Keynote Presentations at TSAPS Meeting 2020, Nov. 12-14, UTA

Fractal Universality in Nature

Diverse phenomena often yield unexpected similarities. In the 17th century Newton thought about the gravitational force between the earth and an apple falling from a tree, and he said "I began to think of gravity extending to the orb of the Moon." Systems of many particles (atoms, molecules, or macroscopic grains) can similarly exhibit universal behavior. For example, studies of phase transitions in the 20th century culminated in Kenneth Wilson's theory of universality in transitions in the phase of systems as different as fluids and magnets, for which Wilson was awarded the Nobel Prize in 1982. The present talk examines spatial patterns that emerge in systems driven away from thermodynamic equilibrium by imposed gradients (e.g., in pressure, temperature, nutrient concentration). Experiments, observations of natural phenomena, and mathematical models are providing insights into the formation of ordered patterns in physical, chemical, and biological systems, as will be illustrated through examples that exhibit remarkable mathematical similarity, such as the wrinkling of the edge of dendrites, some flowers, torn plastic sheets, and bacterial colonies.

Dr. Harry Swinney was awarded a PhD in physics by the Johns Hopkins University in 1968. In 1971-78 he held faculty appointments at New York University and City College of New York. Since 1978 he has been a member of the physics faculty at UT-Austin. In 1983-84 he was a Guggenheim Fellow. He is a member of the National Academy of Sciences, and he is a Fellow of the APS, the Society of Industrial & Applied Mathematics, the American Academy of Arts & Sciences, and the American Association for the Advancement of Science. He was awarded the APS Fluid Dynamics Prize (1995), the Lewis Fry Richardson Medal of the European Geophysical Union (2012), and the Boltzmann Medal of the International Union of Pure & Applied Physics (2013). His research concerns instability, chaos, pattern formation, and turbulence in fluid flows, granular media, chemical systems, and swimming bacteria. He and his students and collaborators have observed, developed, or discovered the transition to chaos in fluids in several different geometries, a laboratory model of Jupiter's Great Red Spot, localized structures ("oscillons") in oscillating granular media, methods for characterizing chaos, "Turing" patterns in reaction-diffusion systems, and anomalous diffusion and Lévy flights in geophysical flows. His papers have been cited more than 45000 times (Google Scholar).

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