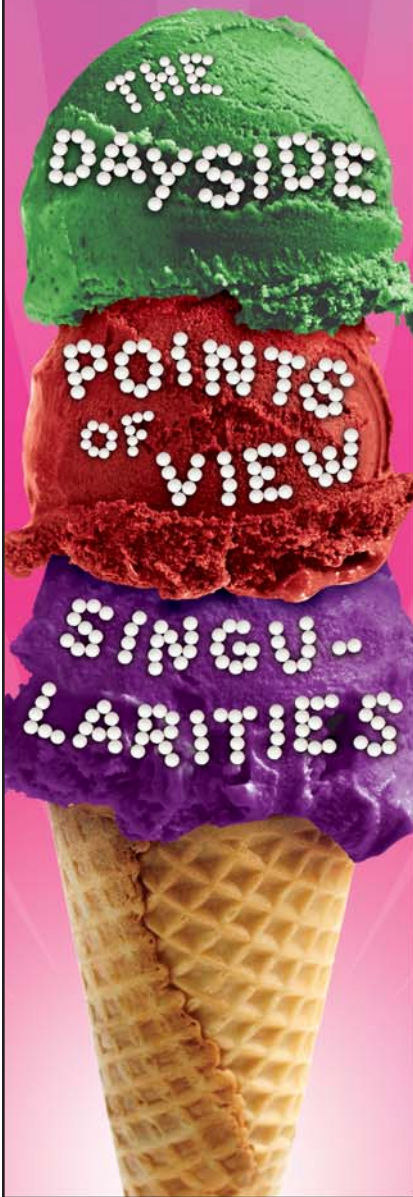


Online-only
content in

3 NEW
FLAVORS:



obituaries

To notify the community about a colleague's death, subscribers can visit <http://www.physicstoday.org/obits>, where they can submit obituaries (up to 750 words), comments, and reminiscences. Each month recently posted material will be summarized here, in print. Select online obituaries will later appear in print.

Vladimir Igorevich Arnold

Vladimir Igorevich Arnold, one of the great mathematicians of the 20th century, died unexpectedly in Paris on 3 June 2010. His achievements were remarkable both for their depth and breadth, and his work had and continues to have a significant impact on the formulation and solution of problems in science and engineering.

Arnold was born on 12 June 1937 in Odessa, Soviet Union. Exposed to mathematical problem solving at a young age, he became a student at Moscow State University, where he received his undergraduate degree in 1954 and his PhD in 1961. His mentor was the mathematician-physicist Andrei Kolmogorov. Arnold's outstanding mathematical abilities became apparent early on when, at the age of 19, he solved Hilbert's 13th problem, showing that seventh-order equations can be solved using functions of two variables. His subsequent work covered an extraordinary range of topics, in many cases opening up new areas of research in mathematics and physics.

In 1954 Kolmogorov proved the existence of quasi-periodic solutions in perturbations of integrable Hamiltonian systems. That problem, motivated by the question of the stability of the solar system, had vexed mathematicians for almost a century, and Kolmogorov's approach provided a scheme for controlling the troublesome "small divisors." Arnold developed a different approach that yielded deeper insights, and, at around the same time, Jürgen Moser enlarged the class of systems that could be treated. The resulting collection of mathematical theorems and techniques is now known as the Kolmogorov-Arnold-Moser (KAM) theory. The KAM theory continues to influence work on global Hamiltonian dynamics across a broad and growing range of applications, such as the foundations of classical statistical mechanics (see the article by Thierry Dauxois, *PHYSICS TODAY*, January 2008, page 55), ionization of atoms in electromagnetic



SVETLANA TRETYAKOV

Vladimir Igorevich Arnold

fields, the internal dynamics of molecules, and the theory of mixing in micro- and nanofluidics. Describing what are now known as Arnold tongues, Arnold also obtained seminal results on the dynamics of maps of the circle. That work provided a foundation for understanding the ubiquitous phenomenon of frequency locking in nonlinear systems.

In the early 1960s, Arnold constructed a Hamiltonian system that exhibited global instability. Cleverly stripping away technical complications, he demonstrated a general geometrical mechanism, now referred to as Arnold diffusion, for instability in systems with more than two degrees of freedom. Such global instabilities have been used to explain aspects of the dynamics of the solar system, the behavior of cold atoms, and energy transfer in molecular systems.

The KAM theory and Arnold diffusion were the cornerstones of a new vision for Hamiltonian dynamics; those ideas were taken up by Joe Ford, Boris Chirikov, and many others, and led to the rapid development of the fields of Hamiltonian chaos, both classical and quantum.

In the late 1960s, Arnold published several papers on classical hydrodynamic stability. His geometrical ap-

proach not only yielded new insights but also allowed generalization and improvement of classical stability results for Euler flows. The Arnold stability theorems and the Arnold method are now standard tools in hydrodynamics, and that work has led to the fertile field of topological fluid mechanics.

Arnold made equally fundamental contributions to the areas of singularity theory (the rigorous mathematics behind catastrophe theory), asymptotics (relevant to wave propagation, caustics, and quantum chaos), and symplectic topology.

Geometrical ideas pervade Arnold's work, which perhaps explains the rapid application of his ideas to physical problems. His harsh criticisms of overly formalistic mathematics undoubtedly resonated with physical scientists, as did his famous aphorism, "Mathematics is the part of physics where experiments are cheap."

Arnold was a prolific author of textbooks, problem books, and historical surveys. With André Avez, he wrote *Ergodic Problems of Classical Mechanics* (W. A. Benjamin, 1968). That seminal book, still one of the best introductions to dynamical systems theory, offered a

balanced discussion of Hamiltonian dynamics and ergodic theory; it also popularized the chaotic torus map now known as the Arnold cat map. *Mathematical Methods of Classical Mechanics* (Springer), first published in 1978, was immediately recognized as a classic and hailed by reviewers as "a masterpiece" and "pure poetry." The text gives a clear modern proof of the so-called Arnold-Liouville-Mineur theorem on the existence of action-angle variables and beautifully confirms the truth of Arnold's dictum that "Hamiltonian mechanics cannot be understood without differential forms." It has become essential reading for physicists and mathematicians alike. Arnold's books on differential equations demonstrate the power of qualitative approaches in the spirit of Henri Poincaré, as opposed to traditional "cookbook" methods.

Like Kolmogorov, Arnold was deeply concerned with the mathematical curriculum. He had firm ideas about the way mathematics should be taught, and he was particularly critical of the axiomatization of mathematics for its own sake and the resulting divorce from the natural sciences. In 2005 he published *Arnold's Problems* (Springer), a collection

Recently posted notices at <http://www.physicstoday.org/obits>:

John Huchra
23 December 1948 – 8 October 2010
Georges Charpak
8 March 1924 – 29 September 2010
John Alexander Tjon
7 December 1937 – 20 September 2010
Robert C. Truax
3 September 1917 – 17 September 2010
Robert Rudy
30 April 1928 – 7 September 2010
Alan D. Franklin
10 December 1922 – 27 August 2010
Nicola Cabibbo
10 April 1935 – 16 August 2010
Elizabeth R. King
1924 – 10 August 2010
Simon Swordy
1954 – 19 July 2010
Daniel Sperber
8 May 1930 – 15 August 2009

of problems posed in his widely renowned seminar, which ran for more than 30 years in Moscow. His many students have themselves had a major impact on the mathematical landscape.

Arnold received numerous awards, including the 1965 Lenin Prize, the 2001 Dannie Heineman Prize for Mathematical Physics, and the 2001 Wolf Prize in

NEW Vacuum Products Catalog



Call 800-824-4166 or go to
www.n-c.com for your free copy.

Nor-Cal Products, Inc.
1967 South Oregon St.
Yreka, CA 96097 USA
Tel: 800-824-4166
or 530-842-4457
www.n-c.com



DUNIWAY STOCKROOM CORP. 2010 COMPLETE CATALOG

Vacuum Equipment & Supplies

The Formula for Vacuum Success: Q = S x P

Manage Gas Load (Q)  	
Pump Gas With Speed (S)  	
Measure Pressure (P)  	

Hardware Supplies

Leak Detectors

Valves

Ion Pumps

Mechanical Pumps

Diffusion Pumps

Turbo Pumps

Vacuum Sensors

Gauge Controls

Cables

WWW.DUNIWAY.COM

Mathematics. It is now known that pressure from the Soviet authorities prevented him from receiving the 1974 Fields Medal, one of the highest awards in mathematics.

Arnold was a professor in the faculty of mechanics and mathematics at Moscow State University from 1965 to 1986. In 1986 he moved to the Steklov Mathematical Institute in Moscow, and in 1993 he accepted a position at the Paris-Dauphine University; thereafter he divided his time between the Steklov Institute and Paris.

The career of Vladimir Arnold showed that despite increasing specialization in mathematics and science in general, it is still possible for one person to make contributions of the first rank in both pure and applied fields of mathematics as well as in the physical sciences. His sudden loss comes as a shock, but his legacy as a scholar and teacher will serve as an inspiration for many years to come.

Gregory S. Ezra
Cornell University
Ithaca, New York

Stephen Wiggins
University of Bristol
Bristol, UK

Richard E. Norberg

Richard E. Norberg was an innovator in nuclear magnetic resonance (NMR), with a productive research career spanning more than 50 years. He died 20 April 2010 in Saint Louis, Missouri, after a brief period of declining health.

Dick was born on 28 December 1922 and grew up in Evanston, Illinois. He attended DePauw University before serving as a US Army Air Forces meteorologist in Europe from 1942 to 1946; he received a chemistry AB, in absentia, from DePauw in 1943. In 1951 he received his PhD in physics at the University of Illinois at Urbana-Champaign, where he was in the group of students working under Charles Slichter. Illinois was an intense and exciting place and time in the development of NMR, with new results appearing rapidly. Others in the Illinois effort who became leaders in NMR include Al Overhauser, Herb Gutowsky, Erwin Hahn, Myer Bloom, Don Holcomb, and Tom Carver. Dick's work at Illinois included, with Holcomb, a groundbreaking relaxation-time study of atomic motion in solid lithium and sodium and the first NMR



Richard E. Norberg

study of a metal hydride, a field with continuing activity today.

Dick moved to Washington University in Saint Louis (WU) in 1954 to work with George Pake. He quickly rose to professor and became department chairman in 1962, serving in that role for 29 years. He was a thoughtful and caring chairman, taking relish in doing



www.rbdinstruments.com
541.330.0723

surface science innovations



USB Autoranging Picoammeter

- adjustable filtering
- 90 V bias (optional)
- application software
- offset null
- data logging
- input ground

9103



Low Temperature Water Vapor Desorption System

- UV increases water vapor desorption rate
- less pumping, more time for vacuum processes

UVB-100



2 kV Sputter Package

- simple design
- ultra-reliable
- easy to maintain
- lowest priced sputter source on the market

IG2

MDC
*Your trusted resource
and solution provider*



Quality You Need **Value You Want**

MDC
engineered process solutions

**Thousands of
High and Ultra-High Vacuum Components
In Stock and Ready to Ship Today!**

ISI™ NEW DOUBLE ENDED TRIAX FEEDTHROUGH



Originally designed for NASA for reducing all noise/reflection to almost nothing by having 3 ways to ground the unit. This feedthrough features improved ceramic to metal seal transitions and can be made to various Amp requirements. Our new Triax Feedthrough features a bayonet connector on both ends and has a small diameter.

For more information contact Kevin Wronoski
kwronoski@mdcvacuum.com or 864-236-5164.

(800) 443-8817

www.mdcvacuum.com

MDC Vacuum Products, LLC and all divisions are ISO 9001:2008 Certified