Quasi-One-Dimensional Spin Chains in CuSiO₃: an EPR Study*

J. Sichelschmidt¹, M. Baenitz¹, C. Geibel¹, F. Steglich¹, A. Loidl², and H. H. Otto³

¹Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany
²Experimentalphysik V, Universität Augsburg, Augsburg, Germany
³Institut für Mineralogie und Mineralische Rohstoffe, Technische Universität-Clausthal, Clausthal-Zellerfeld, Germany

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Abstract. Temperature-dependent electron paramagnetic resonance (EPR) studies were performed on CuSiO₃. This recently discovered compound is isostructural with the spin-Peierls compound CuGeO₃. The EPR signals show characteristics different from those of CuGeO₃ and are due to Cu²⁺ spins located along quasi one-dimensional chains. For T > 8.2 K the spin susceptibility closely follows the predictions of an S = 1/2 one-dimensional Heisenberg antiferromagnet with J/k_B = 21 K. Below T = 8.2 K the spin susceptibility immediately drops to zero indicating long-range magnetic order.

1 Introduction

The linear spin-chain system CuGeO₃ is the first and up to now the only inorganic compound that exhibits a spin-Peierls transition [1]. Regarding the magnetic properties the partial substitution of Ge by Si was an important subject in terms of studying frustration effects [2] and the coexistence of the spin-Peierls state with long-range antiferromagnetic order [3, 4].

To characterize the nature of antiferromagnetic interactions in Si-doped and pure CuGeO₃ electron paramagnetic resonance (EPR) of Cu²⁺ spins provided important results [5–9]. In pure CuGeO₃ the EPR parameters differ from those of conventional one-dimensional (1-D) Heisenberg antiferromagnets. The antisymmetric Dzyaloshinsky-Moriya (DM) exchange interaction was claimed to explain this difference [6]. In Si-doped CuGeO₃ the coexistence of spin-Peierls and antiferromagnetic order is reported for Si concentrations below about 1%. For higher

Si concentrations (up to 50%) a long-range antiferromagnetic ground state is observed [4].

However, for $T > 15$ K the temperature dependence of the EPR parameters does not change significantly for Si-doping concentrations up to 7% [7, 8]. This paper reports the first EPR results on pure CuSiO$_3$ which are very different from pure and slightly Si-doped CuGeO$_3$.

2 Material and Methods

The EPR measurements were performed at X-band frequency on a Bruker ELEXSYS spectrometer and at temperatures between 4 and 300 K. For cooling a continuous-flow helium cryostat was used. The polycrystalline sample of CuSiO$_3$ was synthesized by dehydration of the mineral dioptase [10]. DC magnetization measurements at low fields $H \leq 10$ kOe were carried out on a commercial superconducting quantum interference device magnetometer [11]. Reported EPR spectra of CuO [12] did not show up in our EPR spectra which indicated the high quality of our sample.

3 Results and Discussion

Figure 1 shows the temperature dependence of the EPR linewidth $\Delta H$ (HWHM) and EPR $g$ factor (determined from the EPR resonance field) of the investigated CuSiO$_3$ sample. The inset of Fig. 1 shows a representative EPR spectrum of CuSiO$_3$ at $T = 40$ K (solid line, derivative of the EPR absorbed power). At all temperatures the spectra could be nicely fitted with a Lorentzian derivative (dashed line in the inset of Fig. 1).

![Fig. 1. Temperature dependence of the EPR linewidth $\Delta H$ (HWHM) and EPR $g$ factor, determined by the resonance field. Inset: typical EPR spectrum (derivative of absorbed power, $T = 40$ K) (solid line) and Lorentzian line fit (dashed line).]