THE MATERIALS SCIENCE AND ENGINEERING DEPARTMENT FALL COLLOQUIUM SERIES PRESENTS

THE DOW LECTURE

Andrea Liu

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Exploiting the Malleability of Disorder to Design Functional Materials

Systems with complex energy landscapes, such as glass-forming systems, have far more variation in their properties than those with simple ones that readily crystallize. This natural variation can be pushed even further by design, allowing us to tune in unusual properties and novel functions into materials. For example, when most materials are stretched in one direction, they tend to shrink in the orthogonal directions. Materials that do the opposite and expand in the orthogonal directions when stretched are “auxetic,” and have attracted attention for applications such as high energy absorption. We have found that mechanical spring networks can be tuned easily to the extreme limit of auxetic behavior. Likewise, we have shown that properties common in living matter, such as the ability of proteins (e.g. hemoglobin) to change their conformations upon binding of an atom (oxygen) or molecule, the ability of the brain’s vascular network to send enhanced blood flow and oxygen to specific areas of the brain associated with a given task, or the ability to retain a memory, can be designed into disordered systems using similar principles. The ability to design properties and functions further gives new insight into the relation between microscopic structure and function that may help us both to understand living systems and to design new biologically-inspired materials.

Andrea Liu is a theoretical soft and living matter physicist. Liu received her A. B. degree in physics at the University of California, Berkeley, and her Ph. D. in critical phenomena from Cornell University in 1989. After switching to complex fluids during her postdoc at Exxon Research and Engineering Co., she worked on polymer theory as a postdoc in the Chemical Engineering, Materials Science and Physics departments at the University of California, Santa Barbara. She then joined the Department of Chemistry and Biochemistry at the University of California, Los Angeles, where she was a member of the physical chemistry faculty for ten years before moving to the Department of Physics and Astronomy at the University of Pennsylvania in 2004, where she is now the Hepburn Professor of Physics. She is currently a member of the Board of Directors, General Councilor and Speaker-Elect of the APS and Head-elect of the Physics Section of the AAAS. She is a fellow of the American Physical Society (APS), American Association for the Advancement of Science (AAAS), and American Academy of Arts and Sciences, and a member of the National Academy of Sciences.

Andrea Liu’s research combines theory and computation to study soft and living matter. In living matter, her research focuses on the role of mechanics in biology, with the aim of understanding how new and general collective phenomena, often beyond those typically observed in inanimate soft matter, can emerge at the subcellular, cellular and tissue levels. In soft matter, she and her collaborators have shown that jamming produces solids at an opposite pole from perfect crystals, providing a new way of thinking about the nature of rigidity in disordered solids. The nonequilibrium jamming transition and jammed state thus serve as useful starting points for understanding a broad class of materials, including glasses, granular materials and foams.

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Reception to follow | Willens Wing Atrium

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