NMR study of CDW order in $YBa_2Cu_3O_y$ under hydrostatic pressure

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We address the question whether the enhancement of the superconducting T_c in $YBa_2Cu_3O_y$ with the application of hydrostatic pressure is due to the suppression of a competing charge-density-wave ordered (CDW) phase as proposed by Cyr-Choinière et al. [1]. Using a BeCu clamp cell and Daphne oil as the pressure medium we apply 1.9 GPa (19 kbar) to a very clean $YBa_2Cu_3O_y$ single crystal with an oxygen concentration y = 6.56 (p = 0.109) and increase its T_c from 60.5 K at 0 GPa to 66.5 K.

We have performed ^{17}O-NMR measurements under hydrostatic pressure and studied its effect on the 2D short-ranged CDW as well as the 3D long-ranged CDW in high magnetic fields. Since hydrostatic pressure enhances T_c and the critical field H_{c2} the main effect is a higher onset field towards the long-range CDW order which emerges when CDW patches inside and around vortex cores start to overlap [2]. Neither CDW phase appears to be strongly affected by the applied pressure. This is confirmed by the fact that a negative sign of the Hall effect in $YBa_2Cu_3O_y$ (p=0.11) [3] as well as slow quantum oscillations in $YBa_2Cu_4O_8$ [4] persist under moderate pressures. On the other hand these results are in conflict with two recent X-ray diffraction studies that find a complete suppression of charge order at 10 to 15 kbar [5-6].

[1] O. Cyr-Choinière, D. LeBoeuf, S. Badoux, S. Dufour-Beauséjour, D. A. Bonn, W. N. Hardy, R. Liang, N. Doiron-Leyraud, L. Taillefer, Suppression of charge order by pressure in the cuprate superconductor $YBa_2Cu_3O_y$: Restoring the full superconducting dome, arXiv.1503.02033 (2015).

[2] T. Wu, H. Mayaffre, S. Krämer, M. Horvatić, C. Berthier, P. L. Kuhns, A. P. Reyes, R. Liang, W. N. Hardy, D. A. Bonn and M.-H. Julien, Emergence of charge order from the vortex state of a high-temperature superconductor, Nat.Comm. **4**, 2113 (2013)

[3] C. Putzke, J. Ayres, J. Buhot, S. Licciardello, N. E. Hussey, S. Friedemann and A. CarringtonCharge Order and Superconductivity in Underdoped $YBa_2Cu_3O_{7-\delta}$, Phys. Rev. Lett. **120**, 117002 (2018)

[4] C. Putzke, L. Malone, S. Badoux, B. Vignolle, D. Vignolles, W. Tabis, P. Walmsley, M. Bird, N. E. Hussey, C. Proust and A. Carrington, Inverse correlation between quasiparticle mass and T_c in a cuprate high-T_c superconductor, Science Adv. **2**, 3 (2016)

[5] S. Souliou, H. Gretarson, G. Garbarino, A. Bosak, J. Porras, T. Loew, B. Keimer and M. Le Tacon, Rapid suppression of the charge density wave in $YBa_2Cu_3O_{6.6}$ under hydrostatic pressure, Phys. Rev. B **97**, 020503 (2018)

[6] H. Huang, H. Jang, T. Nishizaki, Y. Lin, J. Wang, J. Ying, J. S. Smith, C. Kenney-Benson, G. Shen, W. Mao, C.-C. Kao, Y.-J. Liu and J.-S. Lee, Direct observation of a critical role of structural disorder in superconducting YBCO under high pressure , arXiv:1710.02769 (2018)