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Superconducting Gap Structure in $La_2(Cu_{1-x}Ni_x)_5As_3O_2$: A μSR Study

The relationship between magnetism and superconductivity has been one of the most discussed topics in condensed matter physics. Within the BCS framework, magnetic impurities can act as pairing breaking agents rapidly suppressing superconductivity. However in unconventional superconductors, such as cuprates and iron-based superconductors, magnetic impurities may enhance superconductivity. In the newly discovered layered superconductor $La_2(Cu_{1-x}Ni_x)_5As_3O_2$ (x = 0.37, 0.45), when Cu^{2+} is replaced by Ni^{2+}, the superconducting transition temperature T_c exhibits a dome structure as the substitution ratio increases and the superconductivity can be preserved until the substitution ratio exceeds 60\%.
Here, we report muon spin rotation and relaxation (μSR) measurements on the newly discovered superconducting material $La_2(Cu_{1-x}Ni_x)_5As_3O_2$ (x = 0.37, 0.45), which help to further study the superconducting gap symmetry of this Ni-doped compound in both underdoped and overdoped regions.
Transverse-field μSR experiments of both samples show that the superfluid density tends to saturate at low temperatures, indicating a nodeless superconducting gap. The single-gap s-wave BCS model best fits the temperature dependence of superfluid density in the overdoped areas and the $s + d$-wave model for the underdoped areas, repectively. The absolute values of zero-temperature magnetic penetration depth $\lambda_{ab}(0)$ were found to be 421 nm and 422 nm for x = 0.37 and 0.45, respectively.
Zero-field μSR rate of $x = 0.45$ does not show an obvious increase with the temperature cooling down, revealing no spontaneous magnetic moments below the superconducting transition temperature T_c, indicating that time-reversal symmetry (TRS) is preserved in the superconducting state of the overdoped region.

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