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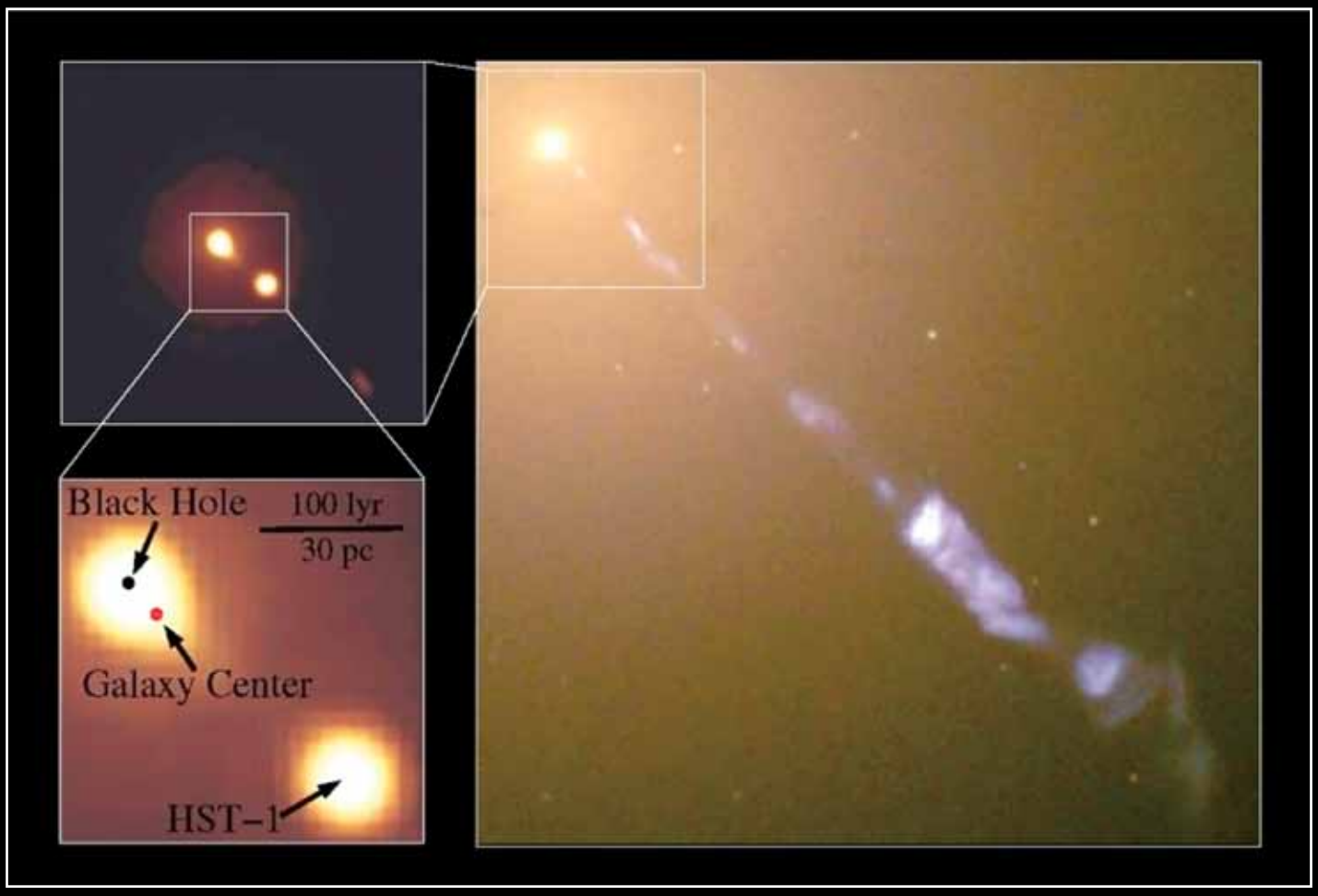
Focusing on the discoveries and innovations faculty and students are making at Florida Institute of Technology

Volume 10, Issue 1
Fall 2010/Spring 2011

DISCOVERY: *Florida Tech*



Who Knew?: Supermassive Black Holes May Roam

A team of astronomy researchers at Florida Tech and Rochester Institute of Technology (RIT) and the University of Sussex in the United Kingdom find that the supermassive black hole (SMBH) at the center of the most massive local galaxy (M87) is not where expected. Their research, conducted using the Hubble Space Telescope (HST), concludes that the SMBH in M87 is displaced from the galaxy center.

It's thought that the most likely cause for the off-center SMBH is a previous merger between two older, less massive, SMBHs.

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"We also find that the iconic M87 jet may have pushed the SMBH away from the galaxy center," said **Daniel Batcheldor**, Florida Tech astronomy assistant professor, who led the investigation.

The study of M87 is part of a wider HST project directed by Andrew Robinson, professor of physics at RIT.

"What may well be the most interesting thing about this work is the possibility that what we found is a signpost of a black hole merger. This is of interest to people looking for gravitational waves and for people modeling these systems as a demonstration that black holes really do merge," says Robinson.

"The theoretical prediction is that when two black holes merge, the newly combined black hole receives a 'kick' due to the emission of gravitational waves. They can displace it from the center of the galaxy."

David Merritt, professor of physics at RIT, adds: "Once kicked, a supermassive black hole can take millions or billions of years to return to rest, especially at the center of a large, diffuse galaxy like M87. So searching for displacements is an effective way to constrain the merger history of galaxies."

Daniel Batcheldor, Florida Tech astronomy assistant professor

Jets, such as the one in M87, are commonly found in a class of objects called Active Galactic Nuclei. It is commonly believed that supermassive black holes can become active as a result of the merger between two galaxies, the in-fall of material into the center of the galaxy, and the subsequent merger between their black holes. So, it is very possible that this finding could also be linked to how active galaxies—including quasars, the most luminous objects in the universe—are born and how their jets are formed.

"We also find that the iconic M87 jet may have pushed the SMBH away from the galaxy center."

Daniel Batcheldor

This research was presented at the American Astronomical Society (AAS) Conference in Miami, Fla., in 2010. It was also published in The *Astrophysical Journal Letters* peer-reviewed scientific journal.

Regardless of the displacement mechanism, the implication of this result is a necessary shift in the classic SMBH paradigm; no longer can it be assumed that all SMBHs reside at the centers of their host galaxies. This may result in some interesting impacts on a number of fundamental astronomical areas, and some interesting questions.

Karen Rhine

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Published by the Office of Research at Florida Institute of Technology

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Geoffrey Swain: Master of Marine Coatings

It's not just paint you see on that ship's hull, or on that boat. A special coating makes a vessel glide more smoothly through the water, helping slime, barnacles and other marine growth just sluice off. And that coating better be biodegradable.

Geoff Swain, professor of oceanography and ocean engineering, has helped develop such coatings for almost 25 years at Florida Tech.

In his time at the university he has received more than $6 million in funding for this work, much of it from the Office of Naval Research. He has also contracted with many leading industries such as Dow Corning Corp., DuPont Canada, General Electric, International Paint, Pittsburg Paint and Glass, and Royal Caribbean Cruise Lines.

Geoff Swain at right

Present day antifouling technologies must satisfy performance, economic and environmental criteria. He and his team at the Center for Corrosion and Biofouling Control test and evaluate ship hull coatings at test sites near Sebastian Inlet and Port Canaveral, at their new campus-based testing tank and aboard their 30-foot research vessel. They also help the shipping and marine industries to select and maintain antifouling systems.

"Our expertise is developing test protocols that allow people to differentiate the performance of various ship hull coatings," Swain explains. "We can test coatings from our research boat at speeds of up to 30 knots, capture real-time video of the biofouling and measure the hydrodynamic performance. This enables us to predict how a coating will perform in service on a ship. No one else can do that."

Many of the standard-industry test methods for differentiating performance were developed at Florida Tech. "This isn't widely known," he says.

A biofoul-free hull allows a ship to operate more efficiently by reducing drag and optimizing maneuverability. This means reduced fuel consumption, lower cost and the eco-friendly benefit of fewer greenhouse gas emissions.

The 10 members of the center's team also evaluate coatings for marine structures and new materials for applications such as aquaculture nets. Over the years, Swain has provided hands-on, real-world experience for dozens of undergraduate and graduate students, doing good for the university as well as good for the Navy, shipping industry and environment.

"I enjoy this group because I know we contribute to improving antifouling technology," says Swain. "I'm fortunate because I interact with a fun group of people who are motivated to find solutions. And that is a good feeling."

Karen Rhine and Christena Callahan

Two Cyber Warriors Lead the Fight

The two cyber security experts go back 25 years but just discovered that recently. **Richard Ford**, director of the Harris Institute for Assured Information at Florida Tech, and **Ronda Henning** '90 M.B.A., the senior secure systems engineer for Harris Corp., found their names in the same technical conference proceedings from the mid-80s.

Orbiting in the same sphere of cyber defense research, speaking at the same conferences, they got acquainted in the later '80s and became colleagues. But in the last three years their relationship solidified as the duo that leads the work of the Harris Institute at Florida Tech.

Heading a team of eight, they've published a half dozen collaborative papers, put their heads together on several government funding proposals, lead an annual cyberspace safety forum, coordinated a free monthly lecture series on security trends and, of course, directed the institute's research. All of this aims at keeping secure the complex systems that now touch every aspect of our lives.

The institute occupies one floor of a 29,000-square-foot campus building, the Harris Center for Science and Engineering. The year-old showplace building and much of the work of the institute is funded by the international communications and information technology company, Harris Corp., headquartered just a few miles away.

"The kind of work we want to do at the Harris Institute is to think what would the world be like ... 'if?'" said Ford. "We want to try and take some risks here and leap ahead."

"We call this work biologically inspired. It's based on the idea that machines can learn to protect themselves from infection."

Richard Ford

An early Harris Institute project of Ford's, funded twice by the U.S. Army Research Laboratory and Harris Corp., piques the imagination: Can a sick computer heal itself?

"We call this work biologically inspired. It's based on the idea that machines can learn to protect themselves from infection. When you vaccinate against infection—install security software—the machine isn't really learning anything. We're trying to build systems that protect with no help from the outside by building 'antibodies' into the system's memory," says Ford.

"It's especially important to build battlefield systems that don't go down easily. We think that the immune system should switch on in a system, like the human body, when under attack. We're building artificial immune systems, stealing from Mother Nature by design. No one else is doing this work quite the way we are."

Other projects, funded by Harris, are also thought-provoking.

Marco Carvalho, a member of the center's team, leads a study on the unanticipated correlation between data elements in network traffic. He's using unique mathematical models and processes to look for patterns, finding machines talking to machines one wouldn't expect, for example, in an effort to uncover security breaches. A computer system can't be protected without knowing how it may be attacked.

Earlier institute research with dogs and humans on eye movements at the computer screen recently received follow-on funding. The new work measures eye-tracking in avatars and virtual worlds to determine cognitive attention in a virtual space.

Researchers follow eye movements to see which computer pop-ups attract attention. The study could lead to better warning pop-ups for secure networks.

"Our philosophy is that the institute's Harris funding is seed money," explains Henning. "This is basic research we hope to transition to government-sponsored funding. We need some preliminary results first."

The two cyber warriors might do well to look into another kind of research: how to clone themselves. Scientists like Ford and Henning are just two drops in the cyber defense bucket.

"It's so hard to find appropriate staffing—to get the right people with the right skill set," says Ford. "Our dependence on computers for absolutely everything opens us to harm and there are just not enough cyber practitioners to help."

A National Public Radio story by Tom Gjelten last July, "Cyber Warrior Shortage Threatens U.S. Security," concurs.

Gjelten wrote, "There may be no country on the planet more vulnerable to a massive cyber attack than the United States, where financial, transportation, telecommunications and even military operations are now deeply dependent on data networking … What's worse: U.S. security officials say the country's cyber defenses are not up to the challenge."

Karen Rhine

Robert van Woesik

Caring for Corals

Although there are no coral reefs off the coast of Melbourne, Fla., Professor of Biological Sciences **Robert van Woesik** puts Florida Tech's expertise in this area on the map. The coral reef ecologist is a renowned international expert, the editor of the journal *Coral Reefs* and a top grant getter on the propagation and health of these fragile marine systems.

Van Woesik has traveled the world exploring the health and reproduction of reef corals in such places as the South Pacific, Mexico, Zanzibar and the Great Barrier Reef. He's funded by such organizations as Global Environmental Fund/ World Bank and the National Science Foundation. Last year he published 10 research papers, one in the *Proceedings of the Royal Society* called "Calm before the Spawn." In it he showed clear evidence that corals will globally release eggs and sperm only during seasonal calm periods. This breakthrough paper now makes marine reproduction predictable—important for marine conservation.

Most recently, van Woesik was chosen to deliver the keynote address at the 24th Meeting of the United States Coral Reef Task Force in Saipan. He also gave an opening keynote address at the European International Coral Reef Symposium in the Netherlands.

To Err is Human

How best do humans interact with machines? That's the concern of human centered design and human factors.

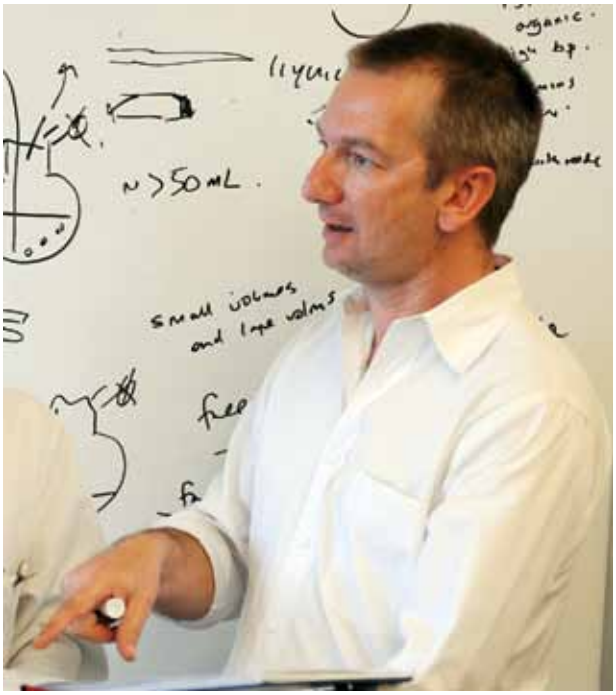
The person to ask at Florida Tech is University Professor **Guy Boy**, director of the Human-Centered Design Institute in the College of Engineering. Much of Boy's work there is on a project funded by more than $1 million over four years from AREVA, an international energy company that offers solutions for nuclear power generation. Now there's an area where the absence of human error is most welcome.

Under the grant, Boy and his graduate students are exploring the ergonomics and human factors in the design and development of nuclear power plant control and management. They are proposing human factors approaches

Guy Boy

and techniques for the safer, and more reliable and accountable control of modern nuclear power plants.

Boy came to the university in 2009 to develop a doctoral program focused on human-centered design in life-critical systems. He is author of four major books, is a permanent member of the Air and Space Academy and in 2010 was appointed chief scientist for Human-Centered Design at NASA-Kennedy Space Center.



Andy Knight

Inside Chemical Warfare Compounds

Andy Knight, associate professor of chemistry, was awarded a five-year, $963,777 contract from the Naval Research Laboratory (NRL), Washington, D.C. With collaborators at the Center for Bio/Molecular Science and Engineering at NRL, Knight and his Florida Tech research group are studying the cooperative effects of organic and inorganic coordination complexes on the catalytic degradation of organophosphorus compounds. These compounds are of interest because of their similarities to a number of phosphorus-containing chemical warfare agents such as Sarin and VX.

Knight's approach is to use gold nanoparticles as a platform for controlling the spatial positioning of molecules around catalytic metal centers. It is much like nature's version of catalytic systems, a three-dimensional arrangement of molecules around a metal within enzymes.

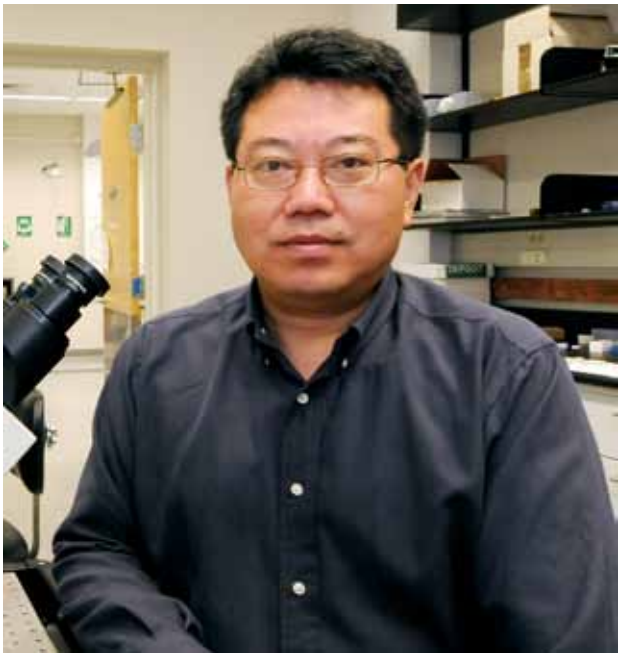
Knight's group, funded by DTRA since 2006, has been working in the broad area of antiviral and antibacterial therapeutics based on metal complexes.

Funding Furthers Alzheimer's Research

An award from the Community Foundation for Brevard continues the foundation's generous support for the work of **Shaohua Xu**, associate professor of biological sciences. The gift was made possible by the Kenneth R. Finken and Dorothy Hallam Finken Endowment Fund for Research into the Cause and Cure of Alzheimer's Disease.

Xu is using atomic force microscopy to test his unique theory of the origins of Alzheimer's disease. Despite many years of investments and research, there is no effective treatment for Alzheimer's because no one really understands its cause.

By examining the interactions of individual molecules, Xu has discovered the biochemical process that appears to drive the disease; something unsuspected by other researchers in the field. Xu's



Shaohua Xu

observations show that normal protein molecules can assemble without any direction into spherical clumps that then join to form chains. These become the tangled treads that choke brain cells in Alzheimer's.

Working with Xu are Sam Durrance, a former astronaut and Florida Tech professor of physics; several Florida Tech graduate students; and Dr. Daniel Woodard, a physician from Kennedy Space Center.

"Everyone is in a rush for a cure. But without knowing what really causes the disease, we are just shooting in the dark. That's why Dr. Xu's ingenious new theory is so important," said Woodard.

Joe Dwyer: Striking Scientist

It's hard not to brag about professor of physics **Joe Dwyer**, whose many original discoveries about lightning continue to find a place in technical as well as popular publications. His ability to procure major grants in an era of squeezed funding budgets also remains a source of university pride.

Joe Dwyer

In summer 2010, Dwyer, Florida Tech research partner Professor Hamid Rassoul, Assistant Professor Ningyu Liu and partners at the University of Florida (UF) won a $9.8 million grant to greatly expand research operations at the UF and Florida Tech International Center for Lightning Research and Testing.

The four-year grant from the federal Defense Advanced Research Projects Agency, or DARPA, lets researchers probe the basic science of lightning using the center's unique rocket-triggered lightning capabilities. Florida Tech will take the lead on the X-ray and gamma-ray observations of thunderclouds and lightning.

"The grant is aimed at exploring how lightning starts in the cloud, how it moves through the air and how it connects to the ground," says Dwyer.

It will fund cutting-edge new instrumentation and research, including the world's first X-ray camera for imaging lightning. The camera will not only take the first X-ray images of lightning, it will also capture high-speed movies of lightning using the X-rays that lightning emits. Operating at 10 million frames per second, if successful, the camera will give researchers a detailed view into the inner workings of lightning.

Researchers at the lightning center, based at the Camp Blanding Army National Guard Base, fire wire-trailing rockets into storm clouds to trigger and study strikes. Investigations have spanned how to better protect electrical power lines, homes and airplanes to lightning's root causes and characteristics. In recent years, a team from Florida Tech and UF was the first to document X-rays produced by triggered lightning. And late last year, the team published research on the possible radiation threat posed by lightning-produced X-rays to airline passengers and crews flying near storms.

"People are used to lightning and so sometimes forget how destructive it is. We have got these 50,000°F bolts striking at random all around us, carrying enough current to blow apart a tree. Yet, how lightning does what it does largely remains a mystery. We hope when we figure out how lightning works we will also learn how to make people safer," says Dwyer.

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MK-145-211

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