Chapter 5

Discussion and Conclusions

In this work, we have shown that the interlayer coupling plays an important role in providing a mechanism for enhancement of T_c. The "Josephson-like coupling between the layers which arises through interaction of electron in the neighbouring CuO_2 planes enhances the transition temperature within the layer.

In our model we assume the existence of coupling due to direct interlayer hopping. As we have shown, such hopping is only a higher-order effect in oxide superconductors. Even though t is small, such small t can arise through phonon or plasmon assisted hopping, for example.

Also in our evaluation of T_c, we assume that coupling constants V_c, V_d and V_{er} do not change significantly with the introduction of small dispersion along the z axis. To justify this assumption it would be necessary to calculate V_c, V_d and V_{er}. Clearly, this is beyond the scope of this work. Therefore we proceed, keeping V_c, V_d and V_{er} fixed.

From our calculation we have shown thatl, within the limits of our assumption, introducting the small hopping matrix element between layers reduces T_c. Finite t may also lead to a very anisotropic excitation spectrum. The anisotropy may be used to explain certain experimental data.

Finally we discuss the intralayer coupling. This coupling owes its strength to a quasi-two-dimensional nature of electronic states. We expect that the coupling constants will either not change or will decrease if the hopping between layers is allowed. The results of our calculation are consistent with such behavior, and one generally expects that in such a case an increased direct hopping between layers would be unfavorable for high-T_c superconductivity, and the reduction in T_c due to direct hopping is offset by an increase of the coupling constants.

In conclusions, we have developed a model of layered high temperature superconductor. Specifically, we explored the implications of T_c mediated by bounding layers due to proximity effect.

Our formulas for T_c revealed that various layer couplings (coherent pair transitions and direct hopping between layers) play substantial roles in determining T_c. The bounding layer plays a role by renomalizing the interaction constants of the system.

Our major results and predictions in the framework of this system are as follows : the introduction of a small interlayer hopping matrix element always reduces T_c, the Josephson-like coupling between layers always enhances T_c. The possible proximity effect in the bounding neighbor layer plays an important role in the enhancement of T_c. These different mechanisms can coexist in principle and the competing effects can provide a way to understand the observed maximum T_c as a function of n (23). The actuality and relative importance in real materials have to be considered individually in correspondence with specific electronic structures. T_c can be obtained by a judicious parametrization of all the relevant coupling constants appearing in the model. We note that the model proposed in the present work is much simplified, we hope our arguments provide a rationale for investigating the T_c's in other multilayered structures.