Evidence for a Tomonaga-Luttinger phase in a S=1 bond-alternating antiferromagnetic chain

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We have performed specific heat (C_{mag}) measurements on single crystals of the quasi-one-dimensional S=1 bond-alternating antiferromagnet Ni(C_9H_24N_4)NO_2(ClO_4), alias NTENP, down to 250 mK in a magnetic field up to 20 T along the chain. NTENP has a singlet ground state with an excitation energy gap at 0 T. In a magnetic field, one branch of the triplet excited state goes down and reaches the ground state at a critical field (H_c), which is 9.3 T for this direction. According to the comparison of magnetic susceptibility with a numerical calculation, the axial single-ion anisotropy constant D of NTENP is D/k_B=13.6 K, with a much smaller orthorhombic term E. Because of the nearly axial symmetry of its crystal structure, this material is an excellent candidate for the Tomonaga-Luttinger (TL) liquid, which has been theoretically predicted to exist at magnetic fields above H_c applied in the chain direction. We have found that C_{mag}/T is constant above H_c over a temperature range above that of the long-range ordered state both for hydrogenous and deuterated samples. This temperature dependence is a probable signature of the TL liquid but has never been observed in a real substance prior to our study.