Massachusetts Institute of Technology

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Biocomplexity Faculty Search Committee
c/o Professor Rob de Ruyter van Steveninck
Biocomplexity Institute
Indiana University
Swain Hall West 117
Bloomington, IN 47405-7105

Dear Search Committee Members:

I am writing in support of Dr. Dezhe Jin's application for a faculty position in your department. Dezhe is one of the top young scientists in the world today working at the interface between theoretical physics and biology. His specialty is theoretical neuroscience, with an emphasis on dynamical models of neural networks. If you are looking for a candidate with superb technical abilities in theoretical physics, combined with the ability to form collaborations with biophysics experimentalists, then you cannot do better than Dezhe.

Dezhe has been a postdoctoral researcher in my lab at MIT since August 2000. Before he came to MIT, his research focused on non-neutral plasma physics, a subfield of nonlinear dynamics. In his doctoral thesis, he studied vortex dynamics in two-dimensional fluids. The theory he constructed was able to explain the formation of two-dimensional patterns that had been observed experimentally in plasmas. From his publications and his recommendation letters, I could tell that he was a real star in graduate school at UC San Diego. I do not normally hire postdocs without prior experience in biology, but I made an exception in Dr. Jin's case because he was such an outstanding candidate.

Dezhe's major achievement as a postdoc has been to formulate a mathematical theory of spiking neural networks. This theory has been described in papers in *Physical Review E* and *Physical Review Letters*, and another paper that has been submitted. Most of the existing theory of neural networks is based on simplified, nonspiking models of neurons. More realistic spiking networks are very difficult to analyze mathematically. As a result, most researchers have managed to study only artificial cases that are lacking in biological relevance. In contrast, Dezhe has managed to build a theory applicable to a class of spiking networks with interesting computational capabilities. This work has implications for brain modeling, because it shows that spiking networks can use recurrent synaptic connections for computation more quickly than was previously thought. This is important for modeling the rapid perceptual judgments performed by humans and animals.

Dezhe's other research is less theory-driven, and more driven by the goal of explaining data from experiments in my lab and other labs at MIT. One project concerns the origin of spontaneous neural activity in the brain. Numerous experiments have shown that neurons in the brain are spontaneously active even without external stimuli. Scientists have hypothesized two mechanisms to explain this spontaneous activity. One is that some neurons in the brain's network are intrinsically active, even in the absence of interactions between them. The other is that neurons are activated by noise in the synapses, the chemical communication elements that connect neurons. Since there is experimental evidence in support of both explanations, it has been difficult to decide between them. Dezhe has proposed an experiment that can quantitatively test the hypothesis of synaptic origin. In his proposal, he has found a mathematical relation between the noise levels at the synapses and the spontaneous activity levels of the neurons. This relationship is highly nonlinear, and can be rigorously checked with experimental techniques. This experiment, once carried out, will provide a conclusive evidence for supporting or dismissing the synaptic hypothesis.

Dezhe has also been studying the network mechanisms of feature selectivity in primary visual cortex (V1). For decades it has been known that neurons in area V1 respond selectively to attributes of a visual stimulus such as orientation, spatial frequency, direction of motion, and so on. However, the mechanisms by which cortical microcircuitry compute such quantities is still a matter of debate. Dezhe began a collaboration with Mriganka Sur's lab at MIT, with the goal of explaining experiments in which prolonged exposure to a visual stimulus causes changes in the response properties of V1 neurons that last for many seconds. In particular, the preferred orientation of the neuron is different after adaptation than before. Dezhe has constructed a fascinating network model that explains this experimental finding, and relates it to a famous visual illusion called the tilt aftereffect.

In summary, Dr. Jin is brilliant, creative, and tenacious. He has successfully made the transition from plasma physics to biophysics. He has strong mathematical skills, but is not a slave to formalism. He is very interactive, and will have no problem establishing collaborations with others at your institution. He is bound to be a leader in the area of theoretical neuroscience. I give him my highest recommendation.

Sincerely,

H.S. Seung

H. Sebastian Seung
Associate Professor,
Massachusetts Institute of Technology
& Assistant Investigator,
Howard Hughes Medical Institute