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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

RE: RECOMMENDATION FOR DR. SUNG YONG PARK

Dear Professor Steveninck:

I am writing to give my strongest recommendation to **DR. SUNG YONG PARK**, whom you are considering for a faculty position. Dr. Park was a postdoctoral researcher working with me at Ohio State University between January 2002 and July of 2004. He came here after a year at Harvard, working with Prof. David Nelson. He initially held a prestigious University Postdoctoral Fellowship, and thereafter was supposed on my National Science Foundation Grant, working in theoretical condensed matter physics and biological physics.

Sung Yong is an extremely talented young physicist who was among the most creative and original postdocs I have seen. He showed great abilities in research while he was here, essentially creating his own research program in biological physics and nanoscale physics. My collaboration with him has led to a number of exciting projects, and we are still collaborating on several additional projects.

To be specific, Sung Yong decided, shortly after he arrived here, to work on a novel system consisting of gold nanoparticles and DNA strands in an aqueous solution. The DNA strands attach themselves to the gold particles. At low temperatures, the strands on different particles link together, producing a large aggregate. At higher temperatures, the links dissociate thermally and the aggregate melts into individual nanoparticles. This transition can be seen optically: at high temperatures, one sees a relatively sharp absorption line, arising from the plasmon absorptions of the individual gold nanoparticles. At lower temperatures, this line broadens and red-shifts, as the particles aggregate.

Sung Yong worked out, essentially on his own, first a percolation model, and more recently a model based on a reaction-limited-aggregation model for the the growth and subsequent melting of this nanoparticle composite. He also calculated the optical properties as a function of the structure. His model qualitatively accounts for most of the features observed in experiments at Northwestern, Rice, and elsewhere. Specifically, it explains why (i) the aggregate melting transition is much sharper than that of the individual DNA duplex; (ii) the melting occurs at higher temperatures for larger particles; and (iii) the absorption peak broadens and red-shifts as the aggregate forms. His model even accounts for many details of the optical absorption, i. e. the degree of red-shift, and how this relates to the fractal dimension of the aggregate. It also predicts a certain rebound effect in the optical absorption spectrum, which has been seen in several experiments, and which is related to a sol-gel transition in these composites.

This work has resulted in two papers in Physical Review B, plus one in Physica B. Sung Yong is now extending this model to account for a novel sol-gel transition which occurs below the melting transition, and which may also have been seen in experiments.

Sung Yong gave a well-received talk on his gold/DNA work at a topical conference on electrical transport and optical properties of inhomogeneous media in Utah (most expenses paid by the organizers). He also spoke at the March meeting of the American Physical Society in Austin, on this same topic.

I would like to emphasize that this model was developed entirely by Sung Yong. My main contribution was to make a few suggestions about how to calculate the optical properties of the composite, and to help a little with the writing.

More recently, Sung Yong has on two other problems, both also related the novel properties of gold nanoparticles. First, he has calculated how the optical properties of these nanoparticles are altered when the particles are coated with a layer of nematic liquid crystal. Specifically, he has shown that the absorption spectrum becomes anisotropic with the liquid crystal coating. The calculated anisotropy is in excellent agreement with experiments carried out by Muller et al. Some of this work has just been published in Applied Physics Letters. He has extended this work to show how the optical properties of the coated particles depend on the exact morphology of the liquid crystal coating, and has shown that the experiments are consistent with "boojum-like" morphology, where the molecules are arranged to point from a "north pole" to a "south pole" on the particle. This work will shortly be submitted publication in a major journal, and an abstract has been submitted to the upcoming March meeting in Los Angeles.

Sung Yong has also done lovely work related to the novel properties of gold nanoparticles chains. Specifically, he has studied the propagation of surface plasmon \underline{waves} along chains of gold (or other metal) nanoparticles. Experiments carried out by Brongersma, Atwater, and others at Caltech, Stanford, and elsewhere have shown that energy can propagate along such chains at nearly 10\% of the speed of light, and that the dispersion relations for longitudinal and transverse modes are strikingly different. It was Sung Yong who initiated the work in this area after learning about the experiments.

Sung Yong has advanced the theory of these modes in two ways. First, he has calculated the dispersion relations for these modes including all multipole moments, and not just the dipole moments. A paper on this subject was published this spring in Physical Review B. Secondly, he has worked out the theory for how these dispersion relations are changed when the particles are immersed in an anisotropic host such as a nematic liquid crystal. This work is presently being written up for publication and will be submitted shortly. This work may be useful for applications in nano-optics, since the introduction of liquid crystals represents a means of controlling light and energy propagation in very small structures. We are presently extending this work to include radiation corrections to the plasmon dispersion relations.

During his fellowship period at Ohio State, Sung Yong spent a month at MIT to work on several projects on the physics of nanoparticles. He came back with many ideas about how to use metal nanoparticles as sensors in biological systems, and as agents for targeted delivery of drugs to living cells.

Besides his nanoparticle/DNA work, Sung Yong has done excellent work in other areas. As a grad student at Seoul National University, he worked with Prof. M. Y. Choi on the physics of Josephson junction arrays and on phase transitions in two-dimensional systems. He produced several first-rate papers, including one Physical Review Letter, which won him a fellowship to Harvard University. At Harvard, he worked with Prof. David Nelson on problems in high-temperature superconductivity, especially the melting of a vortex lattice in the presence of an oblique magnetic field. The statistical mechanics of this system maps onto the a problem in non-Hermitean quantum mechanics.

Sung Yong is extremely imaginative in developing new problems and applications in the physics of nanoparticle research. The field of metal nanoparticle research is growing rapidly and has become an extremely important area. Sung Yong is very well positioned to take advantage of these opportunities, especially in projects combining nanoparticles and biological systems.

Besides his research talents, Sung Yong shows promise as a fine teacher. While he was here, he worked for a short time helping to teach a computational physics course with Prof. Richard Furnstahl. I understand that Sung Yong did an excellent job in helping the students develop new projects in computational physics. He certainly knows a great deal about numerical methods, as is obvious from his published work. Besides this, he has given careful and clear research talks which have very much impressed their audiences with the quality of his work.

I am convinced that Sung Yong will have an outstanding career as a researcher and teacher. He is highly original and imaginative in his ability to develop (and solve!) novel research problems, and is working in some of the most exciting areas of condensed matter physics. He has had a great influence on my own research direction in the past several years; indeed, my recently renewed NSF grant is based to a large extent on work done with Sung Yong. In my opinion, he has already made significant contributions in at least three areas (physics of metal nanoparticle systems, physics of nanoparticles combined with DNA, and Josephson junction arrays). These areas are sure to become more important in the future, with the further development of both nanoscience and biological physics. And there are many exciting applications - for example, the gold/DNA materials shows great promise in selective detection of specific DNA sequences by optical tagging.

In short, I believe that with the creativity and great ability he has already displayed, Sung Yong will have a substantial impact in physics in years to come. I enthusiastically support his application for a faculty position.

Yours sincerely,

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