Observation of enhanced nuclear spin-lattice relaxation by superconducting fluctuations in thin films by depth resolved β-NMR

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Superconducting fluctuations close to the critical transition temperature, T_c, manifest themselves in various electronic properties such as paraconductivity, diamagnetism and tunnel conductance. However, no unambiguous signature has been observed by a sensitive probe of the electronic state such as NMR. We report β-NMR investigations of polarized ^8Li nuclei implanted in a thin Pb film (d=300 nm) and in the Ag overlayer (d=40-120nm) of Ag/Nb bilayers, which by proximity effect display bulk superconductivity below 9.1 K. In both systems, at T_c, we observe an anomalous singular enhancement in the T_1 relaxation, which we ascribe to fluctuations of the order parameter. The peak is suppressed by a small ($\sim$ 3 mT) magnetic field. The magnitude of the peak is much more pronounced than theoretical predictions based on the enhancement of the dynamic electron spin susceptibility by superconducting fluctuations in the Gaussian regime (Maki-Thomson contribution). Possible explanations for the enhancement are discussed.