Excitation Hierarchy in the Spin-1 Large-D System NiCl\textsubscript{2}-4SC(NH\textsubscript{2})\textsubscript{2}

S.A. Zvyagin (Dresden High Magnetic Field Laboratory, FZD), J. Wosnitza (Dresden High Magnetic Field Laboratory, FZD), M. Tsukamoto (ISSP, U. Tokyo), N. Kawashima (ISSP, U. Tokyo), C. D. Batista (LANL), J. Krzystek (NHMFL), V. S. Zapf (NHMFL, LANL), M. Jaime (NHMFL/LANL), A. Paduan-Filho (U. de Sao Paulo)

Introduction

Recently, weakly-coupled anisotropic spin-1 chains have attracted renewed interest due to their possible relevance to the so-called field-induced Bose-Einstein condensation (BEC) of magnons [1]. When the field $H$, applied perpendicular to the easy plane, exceeds a critical value $H_{c1}$, the gap closes and at sufficiently low temperatures the system undergoes a transition into a magnetically-ordered phase with a finite magnetization. If the spin Hamiltonian has axial symmetry with respect to the applied field, the AFM ordering can be described in terms of BEC of magnons by mapping the spin-1 system into a gas of semi-hard-core bosons. As suggested [3], a magnetic field here can be regarded as the chemical potential, gradually changing the magnon concentration and providing a unique access to a wide range of the particle densities, from a dilute Bose gas to a strongly interacting boson liquid.

Results and Discussion

The compound NiCl\textsubscript{2}-4SC(NH\textsubscript{2})\textsubscript{2} (known as DTN), is a new candidate for studying the field-induced BEC of magnons. Recently, it was proposed [2, 3] that the field-induced low-temperature transition of DTN to the AFM-ordered state can be interpreted as a BEC of magnons, with values of $H_{c1} = 2.1$ T and $H_{c2} = 12.6$ T (T ~ 0) for the lower and upper critical fields, respectively. Using high-field tunable-frequency BWO-based electron spin resonance (ESR) spectrometer [4] at the NHMFL (DC Field Facilities), we studied the magnetic excitations in DTN in fields up to 25 T. Based on analysis of the single-magnon excitation mode in the high-field ($H > H_{c2}$) phase and previous experimental results [3], a revised set of spin-Hamiltonian parameters was obtained. Our results yield $D = 8.9$ K, $J_c = 2.2$ K, and $J_{ab} = 0.18$ K for the anisotropy, intra- and interchain exchange interactions, respectively. These values have been used to calculate the antiferromagnetic phase boundary, magnetization and the frequency-field dependence of two-magnon bound-state excitations (the modes $E$ and $F$, Fig. 1) predicted by theory [5] and observed in DTN for the first time. Excellent quantitative agreement with experimental data was obtained [6].

![Fig. 1. The frequency-field dependence of magnetic excitations in DTN. Excitations in the quantum-paramagnetic phase are denoted by $A$ and $B$; the mode $C$ corresponds to single-magnon excitations; the modes $E$ and $F$ correspond to two-magnon bound-state excitations [5].](image)

Acknowledgements

Sergei Zvyagin acknowledges the support from the NHMFL through the VSP No. 1382.

References