Abstract Submitted
for the MAR14 Meeting of
The American Physical Society

Quantum and Classical Criticality in a Dimerized Quantum Antiferromagnet CHRISTIAN RUEEGG, Paul Scherrer Institute and University of Geneva, Switzerland, PHILIP MERCHANT, DESMOND F. MCMORROW, University College London, UK, KARL. W. KRAEMER, University of Bern, Switzerland, MARTIN BOEHM, boehm@ill.fr, BRUCE NORMAND, Renmin University, China — We perform high-resolution neutron spectroscopy experiments to probe the spin excitations of the quantum antiferromagnet $TlCuCl_3$ throughout the phase diagram by controlling the pressure and temperature. Because this material has a pressure-induced quantum critical point (QCP) at $p_c = 1.07$ kb and a thermal ordering transition at $T_N(p)$ for $p > p_c$ [1], we demonstrate a number of remarkable properties arising at the interface between quantum and classical physics. Quantum and thermal fluctuations have very similar effects in melting the magnetically ordered phase and in opening excitation gaps, but they operate quite independently close to the QCP. In the QC regime there is robust ω/T scaling of the energies and Γ/T scaling of the widths of the critically damped excitations. This scaling crosses over to a classical critical form in a narrow region around $T_N(p)$. The critically damped longitudinal, or Higgs, mode of the ordered phase [2] is exquisitely sensitive to thermal fluctuations and becomes overdamped in the classical regime.

[1] Ch. Rüegg *et al.*, PRL **93**, 257201 (2004).
[2] Ch. Rüegg *et al.*, PRL **100**, 205701 (2008).

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Date submitted: 15 Nov 2013 Electronic form version 1.4