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**Order by Disorder in the XY Pyrochlore Antiferromagnet $Er_2Ti_2O_7$**[1]

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Crystal field effects associated with $Er^{3+}$ magnetic moments in $Er_2Ti_2O_7$ give rise to local XY anisotropy and effective quantum S=1/2 spins which are antiferromagnetically coupled on this materials cubic pyrochlore lattice [1]. $Er_2Ti_2O_7$ orders into a non-collinear antiferromagnetic $\Psi_2$ state below $\sim$ 1.2 K, in zero magnetic field, but the mechanism for its ground state selection has been a puzzle for more than a decade. We have carried out inelastic neutron scattering measurements on single crystal samples of $Er_2Ti_2O_7$ at low temperatures and in the presence of a strong [110] magnetic field, allowing us to determine the underlying spin Hamiltonian for this quantum antiferromagnet [2, 3]. These results point to ground state selection via an order-by-quantum-disorder mechanism [3], and a concomitant order-by-disorder gap of $\sim$ 0.05 meV has also been observed [4], associated with the pseudo-Goldstone modes in the low field ordered state. In addition, we have explored the sensitivity of the ground state selection to magnetic dilution by preparing and studying single crystals of $Er_{2-x}Y_xTi_2O_7$ [5]. These studies are particularly topical in light of two theoretical predictions [6,7] that the $\Psi_2$ ordered state may be unstable to formation of the related $\Psi_3$ phase at low temperatures, in the presence of quenched disorder. [1] J.D.M. Champion et al., Phys. Rev. B 68, 020401 (2003). [2] J.P.C. Ruff et al., Phys. Rev. Lett., 101, 147205 (2005). [3] L. Savary et al. Phys. Rev. Lett., 109, 167201 (2012). [4] K.A. Ross et al. Phys. Rev. Lett. 112, 057201 (2014). [5] J.F. Niven, Proc. R. Soc. A, 470: 20140387 (2014). [6] V. S. Maryasin and M. E. Zhitomirsky, Phys. Rev. B 90, 094412 (2014). [7] A. Andreanov and P. A. McClarty, Phys. Rev. B 91, 064401 (2015).

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