

An atom with  $n$  unpaired electrons has an effective magnetic moment of

$$\mu_{\text{eff}} = \sqrt{n(n+2)}\mu_{\text{B}}, \quad (1)$$

where (In the spirit of order-of-magnitude calculations, I will use single-digit precision for all quantities)

$$\mu_{\text{B}} = \text{Bohr magneton} = 9 \times 10^{-24} \frac{\text{J}}{\text{T}}, \quad (2)$$

For iron atoms,  $n$  is at most 5, and a complex of 40 aligned Fe atoms would therefore have a magnetic moment of at best

$$m = 40 \times \sqrt{5(5+2)}\mu_{\text{B}} = 2 \times 10^{-21} \frac{\text{J}}{\text{T}}. \quad (3)$$

The interaction energy of that moment with the earth's field (about 50  $\mu\text{T}$ ) is at most

$$mB_{\text{Earth}} = 1 \times 10^{-25} \text{ J}. \quad (4)$$

Meanwhile the thermal energy per degree of freedom is

$$kT = 4 \times 10^{-21} \text{ J}. \quad (5)$$

The ratio between those is

$$\frac{mB_{\text{Earth}}}{kT} = 2 \times 10^{-5}. \quad (6)$$

That is the degree of alignment one would expect for the protein complex. Instead, the authors claim an alignment of 0.45. Again, this claim exceeds by about 5 log units the prediction from basic physics, even allowing for an unexplained coordination of the 40 Fe spins. Clearly the reported observations must arise from some entirely different cause, probably unrelated to magnetic fields.