

NMR/NQR Studies on Magnetism of Spin Ladder $\text{Sr}_{14-x}\text{A}_x\text{Cu}_{24}\text{O}_{41}$ (A = Ca and La)

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Hole-doping effects on the spin gaps of the chain and the ladder site are investigated by Cu-NMR and NQR for single crystals of $\text{Sr}_{14-x}\text{A}_x\text{Cu}_{24}\text{O}_{41}$ (A=Ca and La). Two types of spin excitations are discussed. We have confirmed antiferromagnetic (AF) order of Cu moments of the chain for $3 \leq x \leq 6$ of $\text{Sr}_{14-x}\text{La}_x\text{Cu}_{24}\text{O}_{41}$. The magnetic order of Cu spins in the chain is ferromagnetic within the chain, and is antiferromagnetic for inter-chains. The field-induced staggered moments at the ladder Cu site appear far above T_N , and its temperature dependence obeys the Curie-Weiss behavior, suggesting that this staggered field is attributed to the magnetic nature of the ladder Cu spins themselves. A possible origin is ascribed to the disturbance of the coherence of the RVB state by doping centers in the ladder. In addition, long-range AF order in the highly doped compound of $\text{Sr}_{2.5}\text{Ca}_{11.5}\text{Cu}_{24}\text{O}_{41}$ is investigated by heat capacity, magnetization and Cu-NMR/NQR measurements. We suggest that this AF order is primarily responsible for the chain Cu spins.

KEYWORDS: NMR, NQR, ladder compound, antiferromagnetic order, staggered field, spin gap