13 November, 2013

Math in Nature

Introduction:

The natural world is so complex and unpredictable that it might seem math could never be a sufficient tool to understand it. Our lecture aims to widen this view of math and explore how mathematical models and chaos theory give us insights into nature. The first part of our lecture introduces the concepts of math models and nonlinearity, a key idea in chaos theory. We'll see how so much of our world is described by nonlinear systems. The second talk will explore the so-called "butterfly effect." We'll examine how it limits our ability to calculate the future while other properties of chaos can provide insights into its patterns. Finally, the third talk will consider the striking order and structure that arises from chaos and how the self-similarity that appears everywhere from the human body to the large-scale structure of the universe is related to patterns that arise from mathematics itself.

Speakers:

Jess Kunke is a second-year graduate student in the Department of Earth and Planetary Sciences at Harvard. Her research is about improving how we model the effect of particles in the atmosphere on climate and air quality. Jess loves teaching science and math too; before coming to Harvard, she spent two years designing and teaching a Saturday morning advanced science course for interested middle-schoolers exploring high school- and college-level science, building circuits and other fun things. Her recent activity outside of work was to knit the rocket sweater that the little boy wears in The Shining.

Lei Zhu was born in Lixin, a rural, agricultural and peaceful area, Anhui, China in the 1980s, Witnessing the economic development of China and the associated environmental issues lead him to study environmental science at Nankai University. He later pursued a Master's Degree at Peking University, focusing on atmospheric modeling and satellite observations. This experience made him devoted to studying atmospheric science studies, and in the summer of 2011, Lei joined the Harvard Atmospheric Chemistry Modeling Group, where he has been working as a Ph.D. student till now. His current research project is "Better understanding of Volatile Organic Compounds (VOCs) based on HCHO measurements from space: Implications for the southeast U.S. atmospheric chemistry"

Stephen Portillo is a second-year PhD student in the Harvard Department of Astronomy. Working with Prof. Doug Finkbeiner, his research is on the indirect detection of dark matter through astrophysical signals. Having grown up in Edmonton, situated in the stunning vistas of Alberta, Canada, Stephen enjoys every chance to be in the great outdoors.

Glossary

mathematical model– a description of a system using math so that we can study the system, make predictions, and gather useful information about the system.

initial conditions - the conditions that a system starts out with.

linear system– a system which has the property of superposition (see below). In a linear system, a small change in the initial conditions causes a proportional change in the results.

nonlinear system– a system which does not have the property of superposition (see below). In nonlinear systems, small changes in the initial conditions can cause drastic changes in the outcome.

superposition– a property of linear systems such that the result of combining two linear systems is the same as the combination of the independent results.

butterfly (or seagull or "nail") effect- A tiny change/error in initial conditions propagating through a nonlinear system and causing a huge and unpredictable difference in the outcome.

numerical weather forecasting– Uses physical, mathematical and computational models of the atmosphere and oceans to predict the weather based on current weather conditions.

chaos– Chaos theory studies the behavior of dynamical systems that are highly sensitive to initial conditions, also see butterfly effect.

logistic equation - a simple non-linear model that can be used to describe a population of animals that reproduce, but are constrained by their environment

self-similarity– when part of something looks similar to the whole.

fractal– an object with the property of self-similarity (see above).

Upcoming Seminar (20 November, 2013):

Extreme Weather and Climate change

Please join us for Science by the Pint (9 December, 2013)

7:00 PM at The Burren in Davis Square

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