The Time-Dependent Specific Heat of $Na_{0.35}CoO_2 * 1.3H_2O$ Maintained at Ambient Temperature

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The specific heats of three samples of $Na_{0.35}CoO_2*1.3H_2O$, each containing a negligible concentration of paramagnetic centers, are very different. The samples were prepared in the same way, but were held at ambient temperature for different periods of time before the measurements. Qualitatively, the differences in the specific heat correlate with time dependences seen in NQR measurements[1]; and, in a time dependence of the Co oxidation state, that is controlled by the increase in O vacancies in the CoO_2 planes, seen in recent structural studies[2]. As aging time increases, the 4.5-K superconductivity of the two samples with shorter aging times changes in character, and eventually transforms to 7-K CDW ordering for the sample with the longest aging time. These changes are accompanied by a regular increase in the residual density of states. The specific heat of the two superconducting samples shows the presence of different energy gaps on two sheets of the Fermi surface. Non-magnetic, pair-breaking action that produces the residual density of states imposes limits on the possible order parameters with $d_{x^2-y^2}$ id_{xy} providing the best representation of the data. The pair breaking acts preferentially on the small-gap Fermi-surface sheet. Specific-heat data for the shortest-aging-time sample can be interpreted either as showing the presence of nodes in the small gap or as showing the absence of nodes. The data for the other superconducting sample shows no evidence of nodes. Both superconducting samples specific heats can be fitted with the suitably modified phenomenological alpha model using two gaps. The onset of the transition to the mixed/vortex state is independent of magnetic field, which suggests the presence of unusually strong fluctuations.

[1] H. Ohta *et al*., J. Phys. Soc. Jpn., **74**, 3147 (2005)
[2] P.W. Barnes *et al*., Phys. Rev. B, **72**, 134515 (2005)