

Two Particle Correlations from ARPES: A Case Study for Dynamic Spin Susceptibility and Connection with INS Study for High T_c Systems

Utpal Chatterjee^{1,2}

¹*Physics Department, UIC*

²*MSD, Argonne National Laboratory*

Using Angle Resolved Photoemission Spectroscopy (ARPES), one could directly probe single particle excitations of any physical system as ARPES directly measures the spectral function, which is proportional to the imaginary part of the Green's function. To understand the collective excitations of a system under the influence of an external probe, we have to go beyond the single particle excitation description. In linear response approximation, the response function of any physical system is proportional to the "two particle correlation" function of the observable to which the external probe couples. For instance the response of a system to a magnetic field i.e. the spin susceptibility can be shown to be proportional to the spin-spin correlations, measured by Inelastic Neutron Scattering (INS) and Nuclear Magnetic Resonance (NMR) experiments. Similarly the response of a system to an electric field i.e. the electrical conductivity is proportional to the current-current correlation. In Optical Conductivity experiments current-current correlations can be measured. In general, it is very difficult to exactly calculate these "two particle correlations" in High T_c systems, from single particle excitations because of strong correlation effects. However using the diagrammatic Random Phase Approximation (RPA), it is possible to approximately evaluate the "two particle correlations" starting from single particle excitations. Nonetheless it is instructive to do this kind of calculation with experimental single particle Green's function, in order to assess the importance of so-called vertex corrections. Recently we have shown [1] how to calculate various "two particle correlation functions" using experimental Green's function measured directly by ARPES. With our technique, starting from spectral function, measured by ARPES, we can calculate what is seen in INS, NMR, Optical Conductivity experiments, so that results from these completely different kinds of experiments can be directly compared with each other in terms of common underlying microscopic Physics.

For almost all High T_c materials, INS experiments [2] found a universal feature in the dispersion of the magnetic excitations-namely the famous "hour glass" shape, in the superconducting state. We find the same result for spin susceptibility using our ARPES data on High Temperature Superconducting sample of $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$. Hopefully the calculation of the conductivity from ARPES data using this approach will be able to help to resolve some of the long-standing puzzles regarding the temperature evolution of electrical conductivity in the Pseudogap phase of the High T_c systems.

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References:

[1] U.Chatterjee et al cond-mat/0606346

[2] J. Rossat-Mignod et al., Physica C 185,86 (1991); H.F Fong et al., PRL 75,316 (1995); M.Arai et al.; PRL 83,608 (1999); H.F Fong et al., Nature 398, 588(1999); P.Dai et al., PRB 63,054525 (2001); S.Pailhes et al. PRL 93, 167001 (2004).