Mehran Kardar, Room 12-108
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF PHYSICS
CAMBRIDGE, MASSACHUSETTS 02139, USA
Telephone: 617-253-3259 Fax: 617-253-2562

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Prof. Rob de Ruyter van Steveninck
Biocomplexity Faculty Search Committee
Biocomplexity Institute, Indiana University
Swain Hall West 117
Bloomington, IN 47405-7105

Dear Faculty Search Committee:

It is a pleasure to recommend **Dr. Ha Youn Lee** for a faculty position in your department. Dr. Lee joined my group in the Physics Department at MIT in March of 2000, and stayed till June 2001. During this short period, she made significant progress on several new research directions, as described below. We continued to collaborate while she pursued further postdoctoral training, first at UCLA and then at Ohio State University. She rejoined my group as a postdoctoral fellow in January 2003. I am quite impressed with her confidence, maturity, and capabilities. While her background is in statistical mechanics, during the past few years she has focused on problems of biological significance. I am certain that she will be effective in research and mentoring, and hence an excellent choice for a faculty position in your department.

Ha Youn first contacted me about coming to MIT in September 1999, while in the final stages of her doctoral studies at Seoul National University. Her application was supported by strong letters of recommendation from Korea, in particular from Prof. Douchal Kim, whom I hold in high esteem. Having her own financial support in the form of a fellowship, Dr. Lee was quite free ito choose where to carry out her postdoctoral studies. Indeed I suggested that she might be better off elsewhere, as I would be away from MIT on sabbatical leave, starting January 2001. Nonetheless, Dr. Lee decided to come to MIT, confident that she could make headway on new research topics in the nine months that we overlapped. This choice was partly based to her husband having a position at Harvard till the end of 1999.

During the short period that we overlapped at MIT, Dr. Lee made considerable progress on two problems related to pattern formation in biological systems. The first project was inspired by the observation of interesting patterns of *vortices and asters* that spontaneously form in vitro from a mixture of molecular motors and tubules (for example, in experiments by Prof. S. Leibler at Princeton). I had formulated a pair of coupled partial differential equations for the evolution of the densities of motors and orientations of the tubules. After familiarizing herself with the relevant literature, Dr. Lee quickly wrote programs for simulating these equations. Since the computers in our group were not adequate, she marshalled a number of underutilized computers in Korea for running her programs. The equations do indeed produce *vortices and asters* similar to those observed experimentally. We also analytically studied and compared simple vortex and aster solutions, and obtained a 'phase diagram' for possible patterns. An interesting outcome of the simulations was an unanticipated dynamic phase transition between a regime where the pattern coarsens, and one in which the coarsening is arrested as a result of the depletion of motors. A paper based on these results was published in 2002, and inspired several groups to do further research on extensions of this model.

In January of 2001, I left MIT for a yearlong sabbatical at the Institute for Theoretical Physics (ITP) at UC Santa Barbara. Because of her family situation, Ha Youn wanted to stay at MIT for a few more months. Since her Korean fellowship had ended, I was happy to support her from my own NSF grant, as we continued our collaboration through Email and FAX. In June 2001, Ha Youn moved to another postdoctoral position, with Prof. Michal Deem at UCLA. We remained in contact during this period, and in fact were able to meet more frequently due to the closeness of LA and Santa Barbara.

During the next year and half, Ha Youn and I worked intermittently on a problem related to patterns in cortical maps. Specifically, neurons in the visual cortex respond best to rod-like stimuli of given orientation, presented at specific locations in the visual field. Intricate maps of the *global pattern* of orientation preference over the cortex show that the preferred orientation varies continuously across most of the map, except at prominent *pinwheel* centers from which all orientations emanate. Extensive modelling has shown that many developmental rules generate patterns with pinwheels starting from undifferentiated initial conditions. However, upon further evolution the pinwheels disappear by annihilating in pairs; a deficiency that we set out to explain. We argued that this is a feature of dynamics with *full rotation symmetry*, with typical maps evolving to a 'rainbow' pattern with no pinwheels. But oriented segments in natural images satisfy a *reduced symmetry* that is combined with rotations of the visual field. Ha Youn performed simulations on models with the reduced symmetry, and showed that unlike models with full rotation symmetry, the steady state pattern has a stable set of pinwheels. She next verified that the reduced symmetry is indeed a feature of actual cortical maps. To this end, she first had to contact appropriate experimentalists to obtain the raw data from cortical maps of monkey and cat. She then performed statistical tests (by making various histograms from the data) that confirmed our hypothesis. Thus we ultimately connected the stability of pinwheels in cortical maps, to the reduced symmetry which also characterizes the oriented segments in natural images. A paper based on these findings has been accepted for publication, and will appear shortly in the Proceedings of the National Academy of Sciences.

In January 2003, Ha Youn rejoined my group as a postdoc, sharing her time between Boston and her family in Colombus, Ohio. While finishing our earlier work on cortical maps, she embarked on two new projects during this period. One project involves quantifying the statistics of natural images, and how to employ these correlations for optimal harvesting of information. To this end, Ha Youn developed a novel method of analysis of line segments in natural images, and demonstrated and quantified a tendency towards *transverse* variations. She then constructed filters that were optimized for harvesting information from such a data set, and showed that these filters can efficiently reconstruct missing linear portions of noisy images. To carry out this project, Ha Youn had to immerse herself in a diverse literature spanning neuroscience to computer vision. A second (ongoing) project involves the motion of bacteria (such as lysteria) though polymerization of actin. She has been in contact with the group had MIT were some of the relevant experiments are being performed, and undertaken preliminary modeling that unravels some universal features of the observations.

Dr. Lee has a pleasant and confident personality. She does not shy away from new problems as demonstrated by the diverse range of projects that she has tackled since coming to MIT, and before. I am particularly pleased with the progress and outcome of her projects with me as described above; I may add that some of these projects were first started with another postdoc and student, neither of whom could make satisfactory headway. Ha Youn had no difficulty with learning new subjects, performing extensive modeling, or talking to experimentalists about data. Given her recent research interests and current activities, I believe that she will flourish in the area of quantitative analysis of biological systems, and enthusiastically recommend her for a faculty position at your university.

Sincerely yours,

Mehran Kardar

Mehran Kardar
Professor of Physics