T. SENTHIL – In His Own Words

I grew up in Tamil Nadu, India – mostly in Chennai. I got interested in physics in high school, and decided then that I wanted to be a physicist. After high school I joined a 5-year Masters physics program at IIT Kanpur, and then came to the US (to Yale) in 1992 for grad school. My thesis, written under the supervision of Subir Sachdev, was mainly on the effects of disorder on quantum phase transitions. The education I got at IIT Kanpur and Yale was a wonderful preparation for a research career. Toward the end of my grad school, at a Santa Barbara conference, I first heard about the pseudogap phenomenon in the underdoped cuprates, and the non-fermi liquid quantum critical point in heavy electron metals. I was fascinated by these discoveries which were reasonably new then – I realize now 13 years later that I am still primarily working on understanding these two phenomena! I am optimistic though that major progress in these problems is around the corner.

After grad school in 1997 I became a post-doc at the (now Kavli) Institute for Theoretical Physics. I worked primarily with Matthew Fisher, initially on problems of localization of quasiparticles inside superconductors. Sometime in 1999 I got interested in work that Matthew had done with Leon Balents and Chetan Nayak on the theory of quantum disordered d-wave superconductors. I began an intense and very enjoyable collaboration with Matthew on a proper theoretical formulation of the related issue of electron fractionalization in two or higher dimensions. This led to clarification and sharpening of some old ideas on the problem of high temperature superconductivity. Most interestingly we came up with a direct and non-trivial experimental test of one version of the popular idea of spin charge separation. Unfortunately subsequent experiments by Kathryn Moler and D. Bonn failed to see the effect we predicted.

In January 2001 I moved to MIT as an Assistant Professor. Shortly after I recruited two brilliant post-docs - Ashvin Vishwanath and Olexei (Lesik) Motrunich - which very much helped my transition from post-doc to faculty. With Motrunich I constructed simple theoretical models which display fractional quantum numbers and related topological phenomena in dimensions higher than 1. I also took on a talented student, Predrag Nikolic, and started working on frustrated quantum magnets, mostly on the so-called Kagome lattice. In another line of work , intrigued by claims that the Fermi surface might jump at the magnetic quantum critical point in the heavy fermion metals, together with Matthias Vojta and Subir Sachdev, I introduced and analysed the `Kondo breakdown' model for a phase transition out of the heavy Fermi liquid. This model has a second order phase transition where the electron Fermi surface jumps! The model does not describe the magnetic phase well. Despite this it has proven to be useful in understanding the properties of phase transitions where an entire Fermi surface disappears continuously.

In trying to think about how to incorporate magnetism into our story I started toying with the possibility of a `deconfined' quantum critical point: at such a critical point exotic degrees of freedom emerge as useful objects even though they have no meaning deep in either of the two proximate phases. A first question was to find concrete examples of such a critical point. Results of some beautiful work that my post-docs Ashvin and Lesik were then doing on the classical O(3) model with suppressed `hedgehog' defects turned out to be really useful toward this goal. Together with Leon Balents, Ashvin, Subir, and Matthew Fisher, I developed a theory of such deconfined quantum critical points in insulating quantum magnets. This has lead to a flurry of activity. However my original goal of incorporating magnetism into the Kondo breakdown theory remains elusive.

One other important development that resulted from this work was the resolution of a long standing controversy in the theory of quantum spin liquids. The issue was whether certain gapless spin liquid phases could be stable in two dimensions. In collaboration with Michael Hermele, Matthew Fisher, Patrick Lee, Naoto Nagaosa, and Xiao-gang Wen I demonstrated the stability of such phases. With the discovery in the last few years of a number of candidate materials that might be in gapless quantum spin liquid phases, our work has become particularly relevant.

Sometime in 2003 my wife and I decided to take the plunge and move back to India for good – something we had been toying with ever since we first came to the US. I accepted an offer from IISc Bangalore and moved there in Jan 2005. There was some lingering doubt in my mind, and so I officially went on leave from MIT. I had lived outside India for more than 12 years by then. I was pleasantly surprised by many aspects of working and living in India. Despite this both my wife and I decided to return to the US. I officially rejoined MIT in 2007 February. Overall those 2 years in India were an enriching experience and well worth the hassle of two moves.

In the last 2 years I have continued to think about exotic phases and phase transitions of matter. My latest efforts have been in the area of non-fermi liquid metals. This is an amazingly open and fundamental area of research with lots of information from experiments and precious little theory. Armed with my past experience in describing exotic insulators, I am hoping to be able to find a useful theoretical framework for describing such exotic metals.

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