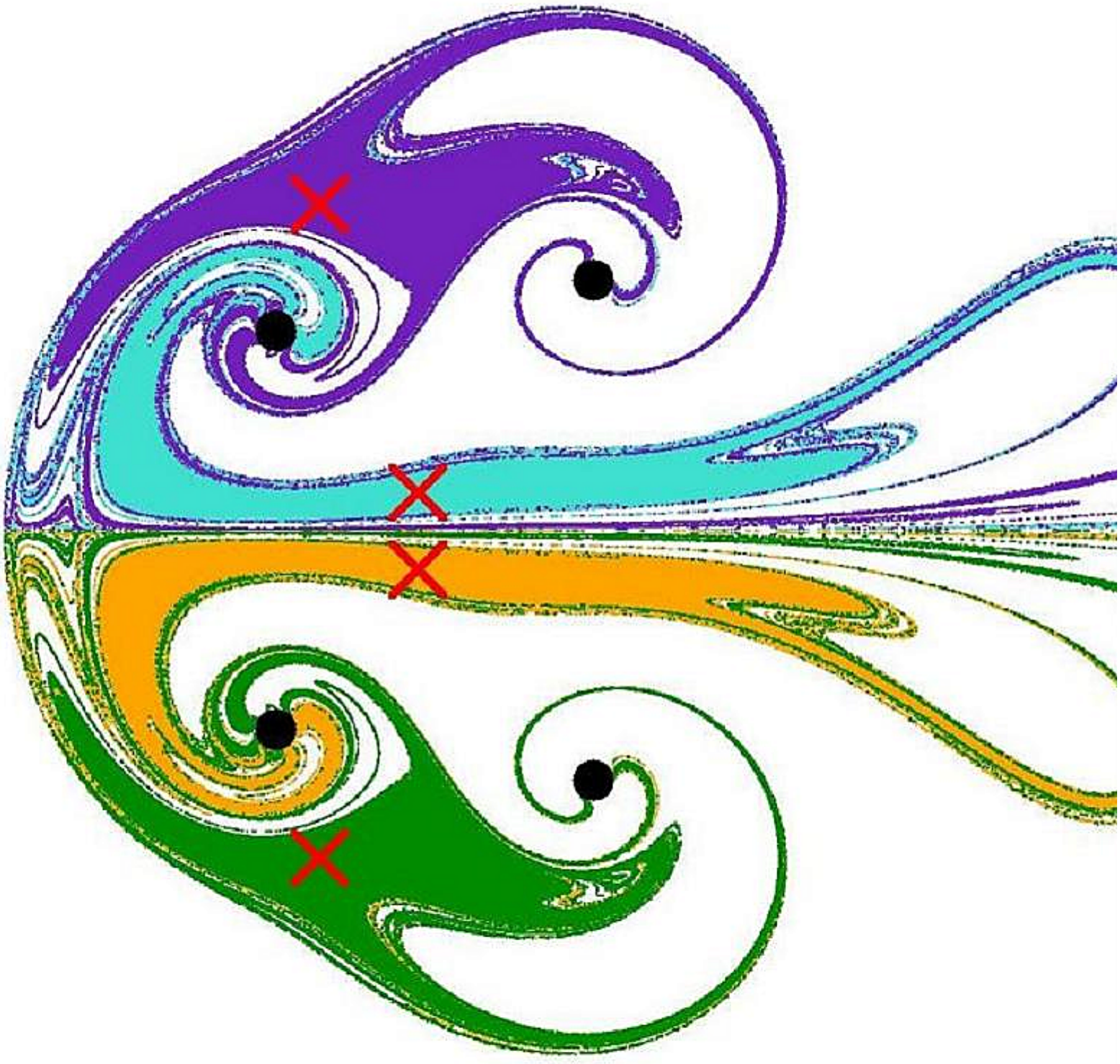
Dimensions

May 2008

Northwestern University's Department of Physics and Astronomy



Counterintuitive Fluid Dynamics
Adilson Motter

The image shows a nonlinear phenomenon in the fluid-dynamical transport of aerosol particles discovered in an international collaboration with Professor Adilson Motter's research group. In this numerical experiment, the particles, which are denser than the surrounding fluid, are attracted to the periodically moving point attractors (x-symbols) as the fluid moves from right to left through a set of four vortices (o-symbols).

To appreciate this phenomenon, imagine that you place a heavy particle in a vortex of a fluid. The centrifugal force will move it outwards, essentially in the same way a fast car slides in a curve. Now imagine the particle in an open flow (the flow of a channel, say) populated with vortices. It would possibly encounter some vortices, spiral outwards, and eventually move away as the fluid does itself, right? Not necessarily. In a rather counter-intuitive way, the outwards motion from successive vortices can drive the particles back to the point where they started, creating a condition of permanent trapping that leads to accumulation of particles in specific regions of the flow. In the image, the different colors represent particles that are eventually attracted to each of the four attractors, which are fixed points in a stroboscopic representation with the period of flow.

The consequences of this effect can be important in other fields, including atmospheric and environmental research because they have implications for the accumulation of aerosol pollutants in the air. They also shed light on the longstanding problem of rain formation as a mechanism for coalescence of smaller "particles", given that cloud droplets in the atmosphere are essentially heavy particles in an open flow.

Leaving aside potential applications, the fact that the particles transported by a fluid can remain confined even when all the particles of the fluid itself move away is very important in its own right. It was previously assumed that only light particles could be trapped, in that case by moving to the center of the vortices. The heavy particles considered in this study are trapped for exhibiting precisely the opposite behavior: each individual vortex scatters the particles away, but does so towards the other vortices. The particles remain trapped by continuously escaping from the vortices. The aesthetic of fractal boundaries of the attraction basins is an added bonus to this research.

Research

About the Author:

Adilson Motter

Before joining the Northwestern Faculty in Spring 2006, Adilson Motter held a Guest Scientist position at the Max Planck Institute for the Physics of Complex Systems, Dresden, and a Director's Postdoctoral Fellow position at the Center for Nonlinear Studies of Los Alamos National Laboratory. He is currently an executive committee member of the Northwestern Institute on Complex Systems.

Motter's research focuses on chaos and the dynamics of complex systems. In early work, he developed techniques for describing partially chaotic Hamiltonian and billiard systems and established the invariance of chaos in general relativity and hence the independence of an observer's perception of time. More recently, he has discovered methods to control the propagation of cascading failures in distributed systems and helped explain the widespread occurrence of synchronization phenomena in complex systems.

His research group is currently studying three different problems. The first concerns the predictive modeling of intracellular networks, which requires insights from both molecular biology and physics. The second problem focuses on the interplay between network structure and dynamics in the emergence of collective behavior in decentralized systems, such as large electric, computer-based and biochemical networks. The third problem concerns the fluid dynamical transport of particles, of which the cover image is a representative example.

Recent publications:

Local structure of directed networks, with G. Bianconi and N. Gulbahce, Phys. Rev. Lett. 100, 118701 (2008).

Predicting synthetic rescues in metabolic networks, with N. Gulbahce, E. Almaas, and A.-L. Barabasi, Mol. Syst. Biol. 4, 168 (2008).

Prevalence of marginally unstable periodic orbits in chaotic billiards, with E.G. Altmann, T. Friedrich, H. Kantz, and A. Richter, Phys. Rev. E 77, 016205 (2008).

Events

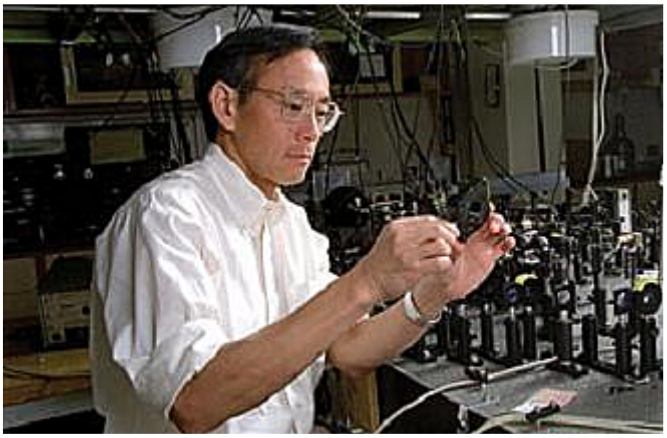
Heilborn Lecture Series

The Walter and Christine Heilborn Lecture Series is being held Wednesday, April 30 through Friday, May 2. This year's speaker is Professor Steve Chu, presently the Director of the Lawrence Berkeley National Laboratory, and Professor of Physics and Professor of Molecular and Cell Biology at the University of California at Berkeley.

Chu has a distinguished career in research, and in 1997, he shared the Nobel Prize in Physics with Claude Cohen-Tannoudji of France and William Phillips of U.S. for his pioneering work on cooling trapped atoms by laser beams and creating what is called "optical molasses." The technique has led to numerous devices to study fundamental problems in physics and cellular biology with unprecedented precision. Additionally, Chu is the co-chair of the International InterAcademy Council study, "Transitioning to Sustainable Energy." The IAC represents over 90 national academies of science around the world.

The topics of Chu's talks reflect his diverse expertise. In his first talk, "What We Can Learn from Single Molecule Experiments of Biological Systems," Chu will discuss the mechanics of bio-molecular systems with a particular focus on RNA enzymes. In his second talk, "Coherent Control of Ultra-cold Matter," Chu will focus on the use of atom interferometry and strongly related rotating Bose-condensates. Finally, in his keynote address, "The World's Energy Problem and What We Can Do About It," at the Northwestern-Argonne Energy Symposium, he will review the global energy problem and discuss recent research which may lead to new technologies which will help ameliorate the world's energy concerns.

For more information about each of his talks, go to http://www.physics.northwestern.edu/heilborn08.



Steve Chu

Northwestern-Argonne Symposium

Under the auspices of the Walter and Christine Heilborn Lecture Series, Northwestern University and Argonne National Laboratory will host a joint symposium on Friday, May 2. The symposium entitled, "Energy-The Challenge for the 21st Century," will focus on changes in the energy market, different sources of energy and new technologies which might help ease the world's energy problems.

For more information about the symposium, please go to http://wildcat.phys.northwestern.edu/events/Heilborn/symposium08.

Colloquia

The department sponsors weekly colloquia which cover a wide range of subdisciplines in the field of physics. The lectures take place every Friday at 4:00 PM, and they are free and open to the public. For more information about individual speakers and the subjects of their talks, please go to www.physics.northwestern.edu/

Dearborn Observatory Tours

Saturn will be visible for most of the Spring, and one of the best ways to view the planet is through the Dearborn Observatory's 18.5-inch diameter telescope. The Dearborn Observatory is open every Friday for free public observing sessions. People who are interested in visiting the Dearborn can find more information online at http://www.astro.northwestern.edu/observatory.php.

Dearborn Observatory

News and Notes

Dearborn Hosts Lunar Eclipse Event

Over 350 people braved frigid temperatures at Northwestern's Dearborn Observatory on the evening of February 20, 2008 to view a spectacular total lunar eclipse. For over three hours, the winter skies over Evanston remained crystal clear giving a brilliant view of the entire eclipse.

Honors:

Tassos Fragkos, a forth year graduate student working with Professor Vicky Kalogera, received a Northwestern University Presidential Fellowship.

Professor Vicky Kalogera received the Maria Goeppert-Mayer Award for her outstanding research related to the origin and evolution of compact objects in stellar systems. The Maria Goeppert-Mayer Award is given to female physicists who have made significant contributions to the field of physics during the early part of their careers.

Professor Horace Yuen will receive the 2008 Quantum Electronics Award from the Lasers and Electro-Optics Society (LEOS) of the IEEE. The Quantum Electronics Award is given to honor an individual for outstanding technical contributions to quantum electronics, either in fundamentals or applications, or both.

Undergraduate student Ryosuke Kita has been awarded a Goldwater Scholarship for 2008-09. Ryosuke is a student in Northwestern's Integrated Sciences Program, and he has been conducting research in the area of extrasolar planet dynamics under the supervision of Professor Fred Rasio.

Professor Prem Kumar is the recipient of a Distinguished Lecturer Award from the Lasers and Electro-Optics Society (LEOS) for 2008-09. The Distinguished Lecturer Awards program is designed to honor speakers who have made high quality contributions to the field of lasers and electro-optics, and to enhance the technical programs of LEOS chapters.

Central section of the CMS detector

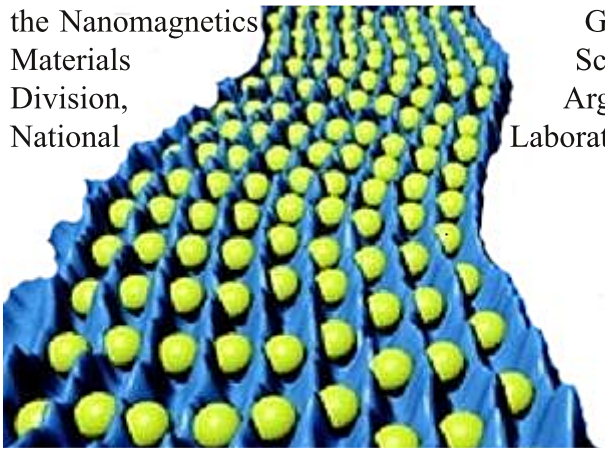
New Appointments:

High Energy physics graduate student Tim Andeen from the Schellman-Buchholz research group has been awarded a prestigious CERN Fellowship which will support him for two years of postdoctoral research at CERN in Geneva, Switzerland starting in July of this year. Tim's dissertation topic is the "Measurement of the W boson mass at D0." Tim joins Anne Dabrowski from Mayda Velasco's group, who received a Fellowship in 2007 and previous recipients Teresa Fonseca and Paulo Rumiero among recent CERN Fellows from NU.

Also, Geralyn "Sam" Zeller, BA 1995, PhD 2002 has been awarded a Director's Fellowship at Los Alamos National Laboratory to continue her work on neutrino cross sections.

The Department sponsors a Domain Dinner

The department sponsored a domain dinner on Monday, April 14, on "Materials for the 21st Century." Featured speakers were Jim Sauls, Professor of Physics, Vinayak Dravid, Professor of Materials Science, and Sam Bader, Adjunct Professor of Physics and Group Leader of the Nanomagnetics Group, Materials Science Division, Argonne National Laboratory.



Self-organized assemblies of magnetic nanoparticles

Compiled by Anne Colilla