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## A MaxEnt- $\mu$ SR study: Precursor effects of the Fe<sub>3</sub>O<sub>4</sub> Verwey transition

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Using muon-spin rotation ( $\mu$ SR) [1] the magnetic fields of Fe<sub>3</sub>O<sub>4</sub> have been previously investigated. The Verwey transition at  $T_v$  (~123 K) and a transition at  $T_w$  (~247 K) are observed. Using Maximum-Entropy (MaxEnt)  $\mu$ SR data of single-crystal Fe<sub>3</sub>O<sub>4</sub> are analyzed with much improved precision. [2,3] We review earlier results [3] and report on our analysis of the temperature dependence of fields with  $B$  (720 Oe) //  $\langle 110 \rangle$ . Below the demagnetization field, extra  $\mu$ SR signals are found at  $B_{ext}$  //  $\langle 110 \rangle$  indicating two frequencies at room temperature (RT) and two at 205 K. [3] At RT, the upper frequency follows the zero-field trend seen in the  $T_v$ - $T_w$  region of the zero-field (ZF) phase diagram. At 205 K, the lower frequency follows the extension of the ZF trend above  $T_w$ . These two ZF trends indicate plausible short-range ordering related to the “extra” 3d-electron conduction behavior. This should further be interpreted as precursor effects to the  $T_v$  transition. [1] Our MaxEnt- $\mu$ SR finding is consistent with diffuse [4] & x-ray [5] scattering results above  $T_v$  providing a clear picture of the magnetic environments in Fe<sub>3</sub>O<sub>4</sub>. This new interpretation indicates two T-dependent magnetizations, reflecting different short-range orders [3-5] in the ZF phase diagram of this Mott-Wigner glass.[6]

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[1] C. Boekema et al, Phys Rev B33 (1986) 2102; Phys Rev B31 (1985) 1233 & references therein.

[2] C Boekema and MC Browne, MaxEnt 2008, AIP Conf Proc #1073 (2008) 260.

[3] C Morante and C Boekema, AIP Advances 10 (2020).025005.

[4] A Bosak et al, Phys Rev X4 (2014) 011040.

[5] G Perversi et al, Nature Comm 10 (2019).2857.

[6] JHVJ Brabers et al, J Physics Condensed Matter 12 (2000) 5437.

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