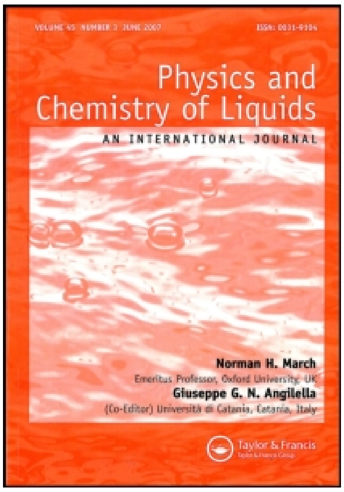

Physics and Chemistry of Liquids
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713646857

Electron or Hole Liquids Flowing Through Antiferromagnetic Assemblies: Proposed Test of *t-J* Model for High *T_c* Materials

N. H. March[a]
[a] Oxford University, Oxford, England

To cite this Article March, N. H.(1996) 'Electron or Hole Liquids Flowing Through Antiferromagnetic Assemblies: Proposed Test of *t-J* Model for High *T_c* Materials', Physics and Chemistry of Liquids, 31: 4, 265 — 266
To link to this Article: DOI: 10.1080/00319109608031661
URL: http://dx.doi.org/10.1080/00319109608031661

Phys. Chem. Liq., 1996, Vol. 31, pp. 265–266
Reprints available directly from the publisher
Photocopying permitted by license only

LETTER

ELECTRON OR HOLE LIQUIDS FLOWING THROUGH ANTIFERROMAGNETIC ASSEMBLIES: PROPOSED TEST OF *t-J* MODEL FOR HIGH T_c MATERIALS

N. H. MARCH

Oxford University, Oxford, England

(Received 30 October 1995)

Li and Gong have recently demonstrated noncanonical Fermi liquid behaviour in doped two-dimensional antiferromagnets described by the *t-J* model. Here we stress the experimentally established correlation in underdoped $YBa_2Cu_4O_8$ that $RT_1 \propto T$ over a substantial temperature range, R being the electrical resistivity and T_1 the nuclear spin-lattice relaxation time. While this linearity is consistent with Fermi liquid theory, a test of the validity of the *t-J* model to describe the normal state of high T_c materials will be to study whether such behaviour can also result from its noncanonical Fermi liquid characteristics.

KEY WORDS: Doped two-dimensional antiferromagnets, hole liquids, spin excitations.

In a recent paper, Li and Gong[1] have used the so-called *t-J* model to discuss the interaction between holes and spin excitations. They argue convincingly that, in this particular model, one is thereby led to 'noncanonical' Fermi-liquid behaviour for holes in doped two-dimensional antiferromagnets. We have no criticism at all to make of the results they present from their theoretical study of this model. Rather, we shall stress some experimental facts and correlations to which we have recently drawn attention[2–4]. At very least, these urge caution in replacing Fermi liquid theory of the normal state of the high T_c superconductors by the noncanonical Fermi-liquid behavior demonstrated by Li and Gong[1] to follow from the *t-J* model. Thus, as the focus for the present Letter, we quote Li and Gong[1] as saying that "the anomalous normal-state properties in the high-T_c cuprates are difficult to explain in the framework of the conventional Landau Fermi-liquid theory".

Returning now to the above comment on high T_c experiments, we have earlier discussed the properties of electron or hole liquids flowing through antiferromagnetic assemblies[2,3]. In this work, we found valuable the two-dimensional

*Correspondence to Emeritus Professor N.H. March, 6 Northcroft Road, Egham, Surrey, TW20 0DU, England.

Fermi-liquid theory of Kohno and Yamada[5] as motivation. These workers derived two formulae of particular relevance in the present context, namely

$$R \propto T^2 \chi(\mathbf{Q}) \tag{1}$$

and

$$(T_1 T)^{-1} \propto \chi(\mathbf{Q}). \tag{2}$$

In Eqns. (1) and (2), R and T_1 are respectively the electrical resistivity and the nuclear spin-lattice relaxation time. Finally $\chi(\mathbf{Q})$ is the wave-vector dependent magnetic susceptibility evaluated at the antiferromagnetic wave-vector $\mathbf{Q}$. As emphasized by Egorov and March[3], while suitable data is not presently available on any one specific high T_c material in the normal state to test Eqns. (1) and (2) separately, if one eliminates $\chi(\mathbf{Q})$ between them the clearcut prediction

$$RT_1 \propto T \tag{3}$$

emerges. This can indeed be tested using only experimental data on R and T_1 for underdoped $YBa_2Cu_4O_8$, and the resulting plot of RT_1 versus T is shown in Figure 1 of Egorov and March[3]. There is a substantial range of temperature over which the prediction (3) of two-dimensional Fermi liquid theory is vindicated, above a certain 'crossover' temperature. Following the theoretical arguments of Noziéres and Schmitt-Rink[6], given before the high T_c cuprates were discovered[7], we have interpreted the crossover occurring before the transition temperature T_c as heralding the formation of charged (2e) Bosons[4]. These then serve as the precursor of the superconducting transition.

The point we emphasize therefore is that before Li and Gong[1] can interpret their noncanonical Fermi liquid results for the *t-J* model as relevant to describe the physics of the high T_c cuprates in the normal state, it is important to bring their theory into contact with the facts displayed in Figure 1 of reference 3. If these can also be explained within the framework of noncanonical Fermi-liquid behavior, then that would greatly enhance confidence that the *t-J* model contains within itself the essential physics of high T_c normal-state properties.

It is a pleasure to thank Mr. S. A. Egorov (Wisconsin), and Professors G. Baskaran (Madras) and R. Pucci (Catania) for numerous valuable discussions on the general area embraced by this Letter.

References

1. J. X Li and C-De Gong, *Phys. Rev.*, **B51**, 6343 (1995).
2. N. H. March, *Phys. Chem. Liquids*, **25**, 65 (1993).
3. S. A. Egorov and N. H. March, *Phys. Chem. Liquids*, **27**, 195 (1994).
4. N. H. March, R. Pucci and S. A. Egorov, *Phys. Chem. Liquids*, **28**, 141 (1994).
5. H. Kohno and K. Yamada, *Prog. Theor. Phys.*, **83**, 13 (1991).
6. P. Noziéres and S. Schmitt-Rink, *J. Low. Temp. Phys.*, **59**, 195 (1985).
7. J. G. Bednorz and K. A. Müller, *Z. Phys.*, **B64**, 189 (1986); see also the review by M. Tinkham and C. J. Lobb, *Solid State Physics*, **42**, 91 (1989).