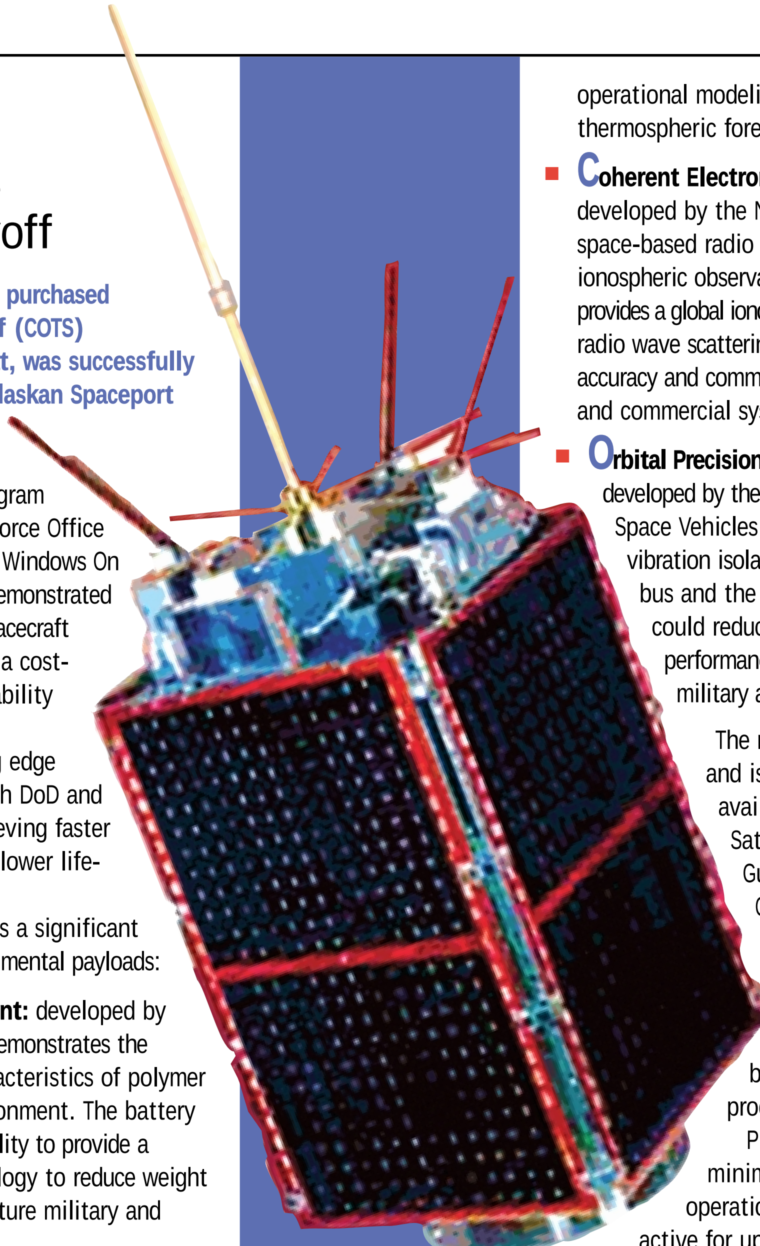
AIR FORCE OFFICE of SCIENTIFIC RESEARCH [AFOSR]
Manager of the Basic Research Investment for the Air Force

Research HIGHLIGHTS

MAY JUN 02

PICOsat:

A Small Satellite Provides Big Payoff



PICOsat (pictured above) is a technology demonstration satellite sponsored by SMC/STP carrying four experiments in the areas of vibration isolation technology, ionospheric observations, and polymer battery characteristics.

The first U.S. government purchased commercial-off-the-shelf (COTS) microsatellite — PICOSat, was successfully launched recently from the Alaskan Spaceport in Kodiak, Alaska.

Built for the Department of Defense's (DoD) Space Test Program and initially funded by an Air Force Office of Scientific Research's (AFOSR) Windows On Science initiative, PICOSat has demonstrated the practicality of using COTS spacecraft platform technology to provide a cost-effective and rapid launch capability for satellites.

With innovative and leading edge technology, PICOSat fulfills both DoD and Air Force requirements for achieving faster mission turnaround times with lower life-cycle costs.

For its size, PICOSat provides a significant capability by carrying four experimental payloads:

- **Polymer Battery Experiment:** developed by Johns Hopkins University, demonstrates the charging or discharging characteristics of polymer batteries in the space environment. The battery is on-board to test its capability to provide a lightweight, flexible technology to reduce weight and cost requirements for future military and commercial space systems.
- **Ionospheric Occultation Experiment:** developed by the U.S. Air Force Space and Missile Systems Center, it uses Global Positioning System signals at the edge of the atmosphere to measure ionospheric properties. It demonstrates remote sensing techniques for future DoD space systems and operational modeling for ionospheric and thermospheric forecasts.
- **Coherent Electromagnetic Radio Tomography:** developed by the Naval Research Laboratory, is a space-based radio beacon providing cooperative ionospheric observations with ground receivers. It provides a global ionospheric map to aid prediction of radio wave scattering, thereby improving navigation accuracy and communications capacity for military and commercial systems.
- **Orbital Precision Platform Experiment:** developed by the Air Force Research Laboratory's Space Vehicles Directorate, it is an anti-vibration isolation test between the satellite bus and the science payload. This could reduce launch cost and improve performance of space-based sensors for military and commercial space systems.

The microsatellite weighs 67kg and is based on the commercially available technology of Surrey Satellite Technology Limited in Guilford, United Kingdom. Currently, it is flying in a 800 km circular orbit with a 67-degree inclination. PICOSat uses a gravity gradient boom for stabilization, while the body mounted solar panels produce on orbit power.

PICOSat is designed for a minimum of one year of on orbit operations, but possibly may be active for up to five.

Since the early 90s, AFOSR's European Office of Aerospace Research and Development (EOARD) program manager, Lt. Col. Jerry Sellers, now current director of the Small Satellite Research Center at the USAF Academy, facilitated the exchange of dialogue between Surrey scientists and the Space Test Program office.

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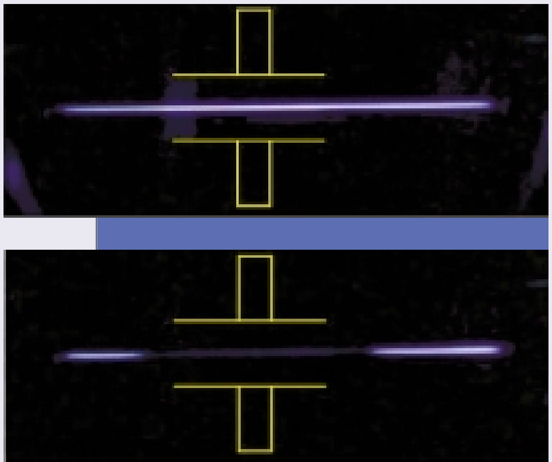
Discovery of a New Mechanism Controlling Persistent Radiation from Hypersonic Vehicles

Professor William Rich and a group of scientists at The Ohio State University have recently discovered a mechanism that may suppress radiation emitted by vehicles that travel at speeds several times greater than the speed of sound.



Schematic of electrodes in the cell overlapped with photographs of the visible plume radiation. TOP, free electrons are present in the flow. BOTTOM, electrons are removed by a small voltage applied to electrodes.

Hypervelocity aerospace vehicles, such as ballistic missiles, emit strong light radiation during parts of their flight trajectory. Scientist knew, for example, that during a ballistic missile's "boost phase," the exhaust from its rocket engines created a radiation source. While scientists were able to glean detailed information regarding the signature characteristics of the radiation, they knew little about the exact mechanisms that produced the radiation. Of particular concern was the surprising persistence of ultraviolet-visible radiation for long distances behind the vehicle.

Rich's group observed that the radiation was caused by various modes of motion of energetic molecules in the flow field. As the flow was heated during the normal course of the flight profile, the molecules were excited to move randomly in translational and rotational motion. Normally, detectable radiation does not arise from these modes. However, at sufficiently high energy levels, the vibrational motions of the flow molecules are excited and emit radiations. Some molecules present in the shock wave, created by a hypervelocity vehicle (most notably, nitric oxide and the hydroxyl free radical), are strong infrared radiators.

Other forms of radiation — at ultraviolet (UV) and visible wavelengths — come from a different molecular mode of motion. When electronically-excited molecules lose energy, they emit UV-visible radiation. However, some electronic states, and all the vibrationally-excited states, do not radiate strongly at UV-visible wavelengths. These states are referred to as "dark states." In experiments conducted at Ohio State, Rich's team developed strong evidence to show that some of the "dark states" strongly affect the UV-visible radiation, through an indirect but critical mechanism.

The group concluded that the critical mechanism controlling this transfer came from the small concentrations of free electrons that are typically present in these hypersonic flow fields. In experiments, Ohio State researchers simulated the flow field environment, including the necessary free electron concentrations, in an easily controllable laboratory flow cell. By switching on weak electric fields, created by small electrodes in the flow cell, the free electrons could be quickly removed.

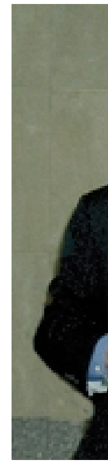
These experiments show that with the electrons removed, the visible and ultraviolet radiation from the flowing gases can be almost entirely suppressed. Rich's team is planning to further investigate the range of applicability of this mechanism and to determine whether the mechanism can provide a possible means to suppress radiation from hypersonic vehicle flow fields.

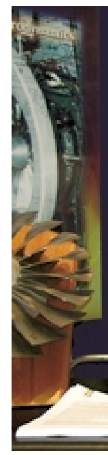
This area of research is supported by the Aerospace and Materials Sciences Directorate of the Air Force Office of Scientific Research.

Dr. Mitat Birkan, AFOSR/NA, (703) 696-7234

AFOSR at 50:

An all-star cast of the world's finest scientists and engineers celebrated the 50th anniversary of the Air Force Office of Scientific Research (AFOSR) on April 25 in Washington D.C. The commemoration reflected on the past and focused on future goals.





The event, which took place in the Ronald Reagan Building and International Trade Center, included exhibits from the Air Force Research Laboratory's nine technology directorates and AFOSR; a keynote address and luncheon with the Chairman of the House Science Committee Sherwood Boehlert (R-N.Y.); and was framed by a series of world-renowned guest speakers.

The theme of the event, "Celebrating 50 years of Scientific Breakthroughs for the Warfighter," concentrated on the essence of what AFOSR does best: building the foundation for revolutionary breakthroughs in science and technology.

"Organizations like the Air Force Research Laboratory and the AFOSR are the well-springs of innovation and discovery across disciplines of science and engineering," noted Boehlert. "We must continue to keep them healthy and vibrant so we may continue to keep the U.S. Air Force on the cutting edge far into the future."

Dr. Lyle Schwartz, Director of the AFOSR, kicked off the festivities with a video tracing the history of the soldier scientist from Archimedes to the past 50 years of accomplishments of the AFOSR. While lauding the accomplishments of the past half-century, Dr. Schwartz's speech focused on the years to come, a theme mentioned many times throughout the celebration.

"We seek the brightest minds," Schwartz said, "wherever they may be found."

Also in attendance were two AFOSR-sponsored Nobel laureates, Dr. Steven Chu and Dr. Alan J. Heeger, who spoke of the necessity of future scientific synthesis.

"The connection between physics and biology is fairly obvious," said Chu. "Without that connection, we would not have the scanning electron microscope, laser eye surgery or x-ray crystallography. AFOSR and its basic research are vital

A Cause for Celebration

TOP: Special guest speaker at the luncheon was the Hon. Sherwood Boehlert (R-NY), Speaker of the House Science Committee, pictured with AFOSR's Director, Dr. Lyle Schwartz

MIDDLE: Exhibitors from the Air Force Research Laboratory's Propulsion Directorate displayed research derived from basic research investments.

BOTTOM: Air Force sponsored high school science fair winners, George Eichinger III and David Schmitz, pose with the 1997 Nobel Laureate in Physics, Dr. Steven Chu.

to technological advances in the future." Heeger concurred, adding, "The key to fighting bioterrorism comes from the combination of disciplines in order to create technologies such as handheld anthrax sensors and the like."

Air Force Materiel Command commander Gen. Lester Lyles spoke about the contribution basic science made to the Air Operations Center, the vital weapon system of the Air Force.

"The heart and soul of the operational Air Force is the Air Operations Center," said Lyles, "and technologies such as the data wall and other technologies born of basic science keep this heart and soul going."

Air Force Research Laboratory (AFRL) commander Maj. Gen. Paul Nielsen agreed with the need to remember the past when focusing on the future.

"When Isaac Newton received credit for his scientific accomplishments, he said that it was because he stood on the shoulders of giants of the past," Nielsen observed. "AFRL and the AFOSR accomplished much in the past five decades, and will continue to achieve great things for many more, thanks to the giants who have served in our laboratory and with our industry and academic partners." Nielson went on, "We must double and re-double our efforts in the 21st century — an exciting time of accelerating scientific discovery. We must continue to transform our military capabilities to protect our nation and the men and women we send into combat."

AFOSR50

Celebrating 50 Years of Basic Research

Other speakers included The Honorable Ronald Sega, director of Defense Research and Engineering and a former astronaut; Dr. Joseph Janni, a former Director of the AFOSR; James Engle, deputy assistant secretary of the Air Force for science, technology and engineering; Dr. Ruth Pachter of AFRL; Dr. David Awschalom, Director of the UC Center for Spintronics and Quantum Computation; Dr. Malcolm O'Neill, Vice President and Chief Technical Officer of Lockheed Martin Corporation and Professor Daniel Hastings, Professor of Aeronautics and Astronautics at MIT.

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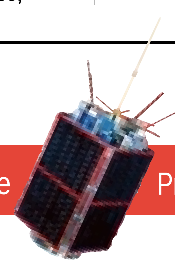

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Through EOARD's Windows on Science program, scientists from other countries visit their U.S. counterparts and facilities. One such visit by Surrey representatives to the Space and Missile Center (SMC) at Kirtland, AFB in Kirtland, New Mexico, resulted years later in the purchase of the microsatellite.

Now heading the ground station at the Academy, Sellers is overseeing the normal mission operations of the satellite jointly with the ground site in Guilford. Using two sites to downlink information greatly increases the amount of experimental data that can be received from PICOSat.

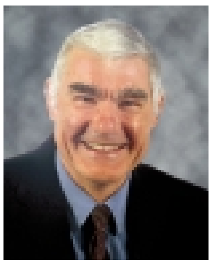
What began as a modest Windows on Science initiative has culminated in a successful joint endeavor with the United Kingdom and a new operational success for the USAF's space program.

AFOSR/EOARD, 011-44-207-514-4376

AWARDS

Capt. Dwight Holland, USAF Reserve, a program manager from the Air Force Research Laboratory's International Office, received the Stanley N. Roscoe Award for the academic year of September 2000-2001 from the Institute of Aviation, University of Illinois.

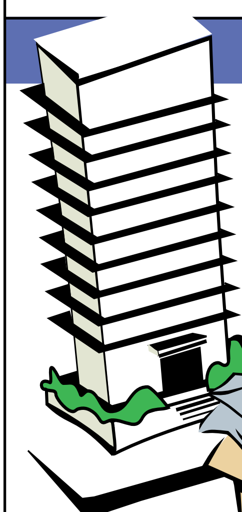
Holland earned the award for ***"the best Doctoral Dissertation written in a research area related to Aerospace Human Factors."*** Besides aerospace human factors research, other areas eligible for the award include aviation psychology, aviation safety, systems/safety engineering, and space human factors/medicine. Holland was also recently elected to be the secretary/treasurer for the International Space Medicine/Aerospace Human Factors Community.



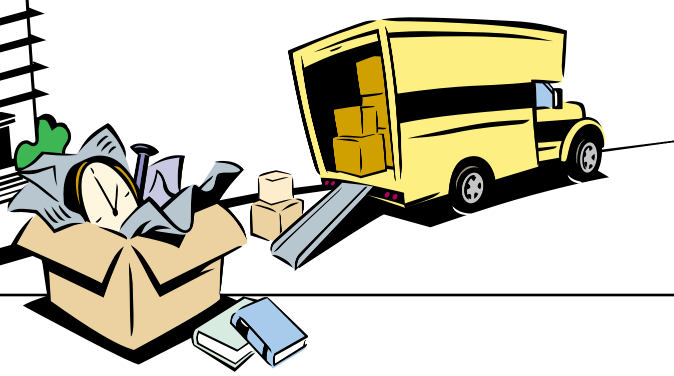
Dr. Raymond Flannery, a physicist at the Georgia Institute of Technology, received the 2001 Sir David Bates prize from the Institute of Physics in Britain ***"for distinguished contributions to the field of theoretical atomic physics and in particular for his studies of recombination processes with applications to astrophysics and plasma physics."*** Flannery is recognized as being a world leader in the field of atomic and molecular collision processes and theories. Flannery is supported by the Physics and Electronics Directorate of the Air Force Office of Scientific Research.

Col. Ronald Reed, program manager for the Air Force Office of Scientific Research's European Office of Aerospace Research and Development, received the 2002 Professional Excellence Award by the Life Sciences and Biomedical Branch of the Aerospace Medical Association. Reed earned the award for his ***"research accomplishments and technical management achievements important to the advancement of life sciences and biomedical engineering sustained over a number of years."***

AFOSR is on the move!



The Air Force Office of Scientific Research is relocating the Arlington, VA office. A move to an adjacent building on the same property will begin in late summer. More information will be provided in the July/Aug issue of *Research Highlights.*



Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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