Comment on ''Superconducting Gap Anisotropy vs Doping Level in High-T_c Cuprates''

In a recent paper Kendziora *et al.* [1] concluded that the superconducting gap $\Delta(\mathbf{k})$ in overdoped $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) is isotropic. They analyzed Raman spectra obtained in the xy (B_{1g}) scattering geometry, which samples regions of the Fermi Surface (FS) situated near the $(\pm k, 0), (0, \pm k)$ axes in reciprocal space, and in the xx ($A_{1g} + B_{2g}$) geometry which should yield [2–4] an approximate screened average over the FS. Their conclusion was based on the observation that pair breaking peaks occurred at approximately the same frequency in both scattering geometries, and that the normalized scattering intensity (I_s/I_n) at low energies was strongly depleted in both geometries and appeared to be in reasonable agreement with theory. However, we would like to add a few remarks which question this conclusion.

As has been shown in Ref. [5], the relative peak positions will also be very sensitive to the shape of the FS and the form of the gap function. Therefore the relative peak positions must be used with caution when comparing the symmetry of the superconducting gap in crystals with significantly different doping levels. Also it is important that one should look at the un-normalized intensities since the Bose-Einstein factors are taken at different temperatures. Moreover, it has been found that normal state response χ'' cannot be taken to be independent of temperature [6]. Therefore the normalization yields an artificial depletion of the response at low energies and thus masks the true low frequency dependence of the data. This can be seen by comparing Figs. 3 and 4 of Ref. [1]. A consideration of the low frequency behavior of the xy and xx spectra in conjunction with consideration of the B_{2g} spectra implies the existence of an anisotropic gap with nodes along the diagonals.

In Fig. 1 we present both the B_{1g} and B_{2g} response functions (χ'') which were obtained from an overdoped Bi2212 crystal ($T_c = 55$ K). Scattering in the B_{2g} spectrum arises from regions of the FS located near the diagonal directions in k space and hence provides information that is complementary to the B_{1g} spectra. In both geometries it is clear (Fig. 1) that (in the superconducting state) although scattering is suppressed for $\omega < 6k_bT_c(240\ \mathrm{cm}^{-1})$ it is still present and increases linearly with ω in this frequency region. This linear behavior is incompatible with an isotropic s-wave gap. The linear dependence of the B_{2g} spectrum at low energies is consistent [3–5] with the presence of nodes along the diagonal directions. Hackl *et al.* [6] also successfully interpreted data obtained from an overdoped Bi2212 crystal in terms of the disordered d-wave model [4].

In conclusion, the superconducting gap in overdoped Bi2212 cannot be isotropic if the un-normalized spectra from all scattering geometries are considered.

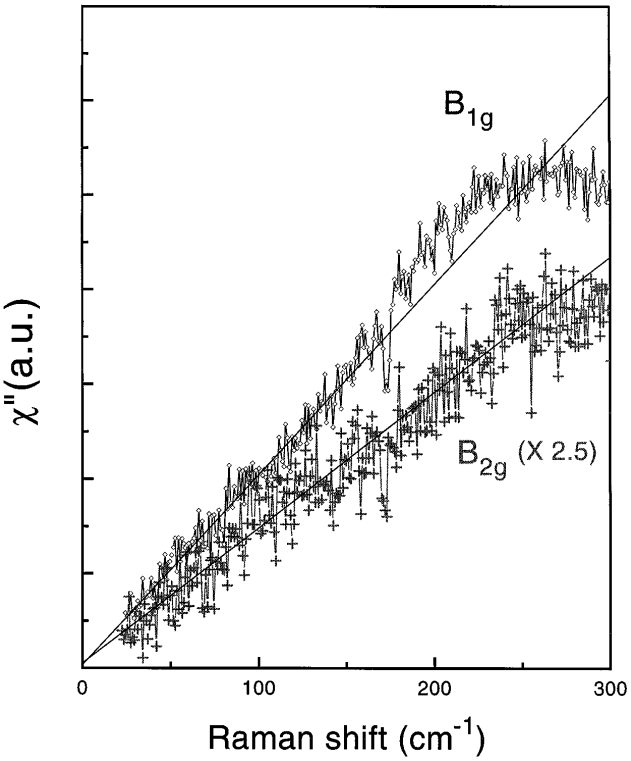

FIG. 1. The low energy B_{1g} and B_{2g} Raman spectra for an overdoped Bi2212 crystal ($T_c = 55$ K) in the superconducting state ($T = 15$ K). The straight lines indicate the linear behavior of the spectra for frequencies $\omega < \Delta_{\max}$. The intensity of the B_{2g} spectra has been multiplied by a factor of 2.5 for comparison purposes.

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