Teterina, Yana A

From: De Ruyter, Robert R.

Sent: Monday, January 19, 2004 5:19 PM

To: Teterina, Yana A

Subject: FW: Leo Silbert recommendation

From: Sidney Nagel [mailto:srnagel@uchicago.edu]
Sent: Monday, January 19, 2004 1:40 PM
To: De Ruyter, Robert R.
Subject: Leo Silbert recommendation

THE JAMES FRANCK INSTITUTE

THE UNIVERSITY OF CHICAGO

5640 South Ellis Avenue

Chicago, Illinois 60637

(773) 702-7190

FAX (773) 702-5863

e-mail: s-nagel@uchicago.edu

January 19, 2004

Biocomplexity Faculty Search Committee

c/o Prof. Rob de Ruyter

Department of Physics

Swain West 117

727 East Third Street

Indiana University

Bloomington, IN 47405-7105

Dear Committee Members:

I am happy to write on behalf of Leo Silbert for a faculty position in your Department. For the past two years, Leo has been a post doc working jointly with Andrea Liu at UCLA and myself. This was a demanding assignment. We hired Leo with the expectation that he would work jointly with the two of us on a simulation project even though we were two thousand miles apart. We needed him not only to produce excellent work but also to help keep our collaboration flourishing. He has managed to do all of this very well.

Leo is an expert on computer simulation. Before joining us, he worked with Gary Grest (Sandia), Thomas Halsey (Exxon) and Dov Levine (Technion) on simulations of granular material. This work was outstanding and provides one of the most rigorous tests of simulation in a granular setting. In those simulations, Leo studied the flow of granular material down an inclined place and made the important connection with the experiments of Olivier Pouliquen at Marseilles. These simulations were long runs with a very large number of particles and treated granular material in as realistic a setting as possible, including friction and boundary effects. Leo's work shed new light on the experiments. He was able to address, in ways that the experiment could not, how the magnitude of friction affected the flows. This was a first-class simulation but, more than that, it was an valuable piece of physics. In that work, Leo was also able to show certain "structural" signatures of flow and the jamming transition. His analysis of the distribution of forces was the first to show the changes in that distribution as the flow ceases in a system with dissipative interactions. Graduate students in my laboratory are presently testing these results experimentally. (So far the indications are that our experiments confirm Leo's work.) In addition, Leo obtained some very interesting results about the nature of close packing. We were delighted and excited to have him join us.

Since joining Andrea and myself, Leo has been engaged in several different projects. In one study, he has been carefully studying the nature of jamming at zero temperature and zero applied stress. This study has several components. The first of these had to do with the purely structural signatures that appear at the onset of jamming. He studied the pair-distribution function, g(r), and showed that there was a divergence in its first peak as the jamming threshold was approached. In order to determine the scaling laws for the peak height and the peak width, Leo had to find and implement new methods for the computation. This was not trivial. The data that Leo produced covers an enormous range and is convincing and beautiful. In compressing slightly above the jamming threshold, Leo found that the shape of the peak had unexpected features. Although Andrea and I did not believe this at first, Leo stuck to his guns and proved to us that he was right and we were wrong. I was surprised and delighted.

More recently, Leo has been involved in investigating other structural features of amorphous structures. In the pair distribution function, a split second peak has long been taken as a signature of an amorphous solid. This has been an empirical observation without a fundamental understanding of what it implies or how it arises. These peaks are located at $\sqrt{3}d$ and 2d (for mono-disperse bead packs where d is the diameter of the particle). Leo has now found that extremely close to the onset of jamming, this split second peak appears to have divergences associated with the derivatives of g(r). This makes a strong case for the relationship of the jamming threshold to the nature of the glassy state.

Leo has also been investigating the dynamics of the amorphous states near jamming . That is, he studied the normal modes of vibration as a function of packing density as the density was lowered to the threshold. He found the amazing result that, quite contrary to expectations, near the threshold the density of vibration states approaches a constant, $D(\omega)$ = const, rather than varying as $D(\omega) = A\,\omega^{D-1}$ which would be expected from ordinary Debye theory. This shows that close to jamming the nature of the normal modes changes from plane-wave-like vibrations to something much more disordered. Leo has also been able to plot out what the modes themselves look like in two dimensions. Every low-frequency normal mode has a large component of high-wavevector components. They look nothing like plane waves. This, more than any other result that we have obtained, indicates to me that the jamming threshold has unique and unanticipated properties.

A third project on which Leo has worked has been to calculate the distribution of jamming thresholds as a function of packing fraction and system size. This was part of a study, including Corey O'Hern now at Yale Universiy, to investigate how the nature of the inter-particle potential influenced the distributions. It soon became apparent that these distributions had a very large finite-size effect. As system size increases, the distributions of thresholds gets narrower and approaches a delta-function in the infinite system size limit. By mapping out the distributions for different finite-range, repulsive potentials, we were able to show that the distributions were independent of potential and that they could be used to held define the meaning of random close-packing in amorphous systems. (The meaning of "randomness" has always been an issue for understanding what "random close-packed" means.) Leo's work was an essential part of this program.

Leo is clearly an expert at computer simulation. His simulations are of exceptionally high quality. Moreover, he also thinks about what the simulations mean. He has tried to formulate models related to force chains for why the density of states is a constant near jamming. Likewise, he has searched for signatures that would characterize the normal modes at jamming.

Leo is gregarious and has played a central role in forming the character of my group in Chicago. I am sure that he will be equally outgoing as a faculty member. His work has attracted considerable attention and he has been invited to give many talks about it. One of his duties, while at Chicago has been to run one of our seminar series. He has excelled at doing this.

I hope I have given you some idea of Leo's breadth of interests and his qualities as a researcher and simulator. I recommend that you consider him seriously for your position.

Sincerely yours,

Sidney Nagel,

Stein-Freiler Distinguished Service Professor,

Department of Physics, The Enrico Fermi and James Franck Institutes