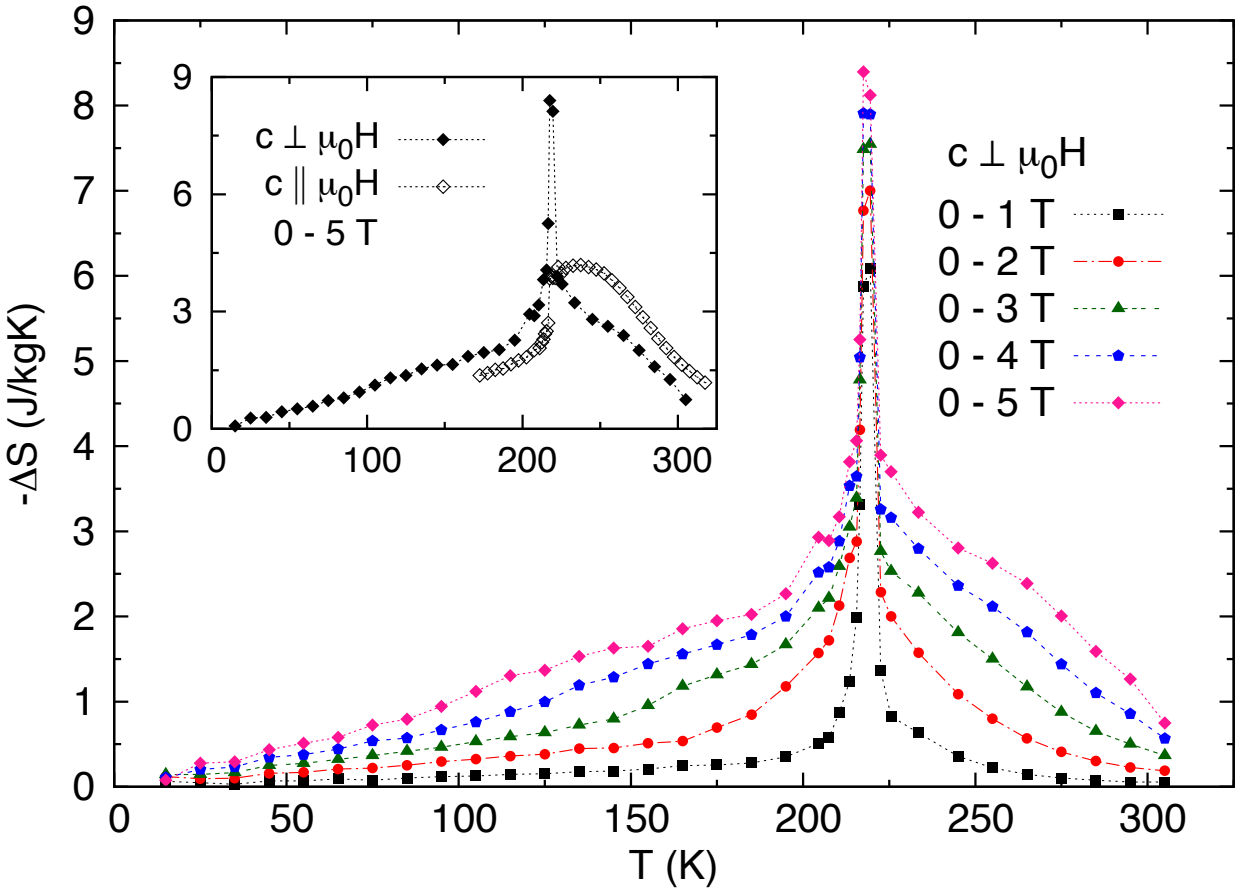


$$M_{total}^2 = M_{\perp}^2 + M_{\parallel}^2$$

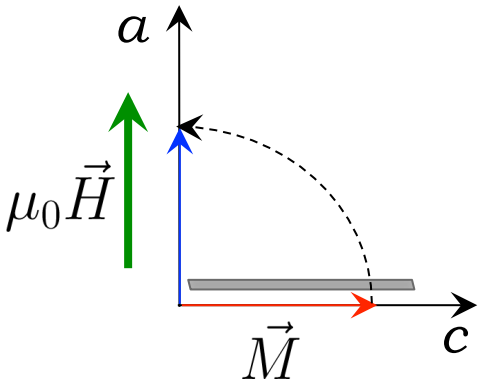


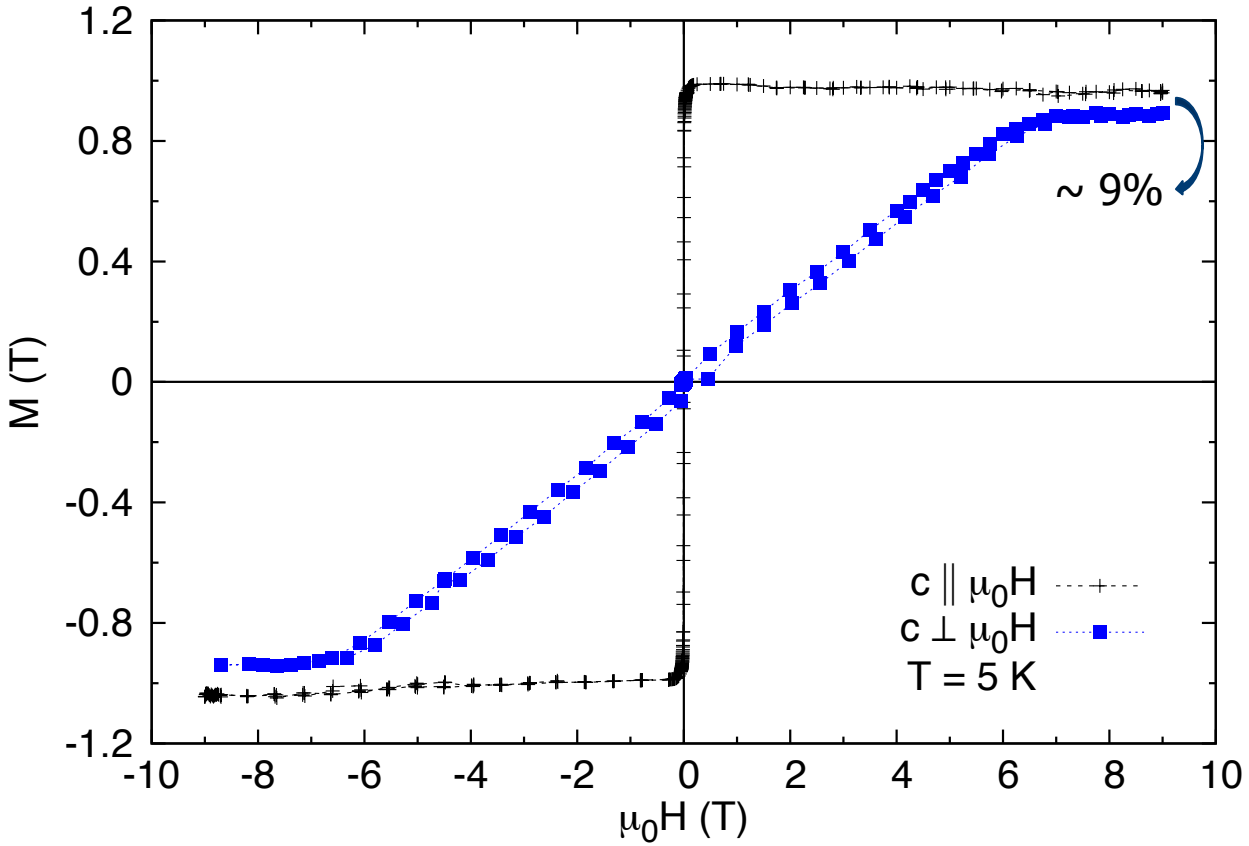
Fe_2P

Entropy Change

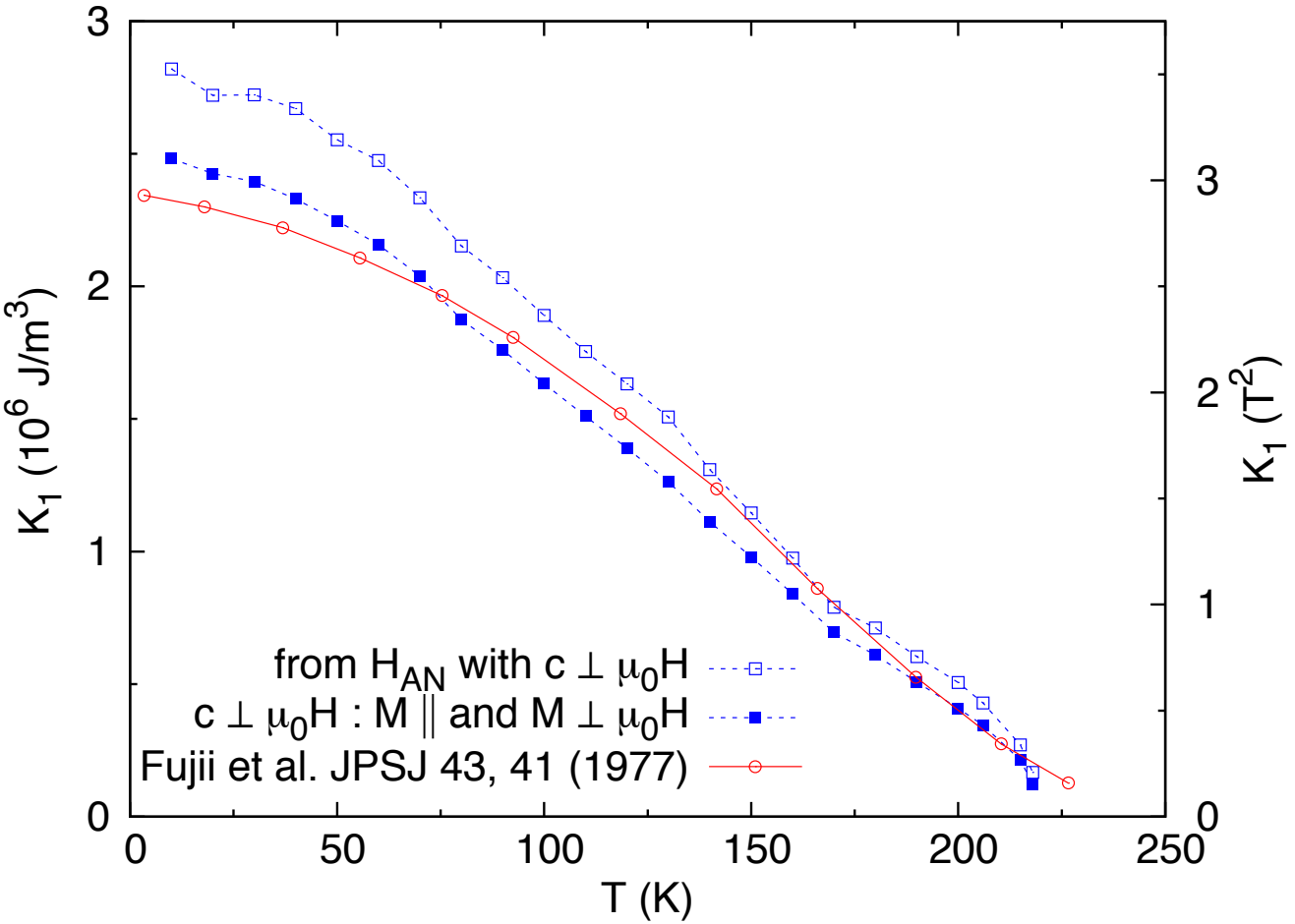


Magnetization anisotropy





Magnetic Anisotropy



Conclusions

- Full MCE characterization of high purity stoichiometric samples
- Low $\Delta S_M \sim 4\ J/kgK$ (0 – 5 T)
- Huge $dT_C/d\mu_0 H$
- Magnetization anisotropy

  localized character of the moment

- Anisotropy plays a crucial role in the MCE for single crystals

  both components of the magnetization must be checked!

PHYSICAL REVIEW B **88**, 094440 (2013)

Acknowledgements

FOM

Swedish Energy Agency

BASF The Chemical Company

Vetenskapsrådet

Thank you for your attention!