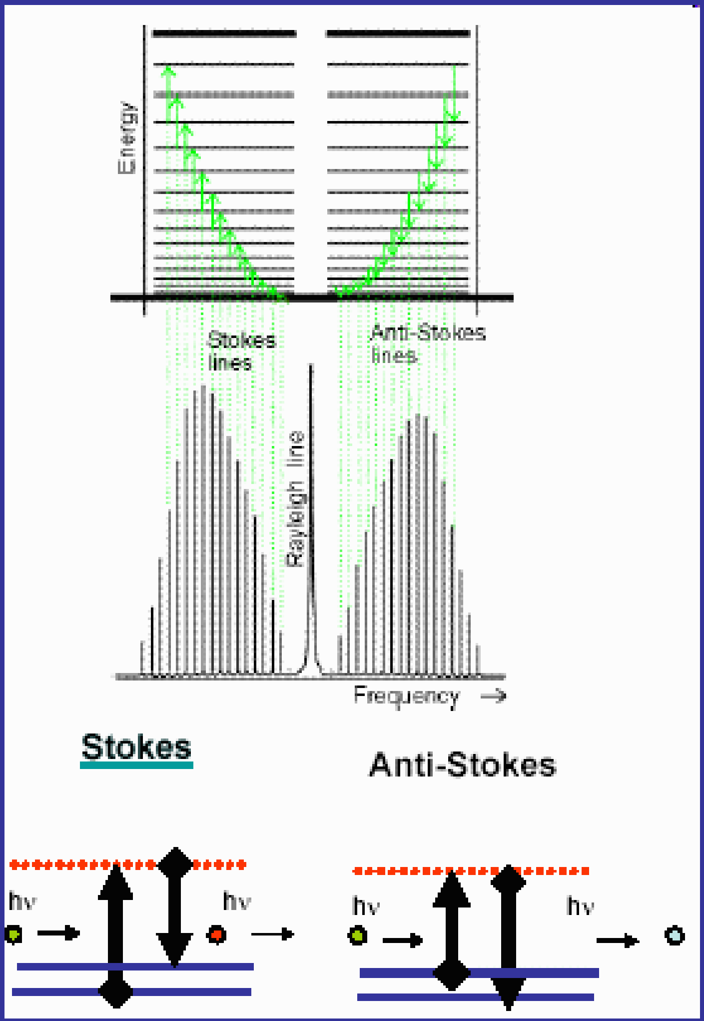
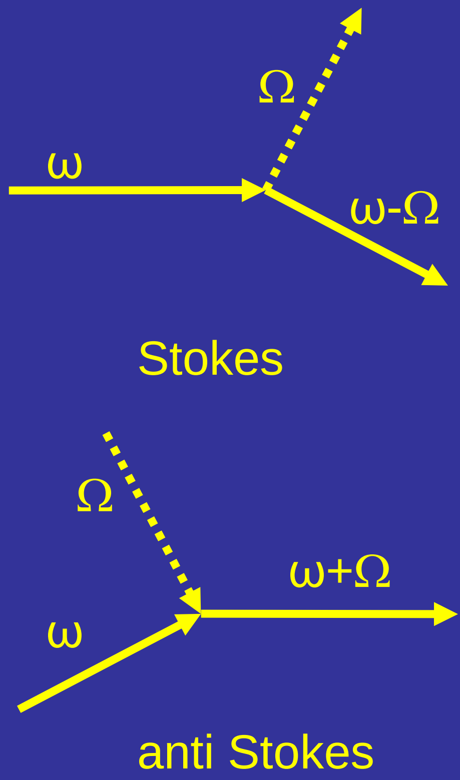
Overview

- Introduction (Fox-Ch1)
  - Response function
  - Optical processes
  - Optical constants
- Waves in solids (Fox-Appendix A)
  - Maxwell equations and wave equation
- Models (Fox-Ch2,3,7)
  - Lorentz model
  - Drude-Lorentz model
  - Transition rates, QM treatment
- Magneto-optical effects, XMCD
- Inelastic light scattering
- Non-linear optics
- Time resolved optics
- Optical modification of matter

Raman scattering

Inelastic scattering





Sir Chandrasekhara Venkata Raman
Nobel prize in Physics 1930
This year: 80 years of Raman effect
"A new radiation", *Indian J. Phys.*, 2 (1928) 387

Inelastic phonon scattering

- Polarization response $P = \varepsilon_0 \chi E$
- Phonons modulate susceptibility

$$P(t) = \varepsilon_0 \chi(t) E(t); \qquad E(t) = E_0 \cos(\omega t)$$

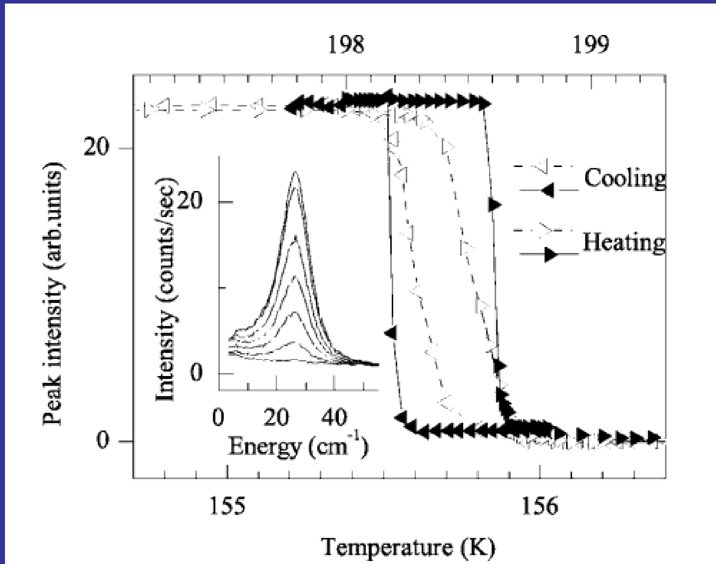
$$\chi = \chi_0 + \frac{d\chi}{dQ} Q = \chi_0 + \chi' \cos(\Omega t)$$

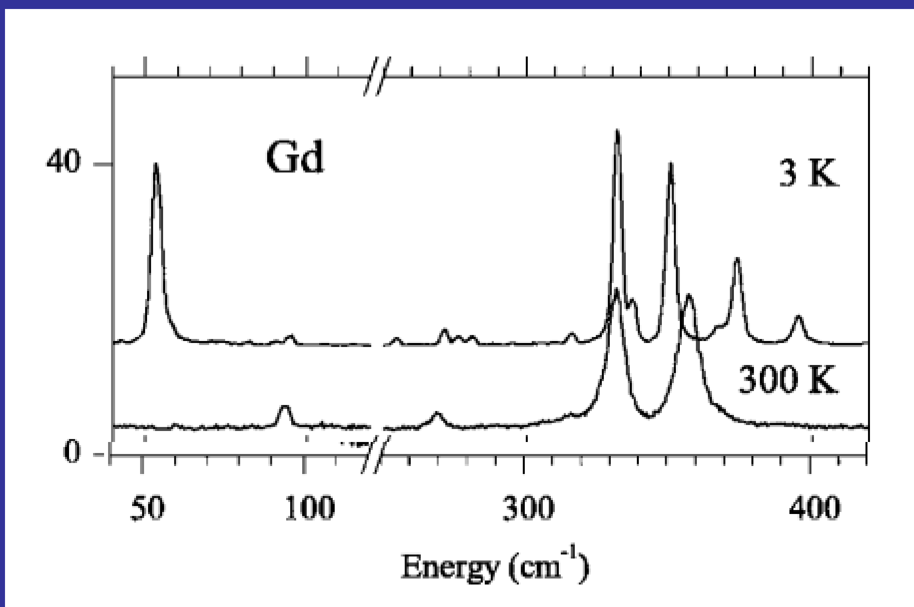
$$P(t) = \varepsilon_0 \chi_0 E_0 \cos(\omega t) + \varepsilon_0 \chi' \cos(\Omega t) E_0 \cos(\omega t)$$

$$= \varepsilon_0 \chi_0 E_0 \cos(\omega t) + \frac{1}{2} \varepsilon_0 \chi' E_0 [\cos([\omega + \Omega] t) + \cos([\omega - \Omega] t)]$$

- Dipole radiation at ω, and $\omega \pm \Omega$
- Rayleigh scattering and Raman sidebands
- Ratio anti-Stokes and Stokes intensity $\frac{I_{anti-stokes}}{I_{stokes}} = e^{-\frac{\hbar\Omega}{kT}}$

Raman scattering

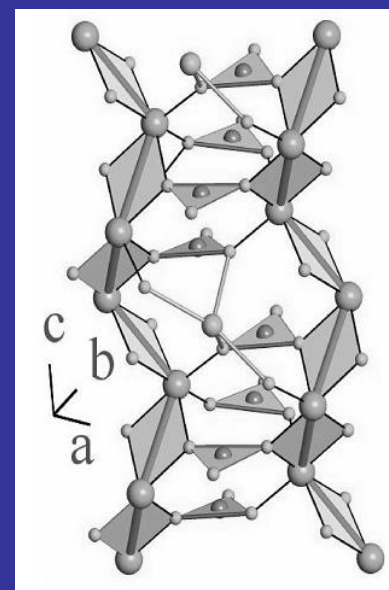




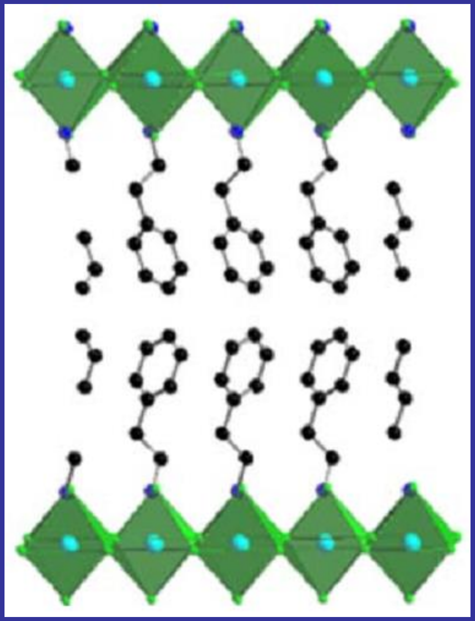
First order phase transition in $RFe_3(BO_3)_4$
D. Fausti et al., PRB **74**, 024403 2006

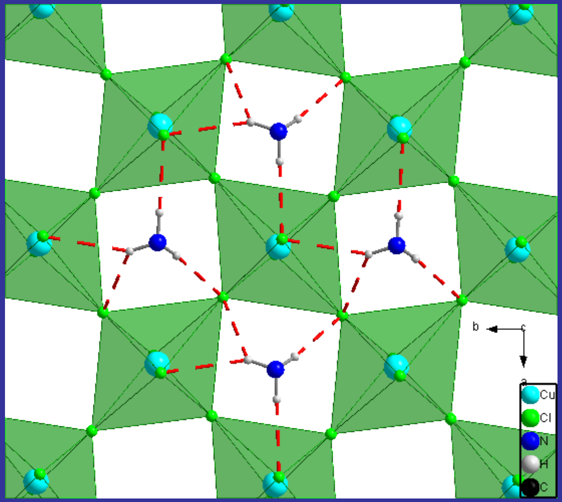
Vibrational spectroscopy

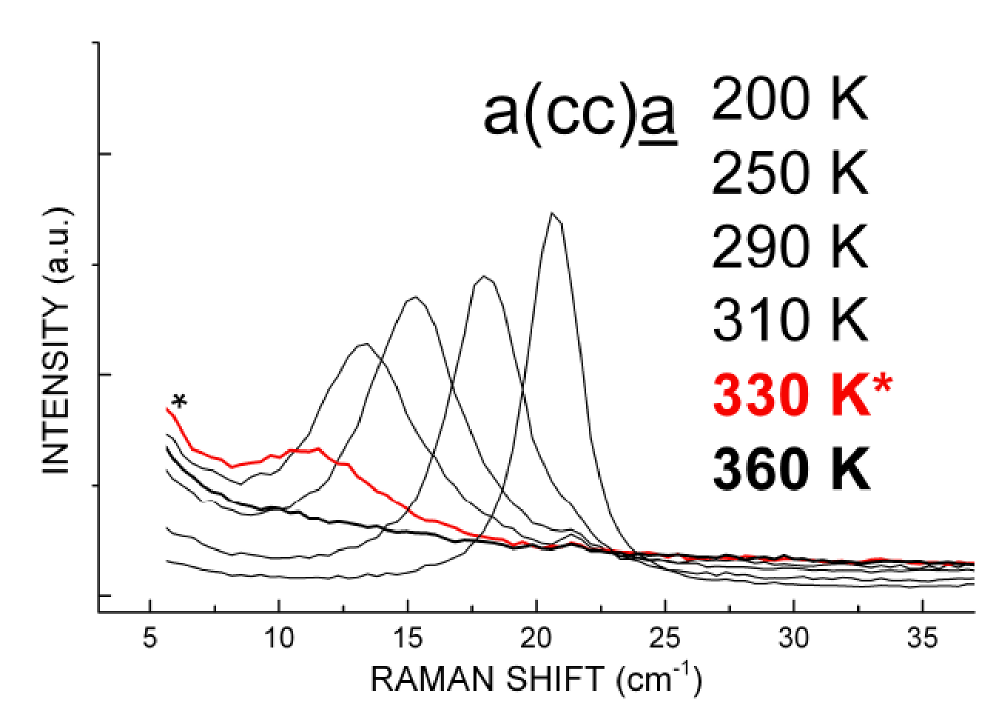
- Symmetry
- Phase transitions
- Coupling to other excitations
- Bond specific (chemical composition)
- Temperature (ratio stokes/ant-stokes)
-
-



Hybrids: Orientational melting

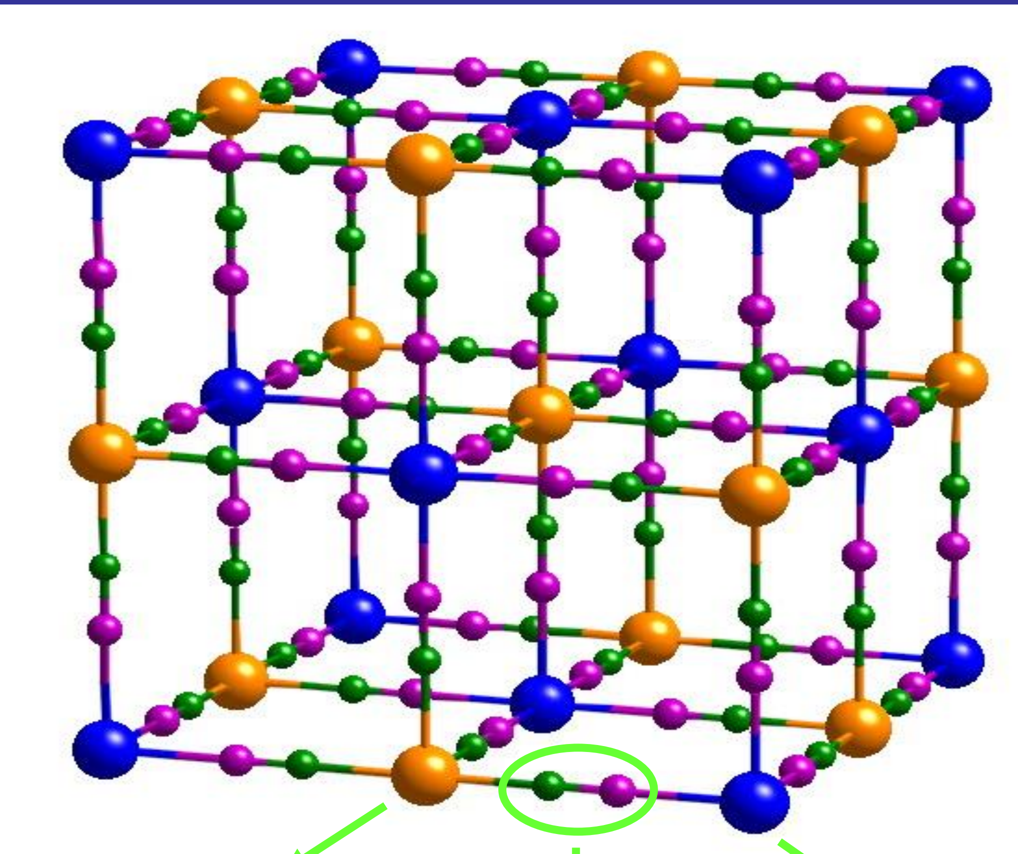






A. Caretta et al., PRB **89**, 024301 (2014)

Prussian Blue analogues



3d-M

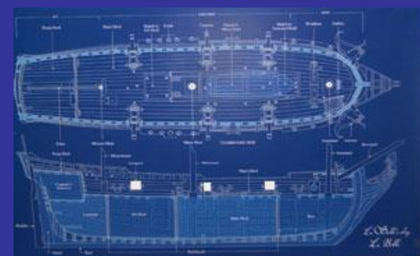
CN-group

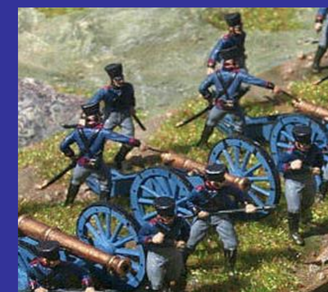
3d-M'

Cubic

CN-bridged 3d elements

Charge transfer compounds

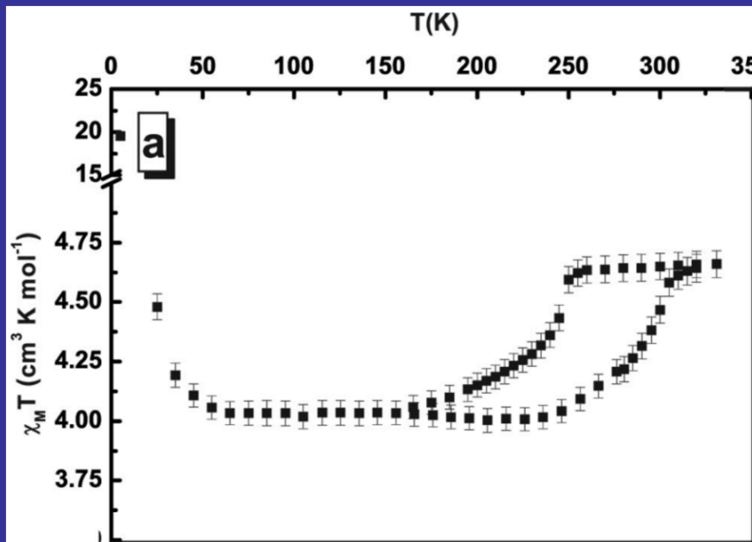


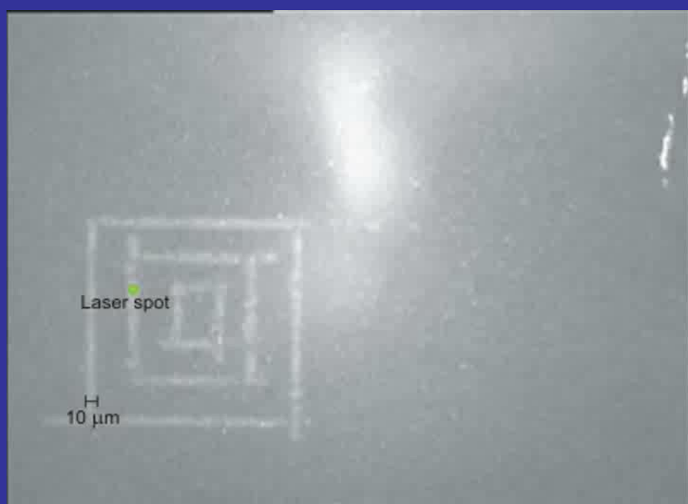


$Fe_7(CN)_{18}(H_2O)_x$

- -Discovered in 1704
- -Dye (paint, uniforms)
- -Blueprint
- -Chelation Therapy
- -Pathology

Light induced switching





Dark: Low T state

Low S Fe^{2+} $3d^6$ S=0;

High S Mn^{3+} $3d^4$ S=2

Light: High T state

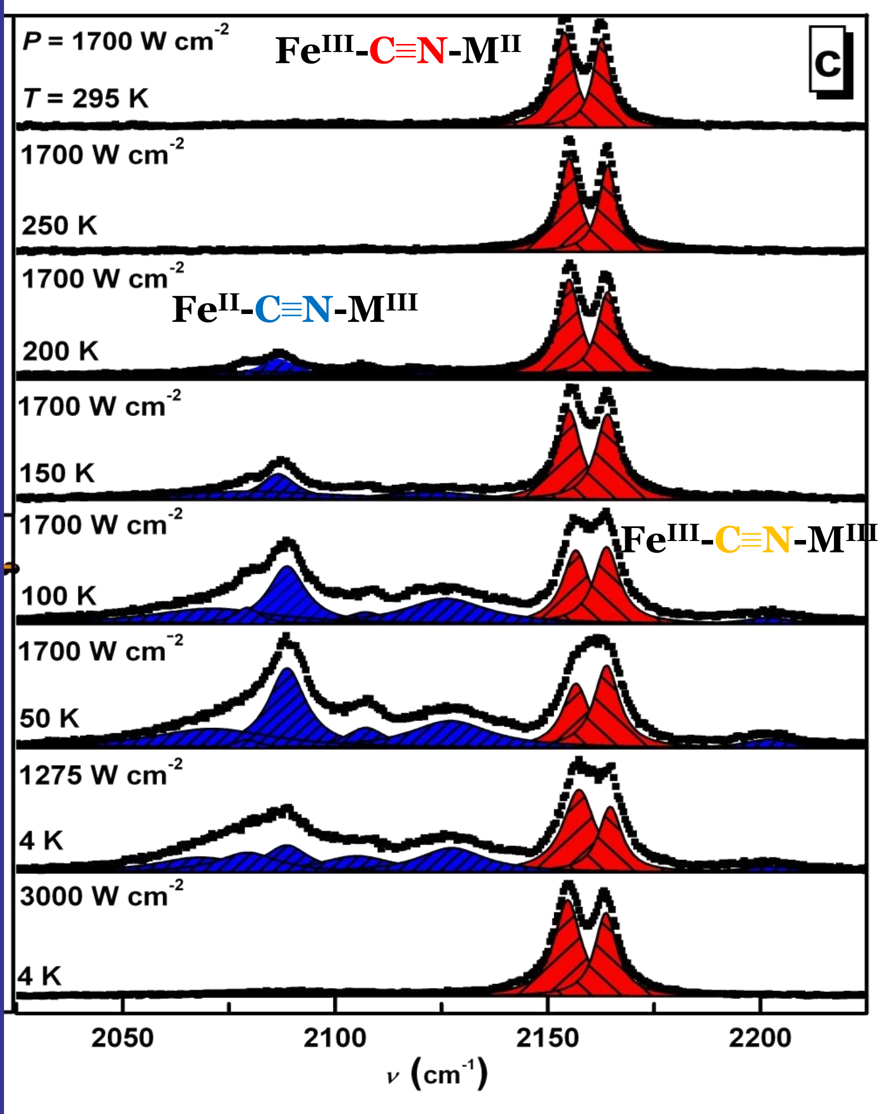
LS Fe^{3+} $3d^5$ S=1/2;

HS Mn^{2+} $3d^5$ S=5/2

Induced state:

Metastable up to ~126 K

Light induced switching



J. Phys. Chem. C **112**, 14158 (2008)

532.6 nm excitation!

Only 50% goes to LT phase

- Also observed in SQUID and Mossbauer data

- Originates from Rb site occupation

Cyano-bridge	ν_{CN} (cm^{-1})
Fe^{II}-C≡N-M^{II}	2065-2100
Fe^{II}-C≡N-M^{III}	2100-2150
Fe^{III}-C≡N-M^{II}	2140-2185
Fe^{III}-C≡N-M^{III}	2185-2220

- Derive the wave equation
- 1.8; 1.12; 1.19

- Derive the response function of a Lorentz oscillator
- 2.3; 2.6;

- 7.1, 7.6, 7.7;