

Blumberg *et al.* Reply: The recent scanning SQUID [1], tunneling [2], ARPES [3,4], penetration depth [5–7], and specific heat [8] experiments provided convincing evidence of $d_{x^2-y^2}$ -wave pairing symmetry for the electron-doped cuprates at low and optimal doping. In agreement with these experiments, the recent electronic Raman scattering studies [9] rule out an anisotropic s -wave scenario: In contrast to conventional s -wave superconductors no gap-threshold structure has been observed in electronic Raman response for any symmetry channel even at the lowest temperatures and frequencies measured. On the other hand, the pair breaking excitations measured by polarized electronic Raman scattering indicate a larger magnitude of the superconducting (SC) gap closer to the middle of the Brillouin zone (BZ) quarters, the vicinity of $(\pm\pi/2a, \pm\pi/2a)$ points, than to the BZ boundaries [9,10]. The latter results are inconsistent with the monotonic $d_{x^2-y^2}$ SC order parameter (OP) function, $\Delta(\mathbf{k}) \propto \cos(k_x a) - \cos(k_y a)$, where \mathbf{k} is a wave vector on the Fermi surface (FS) and a is the ab -plane lattice constant.

Our proposal of a nonmonotonic $d_{x^2-y^2}$ OP for which the positions of the SC gap maxima are located closer to the nodes than to the BZ boundaries [9] reconciles all experimental observations [11]. Indeed, the maximum Raman gap, $2\Delta_{B_{2g}} = 67 \text{ cm}^{-1}$, is consistent with the gap value of $\Delta_{\text{max}}^{\text{tunn}} = 3.7 \text{ meV}$ observed in tunneling spectroscopy [12], and the $2\Delta_{B_{1g}} = 50 \text{ cm}^{-1}$ is consistent with the leading edge gap at the BZ boundary estimated from ARPES experiments [3,4]. For hole doped cuprates, superconductors with short correlation length, the nearest neighbor correlation is strongest and monotonic OP is expected. In contrast, for electron-doped cuprates the superconducting correlation length is longer leading to a nonmonotonic OP.

In the preceding Comment, Venturini *et al.* [13] note that for a nonmonotonic OP a multiple peak/shoulder structure is expected in the Raman response. Their calculation [Fig. 1(a)], however, does not account for realistic FS topology, energy and momentum dependent relaxational behavior, possible impurity scattering rates and inhomogeneous broadening, and is sensitive to the gap functional form. Unrealistically small constant phenomenological damping $\Gamma = 1.3 \text{ cm}^{-1}$ has been used, while, for example, the best fit for the $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_8$ compound required $\Gamma = 43 \text{ cm}^{-1}$ [14], much larger than the separation in fine structure of density of states for our proposed nonmonotonic OP, $\Delta_{B_{2g}} - \Delta_{B_{1g}} = 8.5 \text{ cm}^{-1}$. For larger Γ , the sharp singularities are not expected to be resolved and indeed a flattop structure for spectra in the B_{1g} channel is experimentally observed (Fig. 3 in [9]). Calculations with larger phenomenological damping [Fig. 1(b) in [13]] well resemble experimental data at high frequencies; however, the use of momentum and energy independent damping for in-gap energies is not justified even for strongly anisotropic superconductors

[15,16]: The imposed large values of Γ/ω are unphysical and wipe out characteristic low-frequency power laws.

The low-frequency power laws in Raman response indeed provide independent verification for existence and position of the SC gap nodes. The experimentally observed power laws, approximately cubic for B_{1g} and linear for B_{2g} channels (Fig. 3 in [9]), are in agreement with the expectations for $d_{x^2-y^2}$ -wave superconductors [13,14,17].

We note that for a nonmonotonic OP the phase space of the nodal regions is reduced relative to the monotonic OP. As a result, a stronger activated-like contribution in thermodynamic properties is expected. Measurements down to sub-Kelvin temperatures are required to emphasize the nodal behavior: The power laws are dominant only below a crossover temperature that depends on the nodal velocity. The disagreements of thermodynamic and penetration depth measurements at relatively high temperatures with fits to monotonic d -wave OP are therefore not surprising.

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