Structural and Magnetic Properties of Spinel FeV_2O_4

2008. 7. 10 Lab seminar

Kaist
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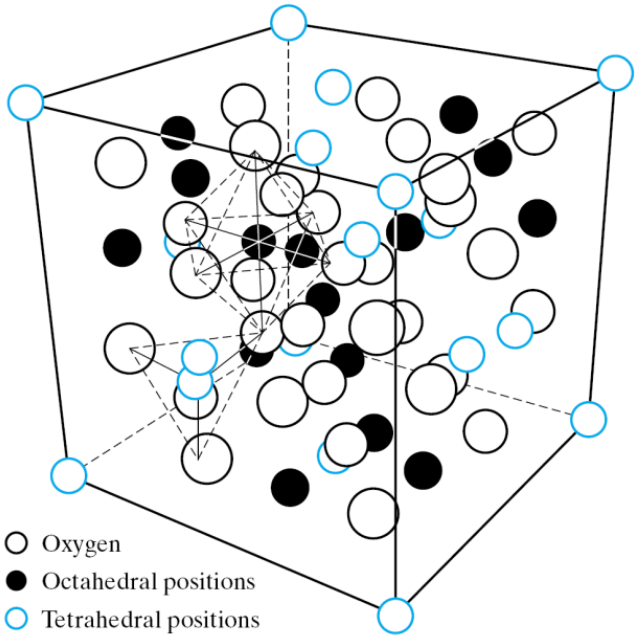
Introduction

- 1 site having orbital degrees of freedom

	T_S (Cubic → tetragonal)	T_N
ZnV2O4	50K (a>c)	40K
MnV2O4	57K (a>c)	57K
FeCr2O4	135K (a>c)	80K

Ref.
S.-H. Lee, D. Louca, H. Ueda, S. Park, T. J. Sato, M. Isobe, Y. Ueda, S. Rosenkranz, P. Zschack, J. Íñiguez, Y. Qiu, and R. Osborn: Phys. Rev. Lett. **93** (2004) 156407[APS].
T. Suzuki, M. Katsumura, K. Taniguchi, T. Arima, and T. Katsufuji: Phys. Rev. Lett. **98** (2007) 127203[APS]
M. Tanaka, T. Tokoro, and Y. Aiyama: J. Phys. Soc. Jpn. **21** (1966) 262[IPAP].

Spinel structure (AB2O4)



[From F. G. Brockman, Bull. Am. Cream. Soc. 47, 186(1967)]

- 2 sites having orbital degrees of freedom

-FeV_2O_4 : several Ts and 1 T_N

Structural and Magnetic Properties of Spinel FeV_2O_4 with Two Ions Having Orbital Degrees of Freedom

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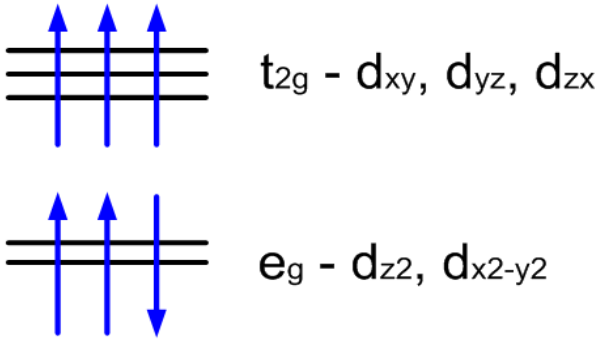
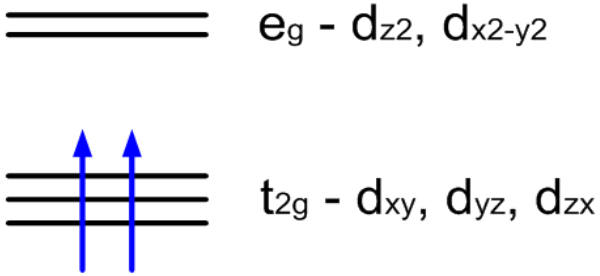
FeV2O4

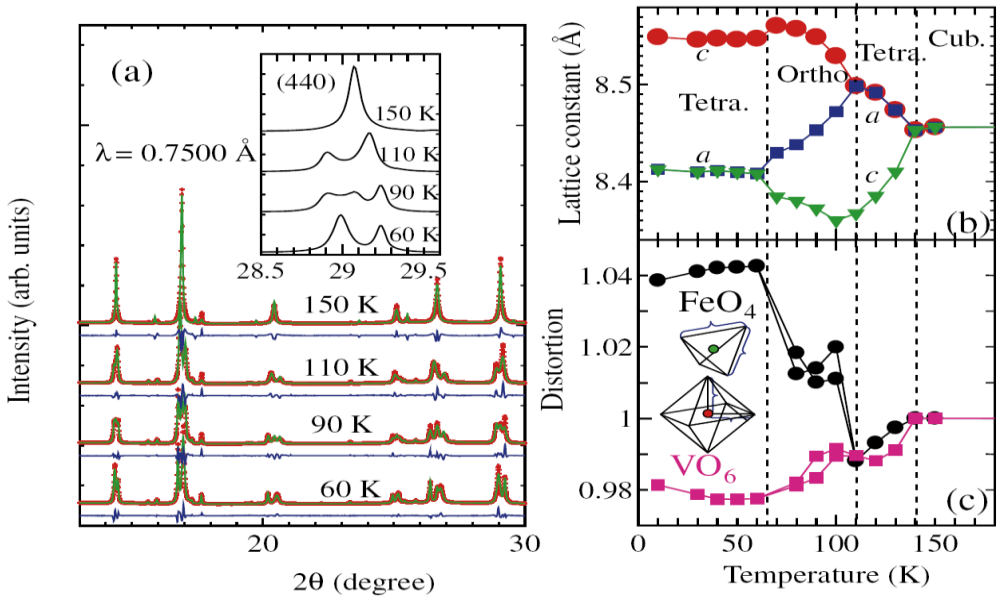
- Fe^{2+}
- S=2
- high-spin electron
- In the tetrahedral site



- V^{3+}
- S=1
- high-spin electron
- In the octahedral site



X-ray powder diffraction

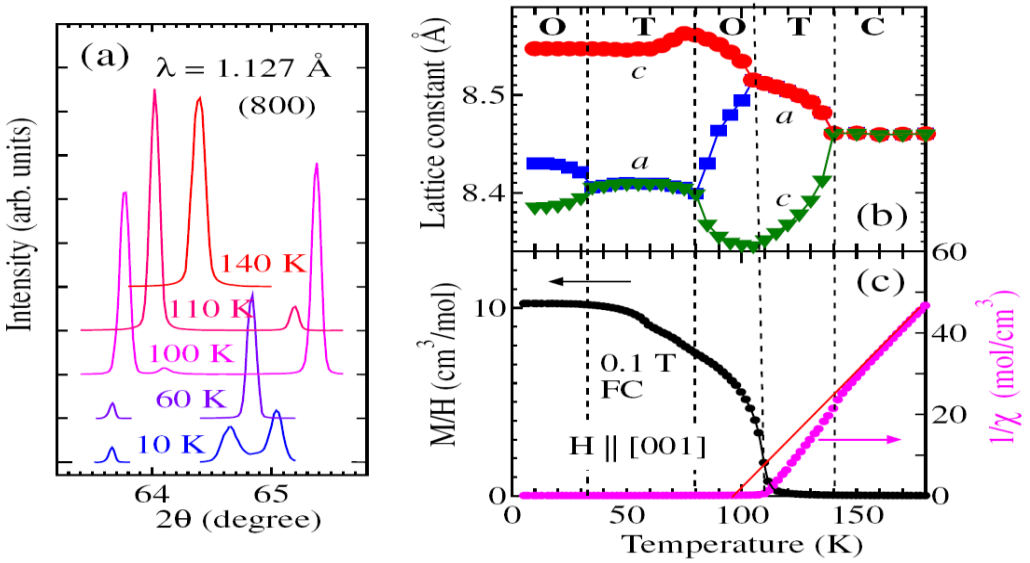


- Structural phase transition (with decreasing temperature)

- cubic → tetragonal → orthorhombic → tetragonal

- VO6 : compressed
- FeO4 : compressed (high-temperature tetragonal) → elongated (orthorhombic and low-temperature tetragonal)

X-ray diffraction on the Single crystal

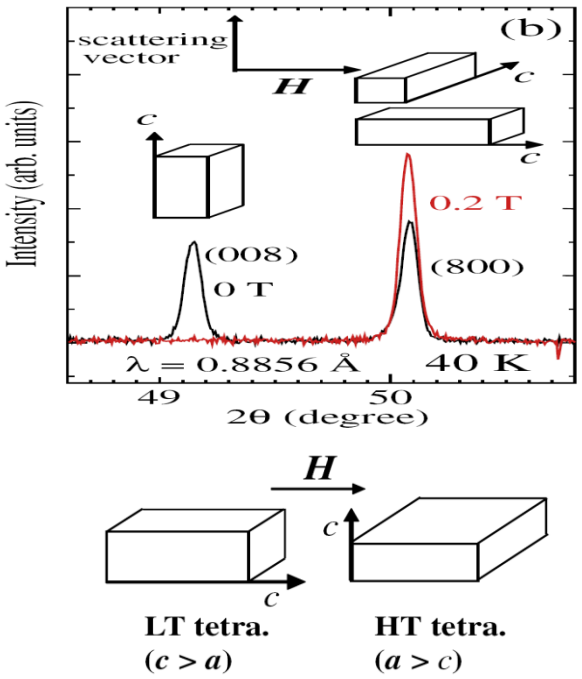


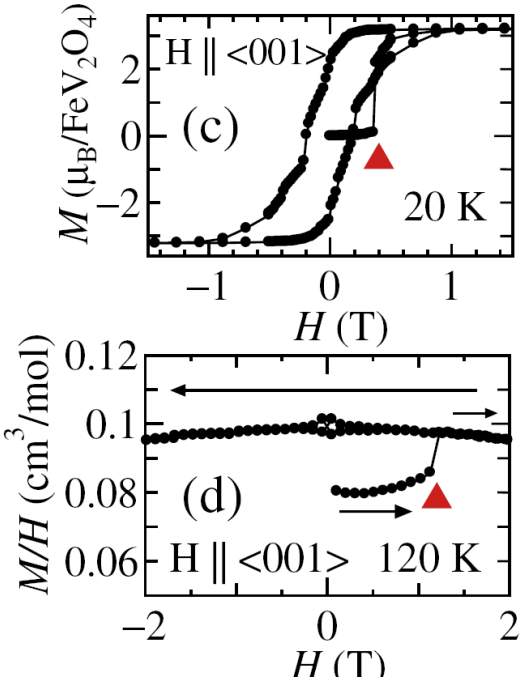
- Structural phase transition (with decreasing temperature)

- cubic → tetragonal → orthorhombic → tetragonal → orthorhombic

- Temperature dependence of magnetization
- Coupling between the magnetism and the crystal structure

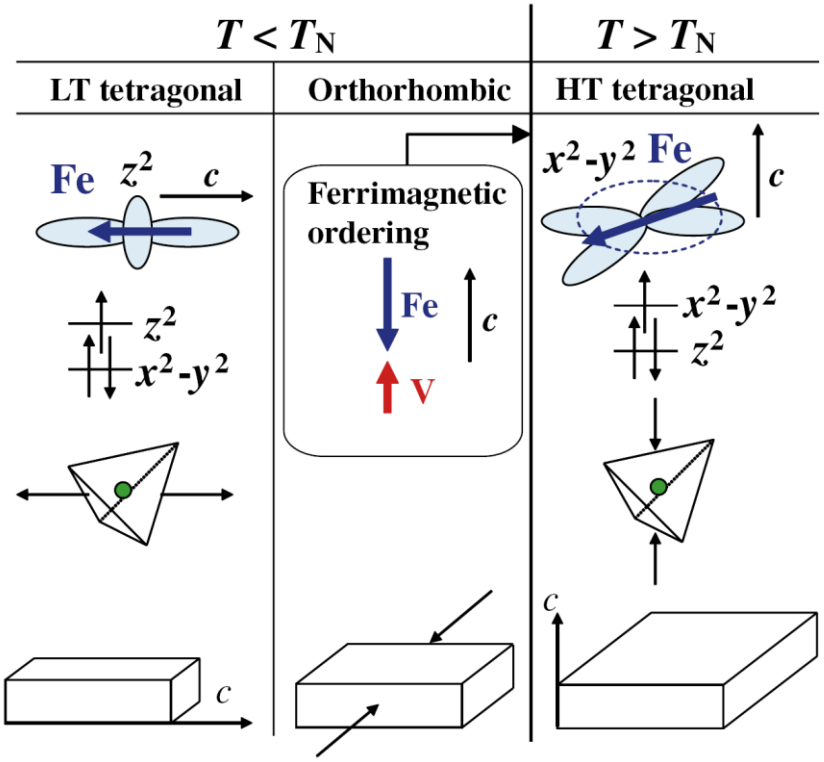
Alignment of crystalline domain





- C-axis is aligned along the magnetic field direction at 0.2T
- The alignment of crystalline domain affects the magnetization curve
- Multi domain structure ➔ single domain structure
- Magnetic anisotropy energy

Possible microscopic mechanism



- t2g energy state splitting because of Jahn-Teller distortion
- Orbital polarization of Fe2+ induced the ferrimagnetic ordering
- Spin orientation of Fe2+ is determined through the coupling with the V3+ spin
- Orbital state of Fe2+ and lattice distortion is determined by the magnetic anistropy

summary

- FeV_2O_4 have unique structural phase transition
- Magnetic easy axis
  - along the ab-plane HT tetragonal phase
  - along the c axis LT tetragonal phase
- Competition and cooperation of Fe^{2+} and V^{3+} make structural phase transition