DANIEL E. PROBER, YALE UNIVERSITY

Adilet Imambekov

honors. As a physics Olympiads competitor, he took first-place prizes in the 1997 and 1998 National Russian Olympiads and received a gold medal at the 1998 International Physics Olympiad.

Adilet continued his studies at the Moscow Institute of Physics and Technology. In his junior year, he passed several Landau Theoretical Minimum exams. He then received his basic theoretical physics training as a member of the Laudau Institute's theoretical group.

After going to Harvard University in 2002 for his PhD studies, Adilet joined the group of one of us (Demler) and concentrated on many-body physics of cold atoms. His first work, which still serves as a guide for new experiments, predicted numerous exotic states for bosons with nonzero spin in an optical lattice.

With his unique ability to fuse ideas from solid-state physics, atomic physics, and mathematics, Adilet was able to make progress in difficult problems when other attempts failed. His approach to the problem of interference between low-dimensional Bose condensates provides a good example. Adilet came up with a beautiful mapping of the problem at hand onto a seemingly unrelated one of statistical properties of random surfaces. His work became instrumental for the interpretation of subsequent experiments in which a new universal dynamical phenomenon, prethermalization, was demonstrated.

Adilet uniquely combined mathematical intuition with deep insight into the physics of quantum phenomena. He went to Yale University to work with another of us (Glazman) as a postdoc in 2007 and became interested in the dynamics of 1D quantum fluids, conventionally described by the widely known Luttinger liquid theory. In simplifying the problem, the standard theory artificially imposes symmetry that distorts a fluid's true dynamic response functions; Adilet's contributions were essential to building a theory free of such artificial assumptions. He combined the existing perturbative results with his own analysis of an integrable Lieb–Liniger model and foresaw the emerging universal dynamic properties of a fluid.

Less than a year later, Adilet built what he called the nonlinear Luttinger liquid theory, which universally describes low-energy excitations of a fluid made of particles with a generic, nonlinear dispersion relation. The theory's beauty is in its simplicity and versatility. It answered the existing questions about the dynamic responses while also providing a platform for tackling other, more difficult issues. While Adilet was making big strides toward developing a theory of quantum quenches and a kinetic theory of nonlinear Luttinger liquid, he joined Rice University as a junior faculty member in 2009.

Remarkably, Adilet's demeanor did not change despite the challenges of being a tenure-track faculty member. He remained warm and open. He quickly forged collaborations with his Rice colleagues and ventured into, for him, a new area of solid-state optics.

Adilet pursued his interests with utmost commitment. For example, when he began graduate school at Harvard, he became fascinated with climbing, mountaineering, and endurance sports. He started training nearly every day, which included running along the Charles River and rock climbing in New Hampshire when possible. Within a few years, he conquered two challenging mountains in Alaska and China and became rather well known among climbers. He also twice qualified for the Boston Marathon, and in May 2012 he won his only Ironman triathlon competition.

Each of us cherished every opportunity to talk to or collaborate with Adilet. He had a wonderful sense of humor and often brightened even the most challenging and confusing physics topic with an unexpected joke.

Adilet's commitment and love of life inspired many of his friends to pursue their own dreams. He showed by example that little is impossible if you are dedicated. Before going on his last trip to Kazakhstan, Adilet was talking to one of us about how one should attempt to get the most valuable result in the most intellectually challenging problem rather than concentrating on getting every paper published: "There is simply too little time," he said. Indeed, Adilet was given very little time. But it was enough for him to make long-lasting contributions to physics and to deeply affect the lives of those who were fortunate enough to know him.

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Akira Tonomura

Akira Tonomura, a Hitachi fellow who developed electron holography and a group director at the RIKEN Advanced Science Institute, passed away in Hidaka, Japan, on 2 May 2012 after his fight against pancreatic cancer.

Tonomura was born on 25 April 1942 in Hyogo Prefecture, Japan. He graduated from the department of physics at the University of Tokyo in 1965 and immediately joined the Central Research Laboratory of Hitachi Ltd. Tonomura was motivated to join the lab because of Hiroshi Watanabe, who, with a single electron micrograph, proved the Bohm–Pines plasma oscillation theory by using electron energy-loss spectroscopy. On

Akira Tonomura

the recommendation of Watanabe, Tonomura pursued research with electron beams to achieve holography, invented earlier by Dennis Gabor. Tonomura frequently communicated with Gabor, who encouraged him to realize aberration correction using electron holography, something that Gabor himself wanted to do, but he lacked a coherent electron source when he was doing his own research.

After demonstrating the basic principle of holography using a conventional electron microscope, Tonomura started developing an electron microscope with a field-emission electron source invented by Albert Crewe. Tonomura intended to use the source, which has a brightness several orders of magnitude higher than that of a conventional thermionic-emission source, to generate a coherent electron wave. It was during that period that Tonomura went to work as a research scientist with Gottfried Möllenstedt at the University of Tübingen in Germany; Möllenstedt had invented a device called an electron biprism for interference experiments. The experience provided much inspiration for Tonomura's future work. After several years of technical development, he achieved high coherence in his electron beams.

Tonomura then went on to use electron holography to observe the paradoxical quantum world, and his 1986 verification of the Aharonov–Bohm (AB) effect is one of his singular achievements. Yakir Aharonov and David Bohm had stated in 1959 that the vector potential is itself a fundamental physical entity and can affect a charged particle in a region where there is no magnetic field and therefore no force acting on the charged particle. The significance of the AB effect was renewed when Tai Tsun Wu and C. N. Yang recognized the effect as an experimental manifestation of the nonintegrable phase factor; they introduced and generalized it to a nonabelian gauge field to explain different interactions in a unified manner. (For a historical review of the AB effect, see the article Tonomura wrote with Herman Batelaan, PHYSICS TODAY, September 2009, page 38.)

To verify the AB effect, Tonomura and his colleagues fabricated a tiny toroidal ferromagnet covered with a layer of superconducting niobium to perfectly shield the magnetic field. They then measured a phase difference between the electrons that traveled through the central hole of the toroid and those outside it. Although the electrons had only progressed through regions free of electromagnetic fields, there was an observable effect produced by the existence of vector potentials. To create a new trend of applying cutting-edge engineering to the various issues in quantum mechanics, an international symposium on fundamental quantum mechanics was established in 1983 after Tonomura's first experiment to verify the AB effect; many international conferences with the same scope have since been held.

Tonomura's experiment in 1986 showed single-electron buildups of electron wave interference fringe patterns. It revealed the dual nature of electrons and was described by *Physics World* magazine as the world's most beautiful physics experiment, ranking above the historical experiments of Galileo Galilei and Robert Millikan.

Throughout his career, Tonomura worked in an industrial research laboratory. He also held concurrent appointments as the group director at RIKEN and principal investigator at the Okinawa Institute of Science and Technology. At both institutions, he led national projects in electron holography aimed at a deeper understanding of quantum effects and explored field distributions in magnetic and superconducting matter. In 2010 he became the core researcher for "Development and Application of Atomic-Resolution Holography Electron Microscope," a project of the Funding Program for World-Leading Innovative R&D on Science and Technology and funded by the Japanese government. However, he passed away before fulfilling his dream.

One notable attribute of Tonomura was his strong will to complete his research. In his first experiment to verify the AB effect in 1982, many other researchers pointed out problems. But with advice from Yang, he conceived of the experiment using the toroidal ferromagnet. Despite its being a difficult experiment, Tonomura allowed no compromise, and he finally succeeded. I remember him saying a scientist should aim for a research target so high that if he cannot succeed, then he can confidently say, "No one else in the world can." In just that way, he was unrelenting in his research, but to the people around him, he was a kind and thoughtful man. Officially and personally, he looked after researchers to ensure they had a good research environment.

When he was first diagnosed in the spring of 2011, even as he sought the best treatment for his illness, Tonomura continued to think about his research and maintained his pride as a researcher until the end.

I am deeply saddened for the premature departure of such a warm and kind colleague and such a great scientist. I have the deepest respect for the man and his many achievements.

Nobuyuki Osakabe
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Tokyo ■

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