High-Temperature Optical Spectral Weight and Fermi-liquid Renormalization in Bi-Based Cuprate Superconductors

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Since their discovery in 1986, the research on superconducting cuprates has been focused on their ”low-temperature” properties, like the superconductivity and the so-called pseudogap, while the high-T properties of the cuprates have been scarcely investigated up to now. The present work is, to our knowledge, the first optical study of two Bi-based cuprates at optimum doping, from their critical temperature Tc to 500 K. We have measured their optical conductivity σ(ω) and their spectral weight W (Ω,T) up to a cut-off frequency Ω. The T-dependence of the carrier kinetic energy (which is proportional to W (T)) is described in terms of the Sommerfeld expansion, which is usually limited to the first term in T^2. We have found that, above 300 K, W (T) deviates from the T^2 behavior in both compounds, even though the extrapolation to a dc conductivity σ(ω → 0) remains well far from the Ioffe-Regel limit. As shown in the Figure, the deviation is well described by the second term of the Sommerfeld expansion, namely that in T^4. This shows that, despite all the anomalies encountered in the behavior of high-Tc superconductors, a Fermi-liquid picture works well up to such a high T. However, the coefficients of both the T^2 and the T^4 term are much enhanced by strong correlations, as shown by our dynamical mean field theory (DMFT) calculations. All measurements have been done by CNR-SPIN and CNR-IOM personnel, using the apparata of the CNR-SPIN laboratory at University La Sapienza.

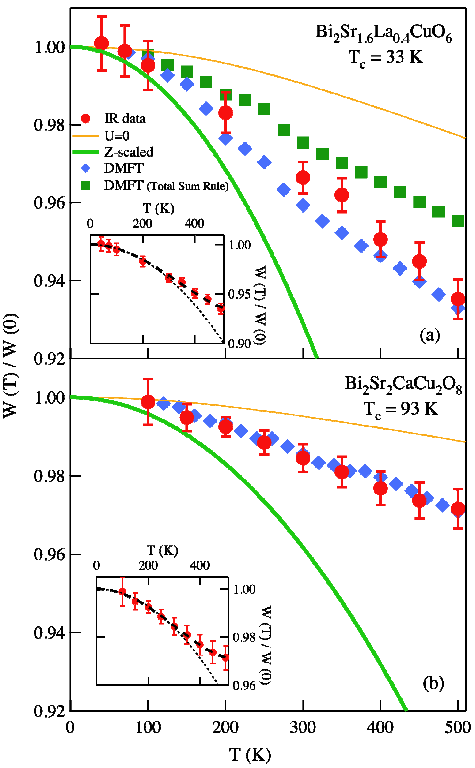

Figure caption. Temperature-dependent optical spectral weight W(T) of optimally doped (a) Bi2Sr1.6La0.4CuO6 and (b) Bi2Sr2CaCu2O8, normalized to the (extrapolated) value at T = 0. The IR data (red dots) are compared with DMFT calculations for the restricted sum rule (blue diamonds) of the single-band Hubbard model. Also shown are theoretical calculations for the non-interacting system (U = 0) and the lowest-order Sommerfeld expansion, where the coefficient B is simply rescaled by the DMFT quasi-particle weight (Z-scaled). In panel (a) DMFT calculations for the total sum rule are displayed for comparison (green squares). In the inset the dotted (dashed) line indicates the fit performed on W(T) data using the Sommerfeld expansion up to the second (fourth) order.