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Biocomplexity Faculty Search Committee,
c/o Prof. Rob de Ruyter van Steveninck,
Department of Physics,
Indiana University,
Swain Hall West 117,
Bloomington IN,
47405-7105

Dear Prof. de Ruyter van Steveninck,

I am writing this letter to support the application of **Paul Miller** for an Assistant Professorship at Indiana University. I have served as Paul's postdoctoral mentor from 1997–2000. Paul has graduated from the University of Bristol, under the mentorship of Prof. Gyorffy. Paul is an outstanding candidate for a professorship, and one whom I recommend strongly, without reservation. He possesses tremendous physical insight, is an outstanding educator, is a deep thinker on intellectual issues, possesses a serious social consciousness, and makes for an amiable and personable colleague. I should also note that he has a significant funding record, better than most of his peers: (i) he is the principle investigator of a Research Career Award from NIH ($300,000); (ii) he co-wrote a successful research proposal on Josephson junctions for the Office of Naval Research ($280,000); and (iii) he was co-PI on a supercomputer grant that was written entirely by him (I served as PI only to help get the grant awarded).

I hired Paul in 1997 as a postdoctoral fellow to work on my research in superconductivity that is funded by the Office of Naval Research. Paul had recently returned from spending almost a year and a half in Africa to teach as part of the British equivalent of the peace corps. He had decided that taking a hiatus from physics to give back to the world community was more important than immediately continuing with his physics work. I was impressed with Paul both for his demonstrated talent in physics research and for his world citizenship and he was my first choice out of about four dozen applications I received for postdoctoral fellows.

I will first concentrate on Paul's research skills and originality, then on his teaching skills, and finally describe his potential for the future.

I put Paul to work on a problem to examine the combined effects of vertex corrections and nonconstant density of states on materials that have relatively large phonon frequencies. Our strategy was to focus on experimental results that could not be mimicked by changing parameters in the standard Migdal-Eliashberg theory of superconductivity. I provided Paul with some notes on the problem, and some simple programs that could only calculate properties from the normal state. He attacked the problem with much vigor, and started producing results much faster than I had expected (especially since it had been almost two years since he had been doing any physics research). By the time the project was complete he had constructed an analysis that produced ordered-phase properties, dynamical properties, and all relevant thermodynamics. Our conclusion from this work was that the only "smoking gun" experiments where vertex corrections are unique in their response lay in the isotope effect.

Paul and I then decided to spend some time examining properties of ferroelectrics. John Price and Chuck Rodgers at the University of Colorado at Boulder had been growing the finest quality thin film samples of strontium titanate, which is an incipient ferroelectric, with a huge dielectric response, but no true ferroelectricity down to zero degrees. Their interest in this material was as an electric-field tunable dielectric film for use in a number of different passive microwave applications. They had improved their growth process (using pulsed laser deposition) significantly, but had not been able to get their thin films to have as good properties as the bulk materials. They believed that some form of dynamical (lattice) disorder was responsible for the discrepancy. We became interested in this problem and spent about six months working on a number of different theoretical models for the experimental data, but were unable to find a workable theory to describe the behavior of the films. Paul led the way in this work, both in the formulation of the theories, and in the analysis. It is a shame that it was unable to produce any publishable results.

Motivated by our funding agency, we decided to launch a new project on studying inhomogeneous strongly correlated materials. We envisioned a geometry consisting of stacks of planes of different materials, and devised an algorithmic scheme to self-consistently solve for the many-body Green's functions. The algorithm was developed jointly, but Paul realized quite soon, that the computation could be sped up dramatically by using properly chosen techniques from the recursion method. He managed to improve the speed of the codes by more than two orders of magnitude without any loss in accuracy. This procedure for solving these inhomogeneous many-body problems is applicable to a number of different nanoscale systems. We are applying it to the Josephson-junction, where it is the strong-coupling and retarded generalization of the well-known Boguliubov-De Gennes equations. The algorithmic development took over one year, since it involved once again calculating both ordered phase and normal state properties as well as real-frequency dynamics for the charge transport. Paul carried out the lion's share of this work himself, and has parallelized all of his codes so they can run efficiently on both Beowulf-type computers and on large national supercomputer-center computers.

What impressed me the most about Paul's abilities on this project was his identifying the critical issues and tackling them as they arose. This is a new field of work for me, and Paul was more of an expert on Josephson junctions than myself. We worked together on writing a proposal for the Office of Naval Research, and I am confident that without Paul's contributions we would not have been successful in winning the award. In addition, Paul wrote a grant for supercomputer funds, which we decided I should be the principal investigator on, and he just the co-PI because I had an already established track record in supercomputing. This grant was awarded, but all of the credit for it goes to Paul. He also was PI on a RCA grant from NIH for $300,000. It is rare to find a postdoctoral fellow who has as much expertise in grantwriting, and as much success at it as Paul already does.

Paul left working in my group to join the neuroscience group at Brandeis University. Paul had expressed to me, fairly early on, that he had interests in applying physics ideas to biological problems. Since my research was not moving in that direction, I was unable to help foster Paul's growth there. He has made much progress over the past four years. He has developed a computational network model for short-term memory and has investigated a molecular switch that could be the underlying basis for long-term memory. I believe he will continue to flourish in the broadly defined neuroscience field over the years to come.

Now I would like to comment on Paul's teaching abilities, as I believe him to be an outstanding educator. We take teaching very seriously here at Georgetown, and I always offer to my postdoctoral fellows the opportunity to help with teaching if they would like to. We have been active in the Physics Education Research community serving as an official test site for the University of Washington's Tutorials in Introductory Physics since 1995 and using Eric Mazur's conceptests in the lectures. We have found that students respond extraordinarily well to these conceptual exercises, and I believe that incorporating them into our curriculum has aided in both our recruitment and in our retention of majors (when I arrived here we averaged two majors per class, and we now average 15). Paul knows how to incorporate these kinds of teaching techniques, and I believe they can have a successful impact on the teaching in your department.

I have been involved in teaching a course in quantum mechanics and materials science to nonscientists since 1996. This course is not by any means a traditional physics course. Although the students grapple with many of the bizarre concepts of quantum mechanics (in, for example, the two-slit experiment), they do not need to know any sophisticated mathematics, due to an ingenious model developed by Richard Feynman. Paul has either been an active teaching assistant (which involves much contact with the students during tutorials, conceptests, and office hours) or a joint lecturer in this course every semester since he arrived. He has an ability to explain many of these confusing and bizarre ideas to students in a clear and precise way that promotes their understanding.

I know, firsthand, that Paul will be an excellent lecturer. I have had him develop instructional materials for our class in 2000, and had him deliver about half of the lectures himself. One of the items I had him work on was a tutorial to help understand how electrons form energy bands in a solid. Paul developed a nice tutorial that started with the wavefunctions of two atoms, and showed how the energy degeneracy was lifted by the bonding and antibonding states, and then generalized to N atoms, with the degeneracy being now spread out into a band. I have found students understand these concepts much better now than they did before this tutorial was created.

Paul also taught as a lecturer in an oscillations class at Brandeis University. I have reveiwed his student evaluations and comments and find that he performed well at this task. Students praised him for the clarity of his lectures, for his preparation skills, and for his assistance outside of class. They complained about the text being too difficult and the course requiring too much work. Overall, his lecturing experience went well, and he should have no problem lecturing in courses in his first year.

In summary, I find Paul to be a very competent researcher and to possess much originality in his approaches to problems. I consider him to be a deep thinker on scientific issues and to have wide-ranging interests. He is the type of person that can easily synthesize ideas from disparate fields, which is a skill that serves him well in an interdisciplinary field like neuroscience. Paul's physics work is of high quality. His total productivity is strong even though he took a hiatus from research to perform service. His work was used by my group for four years after he left, resulting in an additional six publications (including a review article, a Physical Review Letter, and an Applied Physics Letter).

I believe Paul is deeply committed to work in neuroscience. He clearly expressed an interest in applying physics ideas to biological fields even during his time at Georgetown. He took a postdoctoral fellowship in neuroscience (when he could have taken postdoctoral fellowships in physics) because he was excited by the opportunities available there. Paul has great skill in simulating complex systems and in making efficient use of computer codes (especially in parallel computation). These are skills that are very useful in his neuroscience research. I think his best work in that field is yet to come. I believe he is an extremely well qualified candidate for an Assistant Professorship. I give Paul my highest recommendation, without any reservations. I believe he will excel in research and teaching and is likely to develop novel ideas in new areas that can benefit from the rigors of physics reasoning. I know you will have many applications to consider, but Paul Miller's is certainly worth a second look. You will not be disappointed.

Best regards,

James K. Freericks
Professor
Department of Physics