THE NATIONAL ACADEMIES

RESEARCH ASSOCIATESHIP PROGRAMS

The Postdoc

Summer 2013

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Meet Rebecca Rivera!

Right: Rebecca Rivera, former DTRA/CBD NRC Associate, currently Laboratory Manager/ Research Scientist II, Marine Veterinary Virology

Rebecca started working on her bachelor's degree at age 16 where she had the opportunity to work on a molecular genetics related project entitled "Reconstructing the Population History of Puerto Rico by Means of mtDNA Phylogeographic Analysis." In 2000 she was awarded a Travel Award to present her data at the 50th Annual Congress of the American Society of Human Genetics Project later published in the American Journal of Physical Anthropology. By age 20 she was accepted at U.C. DAVIS to do her Ph.D. in Comparative Pathology with a pre-doctoral NIH grant. There her work was mainly immunology and virology related. She focused on vaccine developments for HIV-1, HCV and HPV. Rebecca graduated in 2006 and her Dissertation was "Immunogenic Properties of a Synthetic Peptide Mixture Derived from the Hypervariable Regions of HIV-1 Envelope lycoprotein gp120". *Rebecca continued on page 3*

Also see Scientific American "How Kitty is Kiling the Dolphins": http://www.scientificamerican.com/article.cfm?id=pathogens-from-humans-cats-kill-seals-dolphins

Rebecca using biological hood

"The Postdoc" highlights research and activities of NRC Associates and Advisers in participating federal government agency laboratory programs with the NRC. Our newsletters are available in print and on our website: http://sites.nationalacademies.org/PGA/RAP/PGA_047804. Newsletter manager: Suzanne White (swhite@nas.edu)

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

NRC Representation at 2013 Meetings

Meeting/Conference	City, State	Date
Mexican American Engineering and Science Society	Houston, TX	9/25/13-9/28/13
Society for the Advancement of Chicanos and Native Americans in Science	San Antonio, TX	10/3/13-10/6/13
Hispanic Association of Colleges and Universities	Chicago, IL	10/26/13-10/28/13
American Indian Science and Engineering Society	Denver, CO	10/31/13-11/2/13
Annual Biomedical Reserach Conference for Minority Students	Nashville, TN	11/13/13-11/16/13
American Society of Tropical Medicine and Hygiene	Washington, DC	11/13/13-11/17/13
American Geophysical Union	San Francisco, CA	12/9/13-12/13/13

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Dear Colleagues:

On behalf of the National Research Council, I am pleased to transmit to you the report: **The Future of Scientific Knowledge Discovery in Open Networked Environments: A National Workshop**. It is available freely at: http://www.nap.edu/catalog.php?record_id=18258 on the websites of the National Academies Press and the Board on Research Data and Information (BRDI).

As you know, BRDI held a national workshop on this topic in Washington, DC on 10-11 March 2011 to bring together key stakeholders in this area for intensive and structured discussions. The meeting explored options to obtain and promote a better understanding of the computer-mediated scientific knowledge discovery processes and mechanisms for openly available data and information online across the scientific domains. The workshop resulted in a report that synthesizes the contributions of the experts, and presents an authoritative and high-level review of the most promising and effective research opportunities in this area.

Copies of the report may be ordered through the National Academy Press (http://www.nap.edu). Please feel free to re-disseminate this information to your contacts.

Rebecca continued from front cover

After that, Rebecca was at Hubbs-SeaWorld Research Institute, first as a Research Biologist in 2006, then as a NRC Postdoctoral Research Associate 2007—2012 (?); then as a Laboratory Manager/Research Scientist II, looking for viruses that may affect marine mammals; and now as a NRC Postdoctoral Research Associate (June 2012-2014)

Rebecca's abstract: Assessing the pandemic potential of ocean-borne pathogens

Over the past six years, the Navy Marine Mammal Program and its collaborative partners, including Hubbs-SeaWorld Research Institute, University of Florida, the Marine Mammal Center, Mote Marine Laboratories, and SeaWorld, have been funded by the Office of Naval Research and the Department of Defense to discover viruses in marine mammals and to assess their risks to Navy dolphins and sea lions. Findings from this research and others have demonstrated that 1) a wide variety of viruses are associated with infectious disease in marine mammals, 2) a number of marine mammal viruses are closely related to those that infect humans, and 3) human and marine mammal viruses can recombine and create viruses that likely infect both marine mammals and humans. The potential role of the ocean in harboring pandemic pathogens is unknown, and marine mammals may provide important clues regarding which pathogens have the greatest pandemic potential. With the support of the Defense Threat Reduction Agency, and to investigate the pandemic potential of ocean-borne pathogens, the following actions are being implemented over 24 months: 1) literature review of pathogens that infect marine mammals and have the greatest pandemic potential, 2) development of a Working Group of leading experts in emerging infectious diseases and pandemics, 3) implementation of targeted, near-term proof of concept projects supportive of the overall project goal, and 4)development of a 5-year investment strategy to support longer-term research projects. To date, a summary of marine mammal pathogens has been completed; a Working Group has been established, including over 20 members from the Centers for Disease Control and Prevention, Mayo Clinic, Stanford University, Columbia University, Naval Health Research Center, and the University of Florida; and proof of concept projects with Working Group members are underway. Use of multi-institutional collaborations of experts has been an effective and productive means to address larger scale questions with minimal resources.

Rebecca Rivera,1
Stephanie Venn-Watson2
1 ***National Research Council Postdoctoral Associate at the Navy Marine Mammal Program, San Diego, California, 92106, USA***
2 ***National Marine Mammal Foundation, One Health Medicine and Research Program, San Diego, California, 92106, USA***

Acknowledgements: The authors would like to thank the staff at the Navy Marine Mammal Program for their assistance in gathering data as well as the advisors and experts involved in this project. This research was being performed while Dr. Rebecca Rivera holds a National Research Council Research Postdoctoral Associateship Award at the Navy Marine Mammal Program

Rebecca's bio:

NRC Research Associate
Navy Marine Mammal Program
June 2012 – Present (1 year 1 month)
Biosurveillance of ocean-borne pathogens

Scientist II / Lab Manager
Hubbs-SeaWorld Research Institute
June 2010 – May 2012 (2 years)
Over the last five years the staff at the Center for Marine Veterinary Virology at Hubbs-SeaWorld Research Institute in San Diego California has discovered over 30 new marine mammal viruses (previously only 11 had been reported in bottlenose dolphins and sea lions). Tests for these viruses are providing new tools for evaluation of the health of marine mammals, including free-ranging and stranded animals as well as sea lions and dolphins in managed collections. Diagnostic techniques, viral characterization and risk assessments of these viruses in the marine environment and animals are also relevant to human health (zoonosis, emerging infectious diseases).

Scientist I / Lab Manager
Hubbs-SeaWorld Reseacrh Institute
June 2008 – June 2011 (3 years 1 month)
Marine mammal virus discovery, characterization and risk assessments.

Postdoctoral Research Associate
Hubbs-SeaWorld Research Institute
November 2007 – June 2008 (8 months)
Molecular virology

Research Biologist
Hubbs-SeaWorld Research Institute
September 2006 – November 2007 (1 year 3 months)
Marine mammal virology

Dolphins, sea lions serve military

Dr. Mark Xitco, NRC Research Adviser

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http://www.cbsnews.com/2100-500175_162-808201.html

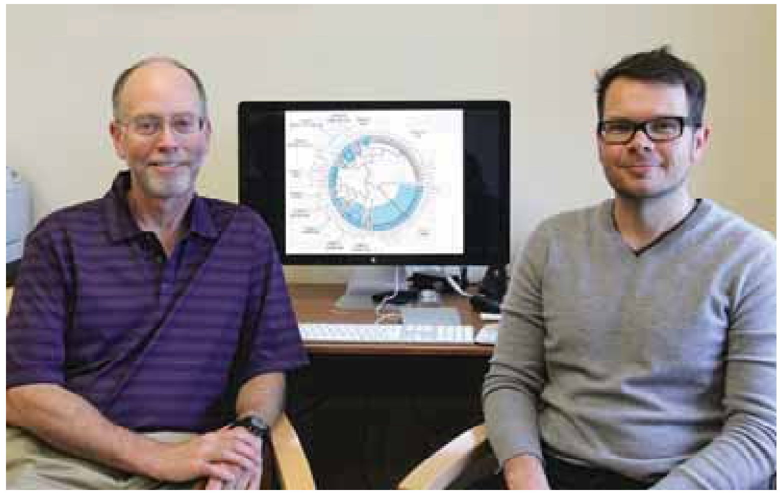
U.S. Pacific Northwest- Population Structure of Clinical & Environmental *Vibrio parahaemolyticus*

If you've eaten raw seafood, especially bivalve mollusks such as oysters,

or dipped a toe into the ocean, you've likely encountered *Vibrio parahaemolyticus* (Vp). Vp is a Gram-stain negative bacterium indigenous to coastal marine waters and the leading cause of seafood-borne bacterial gastroenteritis worldwide.

Central to safeguarding the public from Vp is the ability to distinguish between virulent and avirulent strains of this bacterium. This distinction can be based on the presence or absence or virulence-associated genes and or natural variation in DNA sequence shared between strains. Turner et al. (2013) utilized multilocus typing (MLST), a technique that differentiates strains based on variation in DNA sequence, to type 167 Vp isolates originating largely from the Pacific Northwest (PNW) region of the United States.

Results show that clinical infections in the PNW are caused by multiple genetically distinct strains. Importantly, these clinical strains did not include the pandemic O3:K6 serotype, which is responsible for most clinical infections globally. However, Turner et al. (2013) showed that pandemic strains are abundant in the PNW marine environment, raising the question: why are these environmentally abundant strains not causing illness in this region. The answer to that question is the subject of ongoing research that involves the sequencing of 23 Vp genomes isolated from clinical and environmental sources in the PNW.



Dr. Mark Strom, NRC Adviser, Dr. Jeff Turner, NRC Associate NOAA

Vibrio parahaemolyticus is a Gram-negative bacterium indigenous to coastal marine environments. Subpopulations of *V. parahaemolyticus* carry genes that impart the ability cause illness in humans and this bacterium is notable as the leading cause of seafood-borne gastroenteritis worldwide. The bacterium is commonly transmitted through the consumption of raw or under-cooked bivalves (e.g., oysters), which filter and concentrate the bacterium from the surrounding water column.

Globally, most clinical cases are attributed to the O3:K6 serotype; however, *V. parahaemolyticus*-related illness in the Pacific Northwest (PNW) region of the United States has been attributed to a diversity of serotypes (e.g., O4:K12, O6:K18, O1:K56, O4:K63, O3:K36, O12:K12). Yet, the genetic diversity of the *V. parahaemolyticus* population in this region is largely unknown and somewhat paradoxical in comparison to other geographies. A clear understanding of this bacterium's regional genetic diversity and population structure are needed to accurately identify subpopulations that pose a human health risk.

Turner et al. (2013) have recently published a broad genetic analysis of clinical and environmental *V. parahaemolyticus* isolates originating from the PNW. This study is the product of collaboration between **National Research Council (NRC) associates Dr. Jeff Turner (tenure 2011-2013) and Dr. Eric Landis (2007-2009) under the guidance of Dr. Mark Strom, NRC Adviser, NOAA's Northwest Fisheries Science Center (NWFSC).** The study used repetitive extragenic palindromic PCR (REP-PCR) and multilocus sequence typing (MLST) to show that 167 *V. parahaemolyticus* isolates comprised some 39 REP-PCR groups and 24 MLST sequence types. The discovery of at least 5 distinct sequence types among clinical strains demonstrates that *V. parahaemolyticus* gastroenteritis in the PNW is polyphyletic.

Moreover, Turner et al. (2013) show that a large clonal complex of environmental isolates share the same REP-PCR and MLST profiles as the O3:K6 complex responsible for illness in other geographies (Figure 1). Thus, the absence of clinical O3:K6 in the PNW is not due to the absence of O3:K6 in the environment.

More comprehensive comparisons between distinct sequence types is underway. Specifically, researchers at NWFSC and Dr. Turner (now located at the University of Washington) are focused on the genomic comparison of 23 *V. parahaemolyticus* isolates included in this study. Questions to be addressed include (1) the apparent fitness of the predominant O4:K12 clinical complex (2) the absence of clinical O3:K6 isolates in spite of this serotype's environmental abundance and (3) the evolutionary forces shaping diversity and evolution in this region.

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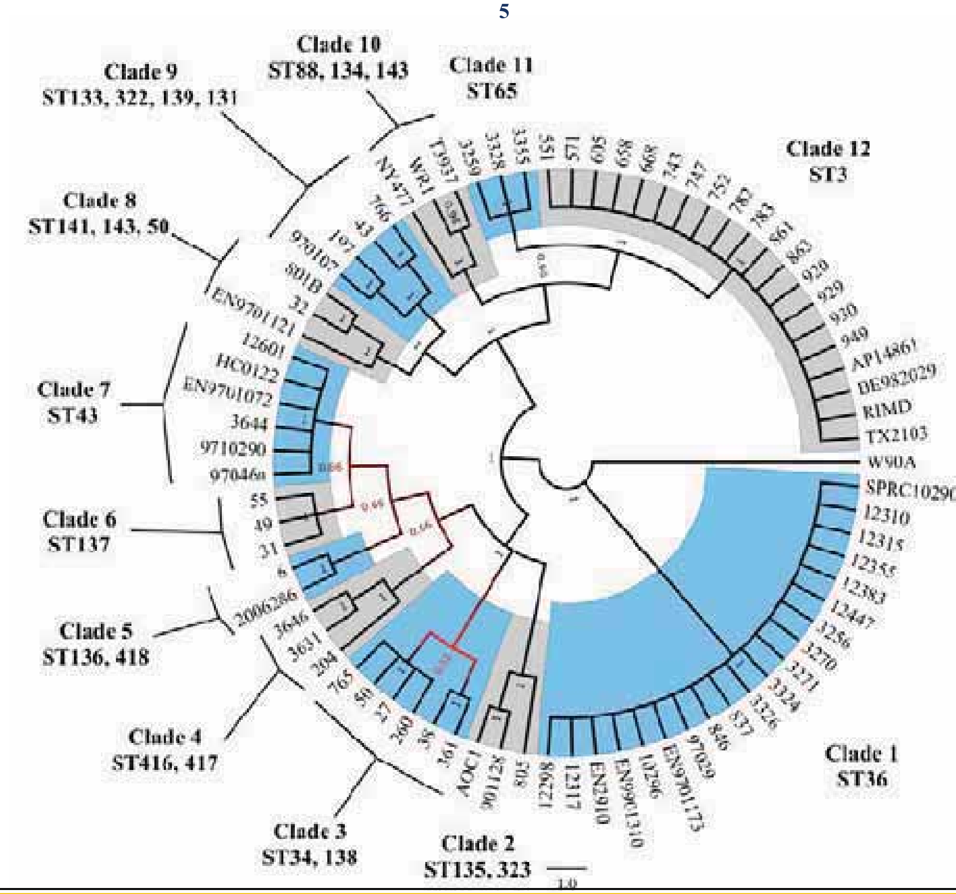
Figure 1. REP-PCR patterns and representative dendrogram. The electrophoresis banding patterns of 167 *V. parahaemolyticus* isolates assayed by REP-PCR is shown. BioNumerics analysis of patterns revealed 39 unique REP-PCR groups comprised of N isolates. The corresponding BioNumerics dendrogram illustrates the genetic relatedness between REP-PCR groups, which we grouped into three major clusters (I, II, III). Groups 27, 28 and 3 comprise cluster I while groups 11, 29 and 34 comprise cluster III and all remaining groups comprise cluster



Spotlight on NRC Staff—Ms. Linda Sligh!

Linda has been with The National Academies for over 25 years providing financial and programmatic support in several departments. In 1987-88, she worked in the Office of Scientific and Engineering Personnel (OSEP) before moving to the Accounting Department. In 1991, Linda joined the Fellowships Office as a Travel Coordinator; then worked briefly as a Travel Supervisor before securing her current position, in 2000, as a Senior Program Coordinator with the Research Associateship Programs.

As NRC Senior Program Coordinator, Linda serves as liaison and assists with the management of the following Federal Laboratories: AFRL, AMRDEC, ARL, ARL/USMA, ARO, ECBC, EPA, EPA/SFFP, NETL, NETL/MHFP, NSRDEC, and RDEC/ARDEC. Linda is effective, and successfully accomplishes this role, as she thoroughly enjoys working with NRC Research Associates, Advisers, and Agency/Laboratory Program Representatives (LPRs) toward the shared goals of an enriching and rewarding postdoctoral research experience in the laboratory, and equally successful Research Associateship Program as a whole.

In December 2012, Linda received an award from the Policy and Global Affairs Division of the National Academies for Program Impact, which includes the training of new coordinators and her participation and contribution toward streamlining processes and workflow.

Outside of her work, Linda serves as Vice President of her Homeowner's Association. When not handling association issues, Linda participates often in raising breast cancer awareness for the Susan G. Komen Race for the Cure charity. In addition, she loves taking long walks with her white Shih Tzu, Snowball.

Comments from LPRs:

"Linda has supported the ECBC associateship program for many years. She is a true professional and always quick to respond to our requirements. The service she provides exceeds all expectations and guarantees a continuing successful relationship with the NRC. She is greatly appreciated!" Harry Salem, ECBC

"Linda Sligh is an excellent example of what support is. Ms. Sligh is always very prompt, courteous, and professional when responding to informational requests from ORD and goes above and beyond to support the needs of ORD and the NRC Program. We greatly appreciate Linda!" MarySue McNeil, EPA

"Enjoy working with Linda! She is a true professional who has skillfully handled our post-doc program for years. She quickly responses to program management from me and fields questions from eight other AFRL locations." Neville Thompson, AFRL

Comments from NRC Associates:

" Linda Sligh is great. She always responds to any questions or concerns I have in a timely fashion, and if she doesn't have an answer for me she directs me to the appropriate person or place"

" Linda does a fantastic job providing support! She has been extremely helpful and responsive in providing support"

"My NRC Coordinator, Linda Sligh has been fantastic during every step of this process. I truly appreciate her great level of professionalism in her job"

" I receive excellent administrative support. In particular, Linda Sligh is a great program coordinator"

Linda Sligh, NRC Senior Program Coordinator

Laser Cooling of Solids-

also known as optical refrigeration—is based on the principle of anti-Stokes fluorescence where laser photons with energy less than the mean fluorescence energy are absorbed followed by phonon-assisted upconversion fluorescence. In layman terms: a high power laser, tuned to the correct wavelength, induces cooling by generating a fluorescence that escapes a solid with higher energy than the absorbed laser energy. The increased fluorescence energy is created by the removal of vibrational energy in the solid, making it cold.

First demonstrated in 1995 at Los Alamos National Labs, optical refrigeration showed cooling by 0.3 K (~0.5 ^{o}F) from room temperature. By discovering improvements in new materials, researchers have drastically improved cooling performance by reaching the cryogenic temperature of ~114 K (~ -254.5 ^{o}F), a temperature drop from the ambient surroundings of ΔT~185K (ΔT~335 ^{o}F)!

Not only is this result the coldest temperature achieved through laser cooling of solids, it is also the coldest temperature for ANY solid state means throughout the world.

Researchers are continuing efforts to improve cooling even further through material analysis and new laser systems. Additionally, researchers are designing an all solid-state optical cryo-cooler, a device that is inherently vibration free while reaching cryogenic temperatures, features ideal for space-based sen-

Dr. Seth Melgaard, NRC Postdoctoral Research Associate at the Air Force Research Laboratory in Albuquerque, NM. Seth, in collaboration with researchers at his alma mater, The University of New Mexico, and Los Alamos National Laboratory, are on the path towards the first all solid-state optical cryo-cooler utilizing laser cooling of solids.

View from 2013 Photonics West: Solid Cooling

Journal article below by David Pile, *Nature Photonics,* Volume: 7, Pages: 348–349 Year published: (2013), DOI: doi:10.1038/nphoton.2013.113. Summ: "Cooling materials using interaction with light has come a long way in the past 20 years. Researchers at the recent 2013 Photonics West showed that they can cool new types of materials and more can be expected in the future using new approaches."

At the beginning of each year, San Francisco hosts one of the biggest and broadest optics conferences in the world. This year, SPIE's Photonics West conference took place on 2–7 February 2013 at the Moscone Center, which is conveniently located close to the Embarcadero, Mission District and numerous other popular destinations.

As the weight of the 415-page technical program indicates, the meeting was incredibly broad. Major themes were grouped under 'sub-conferences' named "Green Photonics", "BiOS", "LASE", "MOEMS-MEMS" and "OPTO". The laser cooling of solids and dense gases (also known as optical refrigeration), although not one of the 'biggest' topics at the meeting, provided some focused sessions that demonstrated the significant recent progress. Optical refrigeration is of interest because it can be realized using compact, cryogen-free systems and does not generate vibrations.

One of the early sessions addressed the problem of cooling optically important rare-earth-doped material systems. Seth Melgaard and colleagues from the USA (Air Force Research Laboratory and the University of New Mexico) and Italy (Università di Pisa) discussed several milestones. They have cooled a 5%-wt. Yb:YLF crystal to ~118 K — the minimum achievable temperature for their pump centered at 1,020.7 nm. Melgaard explained that they improved the cooling efficiency by investigating the effect of doping concentration using 1%, 5%, 7% and 10%-wt. Yb:YLF crystals. They noticed that the parasitic background absorption decreased with increasing doping concentration. The ratio of the background absorption to the resonant absorption of the 10%-wt. Yb:YLF crystal was reduced giving the 10%-wt. Yb:YLF crystal a minimum achievable temperature of 93 K. So far, they have achieved a temperature of 114 K; Melgaard emphasizes that, although this is above the minimum achievable temperature, it is by far the coldest solid-state optical technology in the world.

"We have identified a path towards achieving solid-state cooling to the liquid-nitrogen temperature of 77 K," Melgaard told *Nature Photonics*. "Because of the trend in parasitic background absorption, elemental analysis was performed and it identified iron as the main contributor to parasitic heating. By reducing the iron concentration through purification of the starting materials, model predictions show that solid-state cooling to liquid-nitrogen temperature is within reach."

Also on the topic of cooling rare-earth-doped systems, Angel Garcia-Adeva (Universidad del País Vasco) and colleagues from Spain and France discussed work on using light to cool erbium-doped oxysulphide crystal powders. Garcia- Adeva explained to *Nature Photonics* that lanthanum oxysulphide, a uniaxial P3m wide-bandgap semiconductor material, is an excellent host lattice for trivalent rare-earth ions, as its maximum phonon energy of about 400 cm–1 enhances efficient upconversion processes while strongly suppressing nonradiative multiphonon losses.

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"Our group is currently investigating Er3+-doped La2O2S crystal powders as a promising candidate for all-optical cooling. This material exhibits an efficient infrared-to-visible upconversion under excitation in the 800–870 nm band," Garcia-Adeva told *Nature Photonics*. ***"Indeed, we have obtained efficient upconversion-assisted local cooling when pumping in resonance with a two- or three-phonon annihilation process. Even though this investigation is still underway, our preliminary results suggest that efficient bulk optical cooling could soon be achieved in this system."***

Galina Nemova from Polytechnique de Montréal (Canada) discussed a new theoretical scheme for the laser cooling of rare-earth-doped direct-bandgap semiconductors. Nemova explained that the cooling cycle in conventional laser cooling schemes is based on electron transitions between the excited and ground states of isolated ions (anti-Stokes fluorescence in rare-earth-doped insulator hosts) or between the conduction and valence bands (laser cooling with direct-bandgap semiconductors). In contrast, the cooling mechanism in a rare-earth-doped direct-bandgap semiconductor system (Yb3+:InP) consists of laser excitation of Yb3+ ions followed by thermal quenching of excited ions accompanied by phonon absorption, which provides the cooling; band-to-band radiative recombination in the InP host at the end of the cooling cycle removes energy from the system.

Nemova says that, in contrast to cooling with conventional rare-earth-doped insulator hosts, in which the pump wavelength must exceed the mean fluorescence wavelength, their system can be pumped at a wavelength shorter than the mean fluorescence wavelength, thus benefiting from the high absorption cross-section of rare-earth ions. The increase in quantum defects between the absorbed and radiated photons may give a higher cooling efficiency than the laser cooling of rare-earth-doped insulator hosts.

Following the success with cooling rare-earth-doped solids, groups have also pursued the optical refrigeration of conventional semiconductors. Recently, Qihua Xiong's group from Nanyang Technological University in Singapore has accomplished, for the first time, the net laser cooling of group ii–vi semiconductor CdS nanoribbons to a temperature of about 40 K below ambient temperature. Xiong explained to *Nature Photonics* that coupling between strong excitons and longitudinal optical phonons in group ii–vi semiconductors such as CdS can be harnessed to facilitate laser cooling by the annihilation of one or more longitudinal optical phonons, leading to several k_BT of heat being removed in each cooling cycle.

He explained that net cooling in semiconductors had not been achieved previously, despite many experimental and theoretical efforts on group iii–v gallium arsenide quantum wells. According to Xiong, GaAs-based semiconductors suffer from a high parasitic background absorption and a poor luminescence extraction efficiency, although anti-Stokes upconversion can be readily achieved. The researchers suggest that group ii–vi semiconductors may be more promising than group iii–v semiconductors for an all-solid-state optical refrigerator down to sub-liquid-nitrogen temperatures.

Others discussed the applications of semiconductor cooling to light-emitting diodes (LEDs). Rajeev Ram from the Massachusetts Institute of Technology in the USA explained how electroluminescent cooling broadens the application scope of optical refrigeration. ***"By operating an LED as a heat pump, whereby the electrons transport energy from lattice vibrations to incoherent photons, it is possible to realize LEDs in which nearly all of the energy for photon emission originates as heat,"*** Ram explained. ***"From the conventional device perspective, the electrical-to-optical power conversion efficiency seems to be greater than 100%. In this operating range, LEDs become brighter and more efficient as their temperature rises and more heat is pumped into the device."***

According to Ram, applications for LEDs operating in this electroluminescent cooling regime include mid-infrared sources for sensing in harsh environments and potentially even general illumination.

Also on the subject of LEDs, Volodymyr Malyutenko from the Institute of Semiconductor Physics (Ukraine) has demonstrated an alternative approach to cooling of a commercial green LED operated in continuous-wave mode and self-heated to 150–200 °C. In his set-up, the LED sits on a cooler consisting of a 15 mm × 15 mm × 4 mm silicon wafer pumped by a 1.09-μm-wavelength diode laser. They achieved 5 K cooling in both the LED and the silicon wafer when the pump was operating. The physical concept is based on a light down-conversion process initiated by free carriers generated by the pump. The cooling occurs due to the enhancement of infrared (>3 μm) thermal emission in the silicon when the overall energy of multiple low-energy photons escaping the wafer exceeds the above-bandgap energy of the pumped photon.

There was also a session dedicated to novel approaches for laser cooling. Martin Weitz of Bonn University (Germany) reported an experiment investigating the laser cooling of atomic gases by collisional redistribution of fluorescence. Weitz explained to *Nature Photonics* that this technique is applicable to ultradense atomic ensembles of rubidium atoms with a noble buffer gas pressure of a few hundred bars. Frequent collisions with noble gas atoms in the dense gas system shift atomic transitions to resonance with a laser beam detuned by a few nanometres to the red of an absorption line, while spontaneous decay occurs close to the unperturbed resonance frequency so that the ensemble is cooled. This new laser cooling technique is suitable for cooling high-density 'macroscopic' gas ensembles. The redistribution laser cooling technique is expected to be applied to molecular gas samples in the future.

In the same session, Tal Carmon of the University of Michigan (USA) discussed Brillouin cooling. Carmon explained that although glass tends to be viewed as a stationary medium that interacts minimally with electromagnetic waves, Brownian fluctuations of atoms in solids scatter and Doppler-shift light while exchanging energy with matter. Such scattering from density variations in the form of acoustic waves is called Brillouin scattering; Raman scattering refers to scattering from fluctuations in charge distribution while the molecule's centre of mass stays stationary. Carmon explained that to enable cooling through scattering, the system should prefer 'bluer' wavelengths (anti-Stokes scattering), which extract energy from the material, rather than 'redder' photons, which impart energy to the material.

"Thermodynamically, however, the Planck distribution suggests that the red Doppler shift dominates over the blue shift, which is true for bulk materials in which light of all colours is equally allowed," Carmon told *Nature Photonics*. ***Article ends pg. 10***

Optical refrigeration to 119 K—below NIST cryogenic temperature

We report on bulk optical refrigeration of Yb:YLF crystal to a temperature of ~124 K, starting from the ambient. This is achieved by pumping the E4-E5 Stark multiplet transition at ~1020 nm. A lower temperature of 119 ±1 K (~ − 154C) with available cooling power of 18 mW is attained when the temperature of the surrounding crystal is reduced to 210 K. This result is within only a few degrees of the minimum achievable temperature of our crystal and signifies the bulk solid-state laser cooling below the National Institute of Standards and Technology (NIST)-defined cryogenic temperature of 123 K.

OCIS codes: (000.6850) Thermodynamics; (140.3320) Laser cooling; (160.5690) Rare-earth-doped materials; (300.1030) Absorption; (300.2530) Fluorescence, laser-induced.
http://dx.doi.org/10.1364/OL.38.001588

During optical refrigeration of a solid, heat is removed by the process of anti-Stokes fluorescence [1–3], when the average emission energy exceeds the excitation energy. The energy difference is extracted from the phonon modes of that solid, resulting in cooling of the lattice. Since the first observation of laser cooling of ytterbium-ion-doped glass in 1995 [2], a variety of Yb-ion:host combinations have been cooled (for a comprehensive list, see recent review articles [4,5]). In addition, cooling with rare-earth ions of thulium [6] and erbium [7] has been demonstrated. Optical refrigeration has also motivated the development of a radiation-balanced laser [8].

Cooling to 155 K was recently achieved in the Yb^{3+}:LiYF4 crystal by 0.3% detuned excitation from the optimal pump energy, corresponding to the lowest Stark intermultiplet resonance (E4-E5) [9]. For ideal pumping, a minimum achievable temperature (MAT) of 110 K was predicted [9] and verified spectroscopically [10] for a given level of material purity.

In this Letter we report on bulk laser cooling to (119 ± 1)K of the 5% w.t. Yb:YLF crystal, pumped directly at the lowest energy intermultiplet E4-E5 transition at λ =1020 nm. This temperature is the coldest achieved by any all-solid-state refrigerator to date and corresponds to the first bulk cooling below the National Institute of Standards and Technology (NIST)-defined cryogenic temperature of 123 K. Furthermore, cooling to within few degrees from the MAT signifies excellent agreement with the modeling framework.

A description of realistic materials for laser cooling has to take into account the competing, heat generating, loss terms. The main losses are nonradiative recombination and impurity-mediated heating. Thus, the necessary material conditions to achieve cooling are (i) high external quantum efficiency (EQE) transition in the dopant ion and (ii) high purity of the host material. Ignoring saturation [11], the cooling efficiency, defined as the ratio of power heat lift to absorbed power, is given by [3,11] where $\lambda_f(T)$ is a temperature dependent mean emission wavelength, η_{ext} is the EQE, and α_b, α (λ;T) are the parasitic and resonant absorption coefficients, respectively; the latter is shown to be explicitly wavelength- and temperature dependent. While the nature of the background absorption is under current investigation, a widely accepted view is that it is mainly due to transition metal impurities [12]. Both η_{ext} and α_b are assumed to be temperature independent, justified in earlier local cooling measurements of the MAT [10]. In Eq. (1), a positive value of η_c corresponds to cooling, where a small ratio of α_b/α together with a high value of η_{ext} are the necessary requirements.

$$\eta_c(\lambda, T) = \eta_{\text{ext}}\left[\frac{1}{1+\alpha_b/\alpha(\lambda, T)}\right]\frac{\lambda}{\lambda_f(T)} - 1, \qquad (1)$$

To calculate the cooling efficiency of the material for moderate pumping (ignoring saturation), we have to supplement Eq. (1) with four measured values, namely η_{ext}, α_b, α(λ;T), and $\lambda_f(T)$[11]. The latter two quantities are obtained in a series of experiments where calibrated temperature-dependent fluorescence spectra are analyzed by performing reciprocity [13] and by taking the first moment of the fluorescence function, respectively. Supplemented by the data, the cooling efficiency is calculated from Eq. (1) and plotted in Fig. 1. The blue region corresponds to cooling. The line separating the cooling from the heating (red) region is the spectrum of the MAT. The global minimum of that spectrum, denoted as MATg, occurs at a wavelength of 1020 nm, corresponding to the E4-E5 transition, as mentioned above.

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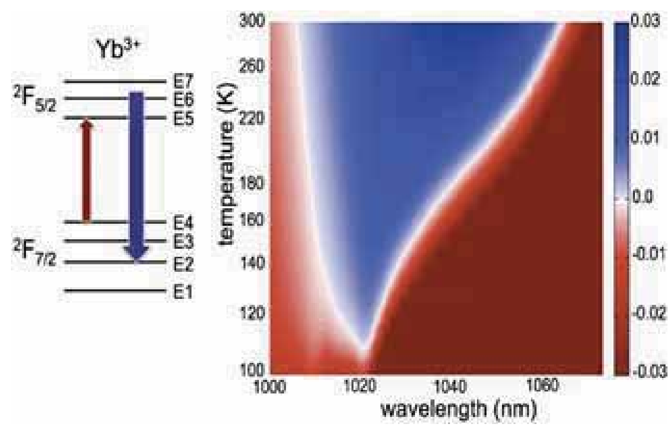

Fig. 1. (Left) The cooling cycle associated with the Stark multiplet of Yb3+, showing explicitly the E4-E5 pumped transition. (Right) Map of cooling efficiency [Eq. (1)] for Yb^{3+}: YLF with ηext=(99.4±0.1)% andαb=(4.4±0.2×10−4)cm−1.

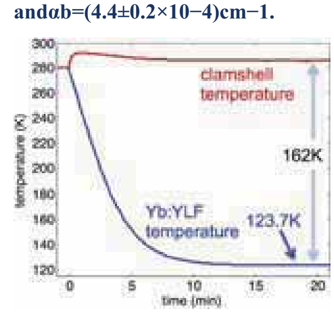

Fig. 3. Temperature evolution of Yb:YLF, from 285 K down to the NIST-defined cryogenic operation point of 123K.

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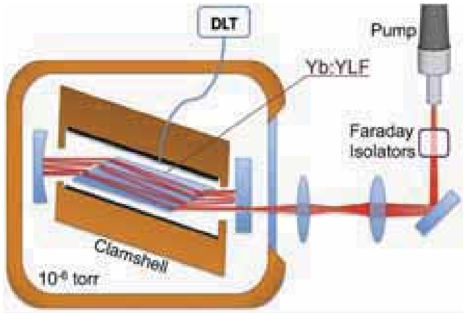
Fig. 2. Schematic of experimental setup



The exact MAT_g value depends on the input parameters of the model and is estimated to be 116 K for the Yb:YLF sample used in this work.

To reach optimal pumping conditions, we acquired a custom-designed linearly polarized high-power (>50 W) Yb:fiber laser at 1020 nm from IPG Photonics. The experimental setup is outlined in Fig. 2. The laser is optically isolated from and focused via a lens pair to a nonresonant cavity that is placed inside a high vacuum chamber. To maximize single-pass absorption [14] and minimize surface reflections, the Yb:YLF crystal is Brew-ster cut for the E∥c orientation. To further maximize pump absorption, crystal of length L=1.2 cm is posi-tioned inside of a Herriott cell [15], consisting of highly reflective flat input coupler and a curved (R=25 cm) back mirror, separated by ~3.5 cm. Saturation of resonant absorption is avoided inside the Herriot cell by optimizing the lens pair separation and focusing spot size at the flat mirror. Pump light is admitted through a 1 mm diameter hole in the input coupler, resulting in five roundtrip passes through the crystal. Unabsorbed pump light exits the 1 mm hole, misaligned from the incident pump, to be dumped externally.

To reach cryogenic temperatures, the heat load on the cooling medium has to be minimized. This is accomplished by placing the sample into a tightly fit copper clamshell structure, which is coated inside with a low thermal emissivity material that is also highly absorbing at the fluorescence wavelengths [16]. The crystal surface area and thus the thermal load are also minimized by mode matching a cross section of the sample (3 mm × 4 mm) to the small laser mode inside of a multi-pass cavity. Crystal is mechanically supported by six op-tical fibers protruding from the clamshell walls, thus minimizing the adverse conductive heat load. The sample temperature is measured from the calibrated changes of the temperature-dependent fluorescence spectrum, us-ing a noncontact differential technique [17]. The vacuum of a main chamber is held at 10^{-6} Torr and a chilled water loop is capable of maintaining the clamshell at a constant temperature around the ambient value.

The temperature evolution of the crystal when irradi-ated with 45 W of the pump power is shown in Fig. 3.A steady-state temperature of (123.7 ±1.0)K was reached with an estimated ~18 W of absorbed power at 1020.70 ±0.25 nm. This result was accomplished while keeping the clamshell temperature around 285 K. A cool-ing power of 50 mW was estimated at the steady state, which, within our experimental uncertainty, corresponds to the NIST-defined cryogenic temperature. A power-dependent red shift of the pump wavelength by 0.7 nm at the maximum pump power increases the MAT to 118 K, in comparison with targeted the MATg of 116 K as per Fig. 1.

Next, we performed a power-scaling study of the steady-state temperature, as shown in Fig. 4. The condi-tion of equilibrium in the cooling dynamics is reached when the cooling power Pcool becomes equal to the load power Pload on the sample at a temperature T. For the dominant radiative load, this condition is given by

$$\eta_c(\lambda, T)P_{\text{abs}}(\lambda, T) = \kappa(T_c^4 - T^4), \qquad (2)$$

where Pabs is the absorbed power, κ is a proportionality constant given by the product of a Stefan–Boltzmann constant and a geometry -and emissivity-dependent coef-ficient [18], and Tc is the temperature of the clamshell. The data of Fig. 4 is fit by a solid line, using Eq. (2) and ηc values from the spectroscopic measurements described above. Very good agreement is found between the measurements and the data-assisted model. In par-ticular, the expected asymptotic behavior of the mea-sured temperature with increasing absorbed power, approaching the MAT value of 118 K, is clearly observed. The achieved temperature also indicates that saturation is avoided [11].

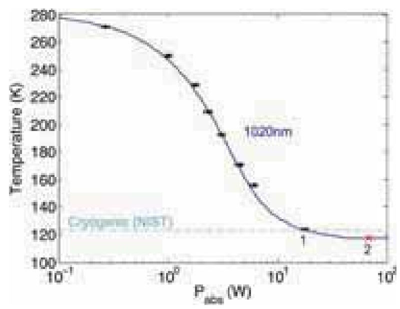


Fig. 4. Steady-state temperature scaling with the absorbed power (black), model prediction (blue line), and lowest temperature achieved by effective scaling of the absorbed power (red "x").

To reach temperatures even closer to the MAT value, either a further increase in absorbed power (Pabs)oran equivalent decrease in the parasitic load (Pload), is re-quired [Eq. (2)]. Figure 4 shows a need for >70 W of ab-sorbed power to reach the MAT, exceeding our currently available pump power. Limited by pump power, a proof-of-principle experiment using the latter approach is per-formed by modifying the water chiller feedthrough to accept liquid nitrogen, which was used to reduce the clamshell temperature Tc.

When the clamshell temperature was lowered to 208 K, a new steady state of 118.7 ± 1 K was obtained, reaching MAT of 118 K (within experimental uncertainty) for the slightly detuned pump at 1020.7(±0.25) nm (note at 1020 nm, MAT is 116 K). Further reduction of heat load did not effect the final temperature, verifying MAT. Im-portantly, cooling was still accomplished by all-optical means and cryogen was used only after the sample had reached its equilibrium temperature of 123.7 K. The new steady state can be projected onto the dataset obtained with the old Tc value of 285 K (Fig. 4). For that, we estimate a factor of ~3.8 reduction of the thermal load on the sample, when going from the old to the new value of the Tc. This factor is given by the corresponding ratio of the heat loads $(285^4 - 123.7^4)/(208^4 - 123.7^4)$, as per Eq. (2). The reduction of the heat load is equivalent to an effective increase of the absorbed power by the same factor, if the sample and clamshell temperatures were 123.7 and 285 K, respectively.

Thus, the final temperature of 118.7 K can also be reached with an effective increase of the absorbed power by a factor ~3.4, the value low-ered from the initial 3.8 estimate by the reduction of the absorption coefficient at the corresponding temper-atures. In projecting the point of 118.7 K cooling, indi-cated by "x," onto Fig. 4, a very good agreement is found with the model prediction. We estimate laser cool-ing power of 18 mW at this temperature; the small value is a direct consequence of the approach to the MAT condi-tion. For comparison, cooling power of ~630 mW is available at room temperature.

Summary paragraph follows:

Optical Frig. summary

In summary, this work demonstrates a new milestone in the field of laser cooling of solids. An absolute temper-ature of 123.7 ± 1 K with an estimated 50 mW of heat lift has been achieved at the E4-E5 Stark resonance of Yb ions, consistent with earlier model predictions and spectroscopic measurements. This represents a new record in optical refrigeration, and is the first de-monstra-tion of bulk laser cooling of solids below a NIST cryo-genic temperature of 123 K. As a proof of principle, we have also shown that a temperature of 118.7 K, only 0.7 deg above the MAT, can be reached upon further optimization.

This work was supported by an AFOSR Multi-University Research Initiative, grant No. FA9550-04-1-0356, entitled Consortium for Laser Cooling in Solids. D. V. S. acknowledges the support of a National Research Council Research Associateship Award at the Air Force Research Laboratory as well as partial support by the National Science Foundation Fellowship.

Solid Cooling end

"To tilt this balance towards the other side and to reverse the energy transfer direction in Brillouin scattering, we used a microresonator in which the blue scattering from sound is resonantly enhanced while red scattering is off-resonantly discriminated." Essentially they achieved reso-nant filtering in the system to 'prefer' blue, thus counteract-ing the Planck-distribution tendency to prefer red. In their set -up, cooling was measured from a reduction in the Brownian scattering when the input optical power was increased, which is opposite to previous experiments on Brillouin scattering in which scattering increases with input power. Carmon pointed out that this Brillouin cooling experiment raises the question of whether resonant colour filtering techniques might also be able to support Raman cooling in solids that are expected to have much higher quantum cooling efficiencies.

Clearly there is a lot of activity in the field of optical refrigeration. Precisely how far cooling can go, and for which materials, are matters of significant de-bate. However, we can no doubt look forward to seeing further rapid progress at next year's Photonics West, to be held in San Francisco February 2014. End

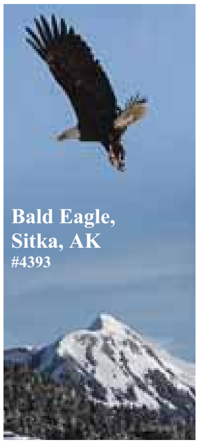
Uncovering Cellular Re-sponse to High Voltage Nanosecond Electric Pulses

nsEP Bioeffects Team (l. to R): Dr. Gleb Tolstykh, Dr. Gary Thompson, Dr. Hope Beier, and Dr. Bennett Ibey

The nanosecond electric pulse (nsEP) bioeffects research team within the Air Force Research Laboratory, 711th Human Performance Wing housed within Joint Base San Antonio, Fort Sam Houston, Texas has been pioneering research on the response of mammalian cells to high-voltage, short -duration electric stimuli. The group's current focus is to elucidate how elec-trical pulses interact with the cellular membranes and the consequential downstream cellular responses elicited. This basic research effort supports a broader aim to better understand the interaction of electromagnetic energy and biological tissues. The team is led by Dr. Bennett L. Ibey, a Senior Re-search Biomedical Engineer within the Radio Frequency Bioeffects Branch.

Dr. Ibey has been inves-tigating the impact of electromag-netic pulses on biological tissue since 2007 and has been an active NRC advisor since 2010. NRC Senior Research Associate, Gleb P. Tolstykh, M.D. Ph.D, a neuro-scientist recruited from the Uni-versity of Texas Health Science Center-San Antonio, has recently discovered that cellular exposure to nanosecond electric pulses can directly stimulate intracellular chemical pathways that are re-sponsible for an array of physio-logical effects such as cognition, hormone secretion, and memory formation. He has also shown that this activation ultimately causes actin detachment from the plasma membrane resulting in cellular blebbing, a commonly observed but poorly under-stood morphological change following electrical stimulation. NRC Postdoctoral Associate Gary Thompson, Ph.D., a biomedical engineer from Clem-son University, has demonstrated that cytoskeletal remodeling, which occurs acutely after cellular expo-sure to nanosecond electric pulses (nsEP) alters the cellular response to successive pulses. In addition, he has shown that cells are more sensitive to nsEP when pretreated with pharmaceutical agents that cause cytoskeletal remodeling. Hope Beier, Ph.D., a Research Biomedical Engineer and former NRC Postdoctoral Associate within the Optical Radiation Branch, has applied her optics expertise to devise a high speed, fluorescence imaging method to capture flow of ions across cellular membranes during nsEP stimulation. In a recent paper, she showed that cellu-lar uptake of calcium occurred symmetrically to nsEP stimulation electrodes in the presence of ex-tracellular calcium, but asymmetrically in the ab-sence of extracellular calcium. The intracellular cal-cium increase occurred immediately (< 1 ms) after the exposure and persisted in the presence of voltage-gated ion channel blockers. These measurements were the first to validate the directional influx of calcium ions into cells from the external solution and the release from intracellular calcium stores during nsEP exposure. In concert, these three findings begin to refine the understanding of how cells react to nsEP. The calcium uptake in cells, along with the activation of intracellular pathways, causes rear-rangements in cellular cytoskeleton and drives changes in cellular morphology and other physiologi-cal responses. In addition to crafting multiple peer review publications the nsEP team has also presented their findings at multiple international conferences.

Thank you Dr. Patrick Bradshaw—program support/ funding through AFOSR-LRIR; Dr. Morley Stone—NRC Site Director and 711th Human Performance Wing Chief Scientist .


Bald Eagle, Sitka, AK
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Why outreach matters for a scientist

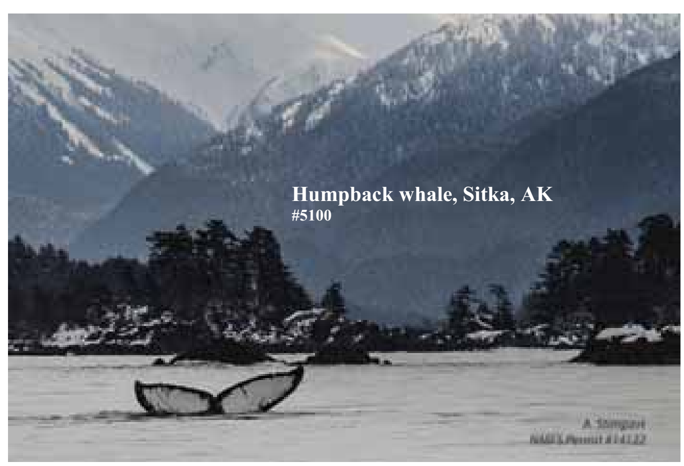
Why are you a scientist? As I move forward in my career (and my tenure as an NRC Postdoc comes to a close), this question frequently arises when I think about where I'd like to go next. I think it might be an important question for many NRC postdocs. I believe one of the most important parts of science is sharing both the results and the process with others. To explore different ways of accomplishing this, I took a short leave of absence from my NRC position to accept a "mini-sabbatical" with the Sitka Sound Science Center in Sitka, AK.

Alison Stimpert, NRC Associate (standing in the back) leads an activity to learn about echolocation with Sitka high school students

As a Scientist-in-Residence Fellow (SIRF), I worked with the science center for one month. I was in residence from mid-March to mid-April, and this was lucky because it turned out to be one of the most exciting times to be in Sitka. The herring spawn around this time, and with the herring comes just about everything else: humpback whales, gray whales, bald eagles, sea lions, fishermen, and spring. The transformation from a rural Alaskan town in winter to a place humming with activity, both natural and human, was impressive.

My obligations for the fellowship included several days of outreach, and beyond that I was free to conduct my own research or work on my own ongoing projects. I participated in a variety of efforts: being a naturalist on a whale watch cruise, running a workshop at a Girl Scouts "Women of Science" Day, giving a public talk for the community, participating in and presenting at the annual whale festival of a nearby island community, and working with high school classes on a project discussing overlap between art and science. This was actually more time overall than was required of me, but I wanted to take the opportunity to get experience while I could. It turns out this type of teaching is *hard.* In contrast to giving a one-sided lecture to university students who are already predisposed to your topics, outreach involves really connecting with your audience – you often have to interact to figure out how to make things relevant for them, and how to inspire curiosity and enthusiasm. And what works is different for every age group and every sector of the population.

Though challenging, I found this type of work to be rewarding, and I think it's important as well. Science needs to be about getting the word out, because it's only going to make a difference if lots of people know about it, and trust it. This will come from good explanations from the scientists, but also from being inspired to *try* science to understand how it works. I think as NRC postdocs, we need to remember to step outside the bubble periodically and make sure our science is reaching people, and this fellowship was a great learning experience for me in engaging the public and learning how to share my work.


Humpback whale, Sitka, AK
#5100

NRL researchers hope to shed light on dark lightning radiation

Scientists now know that thunderstorms, working as powerful natural terrestrial particle accelerators, produce intense flashes of ionizing radiation called "dark lightning." To further their understanding of this phenomena, researchers at the U.S. Naval Research Laboratory's (NRL) Space Science Division are making precise observations of these flashes from space and running detailed simulations to understand the nature of dark lightning and to quantify the radiation exposure it may present to the crew and passengers of aircraft.

Terrestrial Gamma-ray Flashes (TGFs) are extremely intense, sub-millisecond bursts of gamma rays and particle beams of matter and anti-matter. They are associated with strong thunderstorms and lightning, although scientists do not fully understand the details of the relationship to lightning. The latest theoretical models of TGFs suggest that the particle accelerator that creates the gamma rays is located deep within the atmosphere, at altitudes between six and ten miles, inside thunderclouds and within reach of civilian and military aircraft.

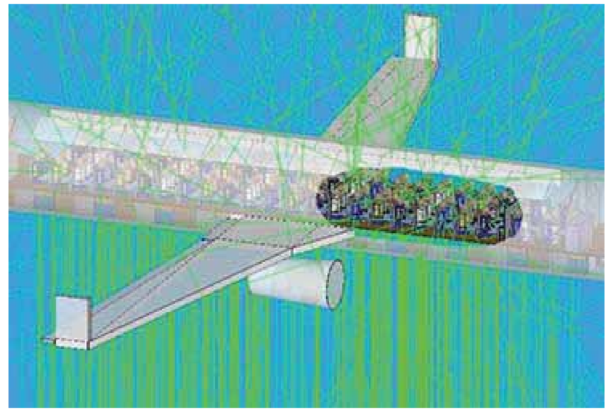
These models also suggest that the particle beams are intense enough to distort and collapse the electric field within thunderstorms and may, therefore, play an important role in regulating the production of visible lightning. Unlike visible lightning, TGF beams are sufficiently broad—perhaps about half a mile wide at the top of the thunderstorm—that they do not create a hot plasma channel and optical flash; hence the name, "dark lightning."

A team of NRL Space Science Division researchers, led by Dr. J. Eric Grove, NRC Adviser, of the High Energy Space Environment (HESE) Branch, is studying the radiation environment in the vicinity of thunderstorms and dark lightning flashes. Using the Calorimeter built by NRL on NASA's Fermi Gamma ray Space Telescope, they are measuring the energy content of dark lightning and, for the first time, using gamma rays to geolocate the flashes.

As a next step, Dr. Chul Gwon of the HESE Branch is using NRL's SoftWare for the Optimization of Radiation Detectors (SWORD) to create the first-ever simulations of a dark lightning flash striking a Boeing 737. He can calculate the radiation dosage to the passengers and crew from these Monte Carlo simulations. Previous estimates have indicated it could be as high as the equivalent of hundreds of chest X-rays, depending on the intensity of the flash and the distance to the source.

SWORD simulations allow researchers to study in detail the effects of variation in intensity, spectrum, and geometry of the flash. Dr. Grove's team is now assembling detectors that will be flown on balloons and specialized aircraft into thunderstorms to measure the gamma ray flux in situ. The first balloon flights are scheduled to take place this summer.

Dr. Meagan Schaal, NRC Associate at NRL



Simulation of a Boeing 737 struck by dark lightning. Green tracks show the paths of gamma rays from the dark flash as they enter the aircraft from below. The radiation dosage to passengers and crew can be calculated from these simulations, which were run with NRL SSD's SWORD radiation transport environment. SWORD is an NRL-developed tool that provides an interface to some of the most commonly-used Monte Carlo simulation engines for modeling the transport of high energy radiation through matter. SWORD is a vertically-integrated system that allows users to graphically set up and run simulations and analyze the results in a single package. ***(Photo: U.S. Naval Research Laboratory)***

This is now part of the NRL research of **Dr. Meagan Schaal, who began her NRC Research Associateship at NRL** in mid June 2013. Prior to starting as a NRC Associate at the NRL, Meagan was already working in the lightning community on x-rays from lightning; and is now analyzing Fermi/LAT TGFs.

Prior to NRC Associateship at NRL, Meagan headlines with the following: **"Physics Ph.D. receives prestigious fellowship to study high-energy thunderstorm radiation"** :

Meagan Schaal, who completed her doctoral degree in physics from the Florida Institute of Technology this spring, received an internationally competitive postdoctoral fellowship award funded by the Naval Research Laboratory (NRL). The fellowship is administered by the Research Associateship Program of the National Research Council (NRC). Her position, which begins June 17 and is renewable for up to three years, will be to work on Terrestrial Gamma-ray Flash (TGF) spectral data from the Fermi Large Area Telescope (LAT), the main scientific instrument on the Fermi Gamma Ray Space Telescope spacecraft.

Schaal will use data from NASA's Fermi spacecraft to study how thunderstorms produce powerful bursts of gamma-rays seen from space. A leading theory is that these bursts are the result of dark lightning within the clouds, large discharges that compete with normal lightning but emit almost no light. Recent observations by another spacecraft called AGILE indicate that the gamma-rays may reach much higher energies than expected.

Schaal's work will help test the AGILE results, and provide a deeper understanding of these fascinating events. Originally from Beach, N.D., Schaal successfully defended her dissertation "X-Ray and Gamma-ray Observations from Lightning" and received a doctorate degree in physics at the spring Florida Tech graduation ceremony May 4. Schaal received her bachelor's degree in physics from the University of North Dakota and her master's degree in space sciences from Florida Tech. She worked under the supervision of Joseph Dwyer, professor, Department of Physics and Space Sciences, and Hamid Rassoul, Dean of the College of Science.

Scientists triggered lightning using rockets (pictured) and then took x-ray images of the bolts (not pictured). *Photograph courtesy Dustin Hill*

Lightning captured by X-Ray camera—a first

Giant camera stops the action at one-sixth the speed of light.

The first x-ray images of a lightning strike have been captured by a, well, lightning-fast camera, scientists say. The pictures suggest a lightning bolt carries all its x-ray radiation in its tip.

During 2010 thunderstorms in Camp Blanding, Florida, the camera's electronic shutter "froze" a lightning bolt-artificially triggered by rockets and wires—as it sped toward the ground at one-sixth the speed of light.

"Something moving this fast would go from the Earth to the moon in less than ten seconds," said Joseph Dwyer, a lightning researcher at the Florida Institute of Technology in Melbourne.

"Scientists have known for several years that lightning emits radiation", said Dwyer, who revealed the photos at an annual meeting of the American Geophysical Union in San Francisco earlier this month.

"But until now scientists didn't have the technology to take x-ray images quickly enough to see where the radiation comes from", he said. (Read "New Lightning Type Found Over Volcano?")

Lightning Imaged by 1,500-Pound Camera

Making a camera capable of taking such quick images was an achievement in and of itself, Dwyer emphasized. ***"You can't just go buy a camera and point it at lightning,"*** he said. ***"We had to make it."***

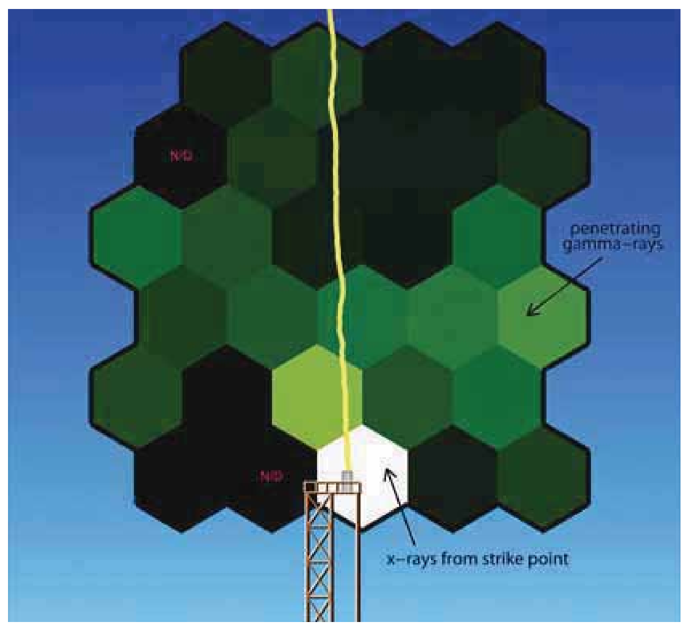
The resulting 1,500-pound (680-kilogram) camera—created by Dwyer's then Ph.D. student Meagan Schaal, now NRC Postgraduate Research Associate at NRL—consists of an x-ray detector housed in a box about the size and shape of a refrigerator. The box is lined with lead to shield the x-ray detector from stray radiation. X-rays enter the box through a small hole that in turn focuses them, like an old-fashioned pinhole camera.

Speedy Trade-Off: Less Data Space

Because lightning moves blindingly fast, the camera was required to take ten million images per second. (Interactive: Make your own lightning strike.)
One challenge in taking such fast pictures is storing the data. To do so, the x-ray detector had to take pictures at a relatively low resolution of 30 pixels, which produced images on a crude, hexagonal grid—as shown in the chart below.

Even so, the resolution was sharp enough to reveal a bright ball of x-rays at the head of the bolt, with almost no lingering radiation along the bolt's trail.

"Almost all the x-rays are from the tip," Dwyer said. ***"We see the x-ray source descending with the lightning at up to one-sixth the speed of light."***



A chart shows x-ray observations of a lightning discharge
(Diagram courtesy Joseph Dwyer)

Triggered Lightning Effective

The lightning bolts were triggered by launching small rockets into the thunderstorms. (See "Volcanic Lightning Sparked by 'Dirty Thunderstorms,' Study Finds.")

The rockets trailed wires behind them to direct the lightning through the camera's field of view.

Artificially triggering the lightning strike likely didn't alter the natural workings of the thunderstorm, Dwyer noted. And, he said, ***"the advantage of triggered lightning is that we can repeat it."***

Richard A. Lovett in San Francisco, for National Geographic News, published Dec. 23, 2010

Space Traffic & High Altitude Arctic Clouds

Scientists at the U.S. Naval Research Laboratory (NRL) have determined that there has been an increase in bright polar mesospheric clouds (PMCs) in the last two years, an unexpected result since these clouds are generally thought to be less prevalent during conditions of high solar activity which acts

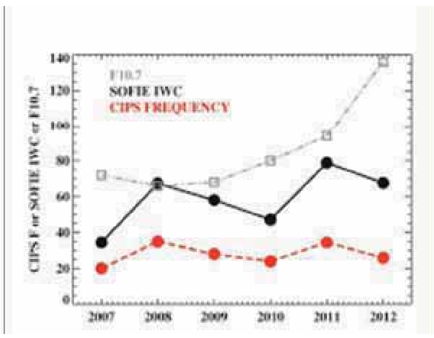


Figure 1. Variation of mid summer polar mesospheric clouds observed by two instruments on the NASA AIM satellite from 2007-2012. The Solar Occultation for Ice Experiment (SOFIE) measures ice water content (IWC) which is a proxy for cloud brightness; the Cloud Imaging and Particle Size Experiment (CIPS) records the frequency of occurrence. The quantity F10.7 is a proxy for solar activity which has increased since 2010. ***(Photo: U.S. Naval Research Laboratory)***

to destroy the tiny ice particles. Their research suggests that the man-made effect of water released by exhaust from space traffic during recent years has overwhelmed the effect of higher solar activity. This research was published in the June 6, 2013, issue of Geophysical Research Letters.

This new understanding of weather at the edge of space serves to test high altitude weather and climate models of the upper atmosphere, including the co-located D&E-regions of the ionosphere which is critical for improving models of over-the-horizon-radar (OTHR) propagation, explains NRL's Dr. David Siskind, a scientist in NRL Space Science Division and principal investigator for the research.

Each summer, the Arctic and Antarctic atmospheres at very high altitudes (the upper mesosphere, 80 to 100 km) become extremely cold with temperatures well below -100°C, despite

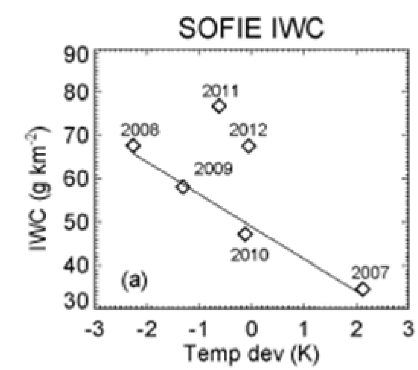


Figure 2: The ice water content (IWC) from the SOFIE instrument on AIM shows that cloud brightness varied linearly with stratospheric temperatures (the x-axis is a measure of these temperatures) for the first 4 summers of the AIM mission. The excess cloud water content seen in 2011 and 2012 is clearly displayed. Based upon theories of solar cycle activity, IWC values of about 40 were expected for 2011 and 2012.

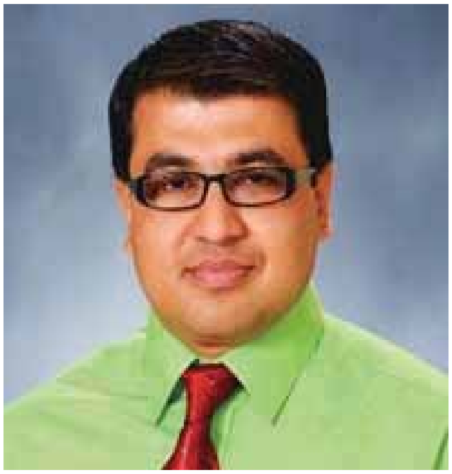
the presence of 24 hours of sunlight. These very low temperatures allow the atmosphere to become supersaturated, and enable thin, wispy ice clouds to condense on nuclei of meteoric dust and smoke particles. Because of the possibility that this region of the atmosphere may be changing due to man-made effects, NASA launched a dedicated satellite, the Aeronomy of Ice in the Mesosphere (AIM) mission six years ago. Scientists used the AIM data to test atmospheric analyses provided by special high altitude prototype versions of the then -operational Navy Global Forecast System (NOGAPS). Previous studies by NRL scientists had shown this high altitude version of NOGAPS could demonstrate how variations in lower atmospheric weather conditions thousands of miles away might "teleconnect" to the Arctic and cause PMCs to vary.

NRL scientists also believe that weather at the edge of space is sensitive to solar activity. An increase in the ultraviolet output of the sun can cause small temperature increases—NRL scientists expected these temperature increases to inhibit the formation of ice particles. In addition, increased ultraviolet light from the sun destroys water vapor molecules, making the already bone dry upper atmosphere even drier. Solar activity was unusually low for the first four years of the AIM mission, from 2007 to 2010, but has increased in the last two years.

Before the AIM mission, researchers estimated that the clouds should have decreased by 20 to 30% because of the high solar activity. Researchers were quite surprised to see that the occurrence of PMCs remained high and even increased (see figure 1). By studying the frequency and ice water content (IWC, which is a measure of cloud brightness) of the ice with weather conditions in the lower stratosphere, scientists see irregularities between the 2011 and 2012 measurements compared with measurements from the previous four years (see figure 2). Instead of 20 to 30% decreases, they saw up to 30% increases.

Researchers suggest that the explanation lies in a water vapor source from rocket exhaust. NRL scientists were the first to discover that individual PMCs could be formed by the exhaust from the space shuttle. Those earlier studies also suggested that these effects might appear in the long-term PMC record. The new results confirm that suggestion and also suggest that this effect can dwarf that from solar cycle variations. A record of H_2O injected into the upper atmosphere by space traffic over the six-year period from 2007 to 2012 shows low amounts from 2007 to 2010 and then large increases in 2011 to 2012, precisely what is needed to explain the inconsistent PMCs. NRL scientists are particularly interested in the 2012 anomaly because it occurred after the termination of the shuttle program. Thus the possibility that the space traffic contribution to PMCs may persist post-shuttle is one that will be of intense interest as new data is studied over the next several years.

Polar mesospheric clouds--also known as noctilucent, or "night shining" clouds--are formed above the Earth's surface near the mesosphere-thermosphere boundary of the atmosphere, a region known as the mesopause. This astronaut photograph was taken when the International Space Station was over the Pacific Ocean south of French Polynesia.
(Photo: Image Science and Analysis Laboratory, NASA-Johnson Space Center. "The Gateway to Astronaut Photography of Earth.")



Dr. Lok Pokhrel, NRC Associate at EPA

EPA Associate dives into the nanoworld to untangle its secrets

A native of the Himalayan country, Nepal, and an alumnus of East Tennessee State University, Dr. Lok R. Pokhrel began in May 2013 as a National Research Council (NRC) Postdoctoral Research Fellow at the US EPA Office of Research and Development (ORD), National Health and Environmental Effects Research Laboratory (NHEERL), Western Ecology Division, Corvallis, Oregon.

"With extensive research background on nanomaterials synthesis, characterization, fate and toxicity evaluation, as reflected by his peer-reviewed publications of research papers, reviews, including an editorial and several conference presentations, Lok brings needed expertise here at NHEERL to synthesize and characterize novel nanoparticles of silver, copper, titanium and cerium, to use them to study their fate and transport in soils and potential toxicity to terrestrial plants", said Dr. Christian Andersen, who is a Research Plant Physiologist and the subject area lead for investigating ecotoxicological effects of nanoparticles within ORD, and is Lok's supervisor. ***"Because of the many unknowns about what the physical-chemical properties of nanoparticles are that may impart toxic responses, Lok's training on statistically-based QSAR (quantitative structure-activity relationship) modeling allows him to study various organic-coated nanoparticles to explore potential links between the unique physical-chemical characteristics that arise from the coating materials and physiological responses",*** said Dr. Paul Rygiewicz who is also Lok's supervisor and a Research Ecologist at the US EPA.

"The goal in developing QSARs for nanoparticles is to build models and databases that can be used to predict the potential toxicity of new particles, which are being synthesized by industries much faster than they can be tested for their possible toxicity. In addition, by linking specific particle attributes with toxicity, Lok's work will contribute to EPA's "green chemistry" efforts by providing information on how to synthesize new particles with characteristics that are safer to ecosystems", Dr. Mark Johnson said. Mark, NRC Adviser, is a Research Soil Scientist at the US EPA and also supervises Lok's research. ***"Our goal is to link Lok's synthesis, organic-coating, and toxicity work with data we will obtain at the Lawrence Berkeley National Lab synchrotron-based micro X-ray (3D) tomography facility that is coupled with Transmission Electron Microscopy. Undertaking this research will enable us to link the location of nanoparticles in tissues with any physiological responses measured and the knowledge gained will contribute to risk assessment of nanoparticles related to routes of exposure in terrestrial ecosystems",*** Mark added.

"It's been a blessing and a wonderful experience to work together with the US EPA scientists here at NHEERL, who not only offer scientific expertise but also bring policy perspectives with regard to science of the small (nanoparticles). Moreover, the summer this year has been amazing and the bounteous recreational activities available in Oregon have really kept me (and my family) engaged when I don't have much 'nano' to do", Lok said.

Drs. Brajesh Dubey and Phillp Scheuerman were Lok's major advisers for his PhD program at East Tennessee State University from where he graduated last spring with his degree in Environmental Nanotechnology. His dissertation was entitled "Evaluation of colloidal stability and ecotoxicity of metal-based nanoparticles in the aquatic and terrestrial systems". Lok has been presenting his research at local, national, and international conferences, and has received several awards, which reflects on the quality and importance of the work he has been doing over the years.

(Photo: Reconstructed wetland mesocosm used for studying potential ecosystem level effects of surface functionalized metals and oxides nanoparticles. Photo courtesy, Mike Bollman)

2013 SCHEDULE

February Review

February 1	Application deadline
February 15	Deadline for supporting documents (transcripts/letter of recommendation)
March 12	Review results finalized
March 20	Review results available to applicants

August Review

August 1	Application deadline
August 15	Deadline for supporting documents (transcripts/letter of recommendation)
Sept 23	Review results finalized
Sept 30	Review results available to applicants

May Review

May 1	Application deadline
May 15	Deadline for supporting documents (transcripts/letter of recommendation)
June 21	Review results finalized
June 29	Review results available to applicants

November Review

Nov 1	Application deadline
Nov 15	Deadline for supporting documents (transcripts/letter of recommendation)
TBD	Review results finalized
TBD	Review results available to applicants

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