NMR investigation of the putative Bose-glass regime in the doped DTN at high magnetic fields unveils the existence of a new, impurity-induced BEC-type phase

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The $NiCl_2$-$4SC(NH_2)_2$ compound, or DTN for short, is one of the most studied archetype materials for the magnetic-field-induced 3D-ordered low-temperature phase of the Bose-Einstein condensation (BEC) type. When DTN is disordered by doping with Br, a localized, gapless Bose-glass (BG) phase is predicted to appear adjacent to the BEC phase [1], replacing the gapped regime of the pure system. Br-doped DTN is thus proposed as a unique thermodynamic model system for studying BG physics.

We have performed the first microscopic study [2], by nuclear magnetic resonance (NMR), of this putative BG regime in doped DTN at high magnetic field, and found a clear signature for a *level crossing* of the energy levels related to the localized, doping-induced impurity states, at the nearly doping-independent field value $H^* \cong 13.6$ T. Observation of the local NMR signal from the spin adjacent to the doped Br allowed us to fully characterize this impurity state and thus quantify a microscopic theoretical model. The level-crossing of the impurity states and their interaction are then providing the building blocks prone to create a new BEC-type order.

Indeed, a theoretical modelling [3], by quantum Monte Carlo simulation, have confirmed this scenario: close to H^* and at very low temperature, a localized BG regime is replaced by a new, delocalized, fully-3D coherent "BEC*" phase. Predicted magnetic field and doping dependence of this phase showed that it is experimentally accessible for higher doping levels [3]. We have thus started a new NMR investigation of 13% Br-doped DTN, and our preliminary data indeed detected the ordering transition at $T_c(H^*) \cong 0.15$ K. The existence of this new, "order-from-disorder" phase is thus definitely confirmed.

[1] R. Yu *et al.*, Nature **489**, 379 (2012).
[2] A. Orlova *et al.*, Phys. Rev. Lett. **118**, 067203 (2017).
[3] M. Dupont *et al.*, Phys. Rev. Lett. **118**, 067204 (2017).