Spin Gap in the Zigzag S=1/2 Spin Chain Compound $Sr_{0.9}Ca_{0.1}CuO_2$

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We present ^{63}Cu Nuclear Magnetic Resonance (NMR) measurements on undoped $SrCuO_2$ and Ca-doped $Sr_{0.9}Ca_{0.1}CuO_2$ single crystals. The crystal structure contains one-dimensional CuO_2 double chains that are magnetically decoupled due to frustration. For $SrCuO_2$ the spin lattice relaxation rate, T_1^{-1}, is temperature independent as it is expected for a one-dimensional S=1/2 Heisenberg spin chain. Doping with nonmagnetic, isovalent Ca takes place on the Sr sites outside the spin chains, and should not affect the magnetic properties of the compound. It is therefore very surprising that we do observe a decrease of T_1^{-1} in Ca-doped $Sr_{0.9}Ca_{0.1}CuO_2$ for temperatures below 90K that clearly evidences the opening of a gap in the spin excitation spectrum. Density Matrix Renormalization Group (DMRG) calculations of the J_1-J_2 Heisenberg model are presented to discuss the origin of this spin gap.

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