QUESTIONS POSED AT THE PROGRAM CONFERENCE

CRITICAL ISSUES IN HIGHER TEMPERATURE SUPERCONDUCTORS

At the Conference that opened this Program, the session leaders posed a set of questions to the speakers and by extension to all the participants. As we enter the last few weeks of our Program, it seems natural to return to those questions. Toward that end, this week at our regular Wednesday afternoon discussion session, we propose to give everyone an opportunity to address any of the questions they chose. There is no pretense that all the questions will be addressed. It is your choice. Also, note that we will be putting these questions up on the Program Wiki so that we can seek input from all those interested, and at greater length. These inputs will help us in our responsibility to disseminate what we have achieved over the summer toward defining a fresh agenda for the field. Stay tuned.

1.0 The Landscape of Higher Tc Superconductivity (E. Fradkin)

1.1 What have we learned on what makes high Tc from the cuprates and other materials?

1.2 What makes a material be “high Tc”? Chemistry? Dimensionality? Luck?

1.3 More is different?

1.4 What can theory reasonably (and honestly) say about Tc and how to raise it (or lower it?)?

1.5 Do we need a new conceptual framework to deal with this problem?

2.0 Lessons from Materials Theory (P. Hirschfeld)

2.1 What are the prospects for direct Eliashberg-style 1st principles computation of pairing interaction in electronic pairing systems with weak-intermediate strength interactions?

2.2 In the absence of such tools, how can theory guide the search for higher Tc?

2.3 In the cuprate and other strongly correlated materials, are there issues where traditional DFT calculations can contribute, where strong correlations play a less important role?

2.4 What are the prospects of applying current methods to problems of inhomogeneous superconductivity in real materials: surfaces, grain boundaries and Josephson junctions …?

2.5 If you look into the future 5 years and assume continued improvements in computer speed and memory, what superconductivity problems could one tackle that are out of reach now?

3.0 Experimental Search Panel (I. Bozovic)

3.1 What are the lessons from history?

3.2 What pattern do you see among known “high-Tc” superconductors?

3.3 Have we exhausted the cuprates, pnictides, MgB_2, BKBO …?

3.4 What new family of compounds would you wish to investigate, and why?

3.5 What new techniques (of synthesis, processing or testing) should we try?

3.6 Do you see a chance for, and value in, metastable high-Tc phases?

3.7 Could theorists help, and how?

3.8 Is there any thing you tried but did not report because it did not work?

3.9 Are we walled-in conceptually? Any out-of-the-box thoughts?

4.0 Pairing Mechanisms (M. Norman)

4.1 In the case of electron-electron interactions, is the concept of a pairing “glue” even meaningful?

4.2 If your theory advocates an instantaneous interaction, does this mean the pairs have no dynamics, or just that the theory has not developed to the extent to address this question?

4.3 If your theory ignores phonons, can you really get away with that? Do you think phonons are even relevant?

4.4 What are the spectroscopic signatures predicted for your theory? Is a McMillan-Rowell inversion or related procedure possible for your theory? Is this question meaningful?

4.5 What would your theory predict in regards to collective modes? Is this even an important question?

5.0 Spectroscopy (J. Campuzano)

5.1 What exactly are the assumptions that go into your data analysis?
5.2 How general are these assumptions?

5.3 Is it possible to make progress without these assumptions?
5.4 Why?

5.6 Do you think that the same “nominal” compounds (e.g., different cations) have different ground states?

5.7 How can experimentalists clear up this mess?

6.0 Emergent Spatial Structure and its Role (J. Zaanen)

6.2 Is there a direct relation between the ‘momentum space dichotomy’ and stripy things?

6.3 Are the STS stripy things a surface artifact?

6.4 Is there an experimental observable that in a sharp and quantitative manner distinguishes strongly organized ‘fluctuating stripes’ from more ‘gaseous’ interpretations?

6.5 Are Anderson’s ‘stripes a red herring?

7.0 Pnictides and Beyond (E. Abrahams)

7.1 What properties of pnictides inform us as to where to look for higher temperature superconductors?

7.2 Is there nesting of Fermi surfaces in the actual materials and what conclusions can be drawn from the answer?

7.3 Is there a resolution of the conflicting results on the pairing symmetry and why is it important?

7.4 Is there orbital order in the antiferromagnetic state and does it matter?

7.5 What is the nature of the quantum criticality and will it tell us anything about the superconductivity?

8.0 Exotic Mechanisms of Superconductivity (L. Balents)

8.1 What is the evidence- theoretical or experimental – that spin liquid physics is actually beneficial for superconductivity?

8.2 If exotic physics is behind higher Tc superconductivity, can it give some guidance for the search for new materials? Is two-dimensionality important? Low spin?

8.3 Many exotic states seem almost to be defined by their featureless appearance when viewed with standard experimental techniques. Can you suggest what kind of experiment might provide a clear smoking gun signature? Can the problem benefit from improvements in spectroscopic or local probes?

8.4 Are they any true exotic ground states or important quantum critical points in the cuprates at T =)? If not, in what range of ω, T, H and x does exotic physics apply and is it in any way universal?

8.5 Is (your) exotic theory quantitative (beyond scaling laws and exponents)? Is there any hope for clear experimental confirmation otherwise?

9.0 Further Afield (E. Fradkin)

9.1 What is the future of "designer materials" approach?

9.2 What can we learn from the experiments with cold atoms? Can they be made colder than LSCO in real terms?

9.3 Will we know if the Hubbard model (in 2D) is superconductor, say, in five years?

9.4 How can novel quantum information ideas deal with the fermion sign problem? Can they? The Grassmann Chip?

9.5 What it the future of quantum Monte Carlo(s) in this context?