

## Hla and Team Develop Molecular Motor

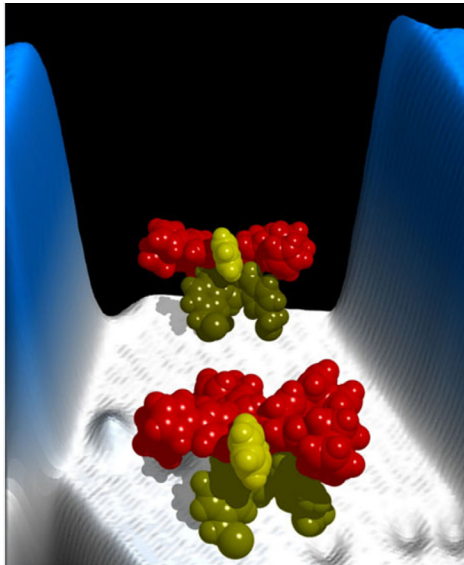
Participating in a cross-Atlantic collaboration, Dr. Saw Hla, Ohio University professor of physics and astronomy, and his team have developed an artificial motor comprised of only about 190 atoms. This nanomachine has three components: a tripod to support it vertically, a rotor necessary to rotate, and an atomic ball bearing to connect the stationary and rotating parts.

At just one nanometer tall and two nanometers wide, this molecular motor is incredibly small. Consider that one nanometer is one-billionth the size of a meter or that a sheet of paper is approximately 100,000 nanometers thick.

Even on the large scale that we are more accustomed to, known as the classical world, machines need fuel to function, and the molecular motor is no exception, though its size places it in the quantum world.

For the nanomachine, energy can be provided by injecting electrons. The machine can also operate by using thermal energy, much like a traditional engine.

Control of the minuscule is very important, and the team is able to influence the clockwise or counterclockwise rotation of the motor based on the point where electrons are injected. In order to maintain control, Hla and his team bring the temperature to minus 450 degrees Fahrenheit.



*This illustration displays the molecular motor structure that the team created.*

“In a quantum world, you can see electrons like waves, it’s like water. Because [electrons are] so small they have different behaviors, and so it is when we are working with the small things that we need to understand this. So nanoscience or nanotechnology is not just a thing of the small, it is the technology of the quantum,” Hla said.

To work with the molecular motor, Hla and his team utilize a tunneling microscope, which is aptly named due to the nature of electrons “tunneling.” In the classical world when unplugged from a power source, the energy ceases to flow, but in the quantum world, contact is not necessarily required for energy to continue to flow. This phenomenon is called tunneling.

While Hla works to understand the  
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## Gerardine Botte Named National Academy of Inventors Charter Fellow

Gerardine Botte, Russ College of Engineering and Technology professor and NQPI member, was named a charter fellow of the National Academy of Inventors in December and recently traveled to Florida to receive her award.

Botte has been issued 11 patents with 27 still pending. Many of her inventions focus on electrochemical manipulation. One of her inventions is currently undergoing the process of commercialization, and has been trademarked the GreenBox, a device comprised of individual cells packing a low electrical voltage of 0.8 volts each. When ammonia-contaminated water passes through the machine, the electrical current divides the ammonia into nitrogen, which is released into the air, and hydrogen, which becomes a valuable byproduct, all in a relatively short period of time, such as a few hours.

“The breakthrough of this technology is that now, for the first time, it takes a stream that contains ammonia, cleans the water, sends nitrogen back to the atmosphere, and produces the cleanest fuel on earth. That is hydrogen,” Botte said.

Of course, the GreenBox is not Botte’s only invention. Another technology which she has developed has the possibility of improving dialysis treatment.

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### DISSERTATION AWARD

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### INTERNATIONAL COLLABORATION

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### EDITORS’ SUGGESTION

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# OHIO UNIVERSITY

NANOSCALE | QUANTUM PHENOMENA INSTITUTE  
OHIO UNIVERSITY, CLIPPINGER LABS ROOM 251  
ATHENS, OH 45701  
TEL: (740) 593-1757 FAX: (740) 593-0433  
WWW.OUNQPI.ORG NQPI@OHIO.EDU

## Director's Corner



Dear Colleagues,

Welcome to the 9th Edition of the NQPI Newsletter. These days, research funding is on everyone's minds. Never easy, obtaining funding can be even more difficult

in trying budget times, which can lead to disappointment and doubt about the future. It is important, however, to try to remember 3 key words: never give up. Tough people survive tough times, firmly believing that rosier times will return.

Meanwhile, Ohio University has moved a step closer to replacement of Clippinger Laboratories. About \$250,000 in funds were approved for hiring an architectural firm to begin exploring possible scenarios for the new facility.

This move follows another important development in which the university has, on paper at least, replaced the original 2-phase Clippinger project with a single \$90M project. This suggests that administrators wish to entertain the idea of a new, all-in-one facility.

This information was revealed to NQPI members during their recent retreat to Zaleski State Forest (at the new Lake Hope Lodge) in which they heard updates from Vice President for Research Joseph Shields and Senior Associate Dean Howard Dewald.

Having a notable impact on NQPI research these days is our fully operational helium liquifier. Capable of producing 400 liquid liters per day, our facility more than meets current needs, providing a readily available source of LHe. And at 95% recovery efficiency, the cost benefit is now being realized, while at the same time we do our part for helium conservation. Elsewhere, skyrocketing costs and limited availability are forcing other institutions to consider investing in such a facility.

As a new initiative, NQPI is considering entering into a bulk contract for LN2. This would save costs and provide several additional advantages including immediate LN2 access for researchers. In light of conserving and maximizing available research dollars, it only makes sense.

Best wishes for a productive summer!

Arthur R. Smith, NQPI Director

## NanoBytes

### Grants

Art Smith and Jeongihm Pak received \$151,000 for their project on revealing exchange interactions in magnetic bilayers of the atomic scale from the National Science Foundation.

Saw Hla received \$33,000 to further his research in low temperature scanning tunneling microscopy study of charge transfer complexes from Argonne National Laboratory.

Eric Stinaff received \$24,000 for his project concerning entangled photon generation using periodically poled lithium niobate waveguide devices from Battelle Memorial Institute.

### Announcement

NQPI will be hosting the Spin-Polarized Scanning Tunneling Microscopy 5 International Conference at Lake Erie, Ohio, in July 2014.

*For a full list of grants as well as publications, please visit [www.ounqi.org](http://www.ounqi.org)*



*Joe Shields addresses the meeting Friday evening.*



*Horacio Castillo presents his research update Saturday.*

## 2013 NQPI Member Retreat

NQPI Members met April 26-27 at Lake Hope State Park to discuss the budget, research updates and potential building upgrades.



*Attendees enjoyed the scenic state park with a hike.*

*Front Row, L to R: Wojciech Jadwisienczak, Horacio Castillo, Savas Kaya, Kay Kemerer  
Back Row, L to R: Allan Showalter, David Ingram, Art Smith, Emma Dean, Saw Hla*

# International Collaboration Discovers Homogeneous Manganese and Gallium Nitride Combination

A close collaborative effort involving Ohio University's NQPI, Argentina's Centro Atómico Constituyentes and Spain's Centre d'Investigació en Nanociència i Nanotecnologia has culminated in a published article, *Manganese 3x3 and  $\sqrt{3}\times\sqrt{3}$ -R30° structures and structural phase transition on w-GaN(0001)* studied by scanning tunneling microscopy and first-principles theory in Physical Review B. Despite being located on three different continents, the authors have identified a way to create a homogeneous mixture consisting of manganese and gallium nitride.

"A big explosion of effort was made in the early 2000s, but the end result was a little inconclusive," said Arthur Smith, Ohio University professor of physics and astronomy who led the international collaboration.

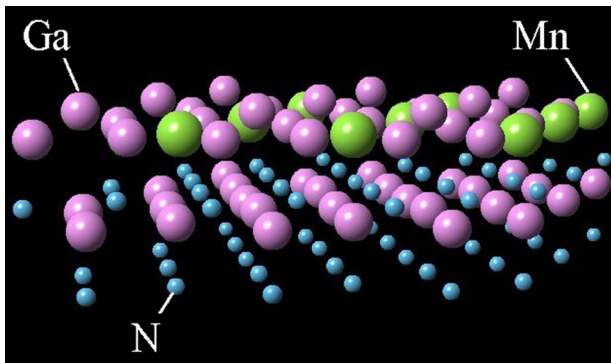
"It proved very difficult for many scientific groups to achieve a homogeneous mixture of manganese and gallium nitride," Smith said.

Manganese and gallium nitride traditionally have merged as well as oil and water, but with a few alterations, the researchers were able to create a harmonious mixture. However, the homogeneous mixture is limited to the surface.

gane, the study took advantage of the nitrogen polarity of gallium nitride. A triplet of three manganese atoms is formed in what the paper refers to as 3x3 trimer structure. A metastable structure up to approximately 105 degrees Celsius, the manganese atoms break apart and bond with nitrogen when the sample is heated.

Once heated, the 3x3 structure becomes the  $\sqrt{3}\times\sqrt{3}$  structure wherein the manganese atoms attach to the underlying nitrogen layer, creating a manganese-nitrogen bond. The  $\sqrt{3}\times\sqrt{3}$  structure is stable at both high and low temperatures. Though the 3x3 structure can be converted to the  $\sqrt{3}\times\sqrt{3}$  structure, the change is irreversible.

Having shown that it is possible to create a stable structure with these materials, researchers will explore the prospect of whether the structure has the required magnetic properties at room temperature in order to function as a spintronic material. ✨



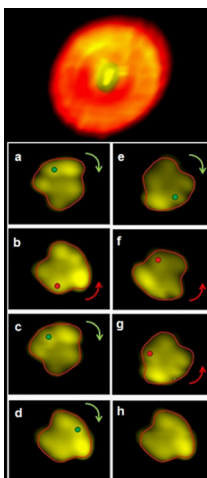
The surface manganese atoms take the place of the gallium atoms and combine with the nitrogen atoms.

"We found a way to put the manganese so that it would make a uniform coverage—absolutely perfectly uniform," Smith said.

Opposed to conventionally using the gallium polarity to attach to the man-

## Motor, from page 1

fundamentals of the quantum world and how it works, it is the possible applications that garner the most attention. The hope for the molecular motor is that it will be able to transport information at the small scale. For something so small, the molecular motor provides a vast array of possibilities such as eliminating pollution from water or air; infiltrating



This image displays the molecular motor's range of motion.

diseases, such as cancer, within the body; or even improving electronics.

Understanding a new world, such as the quantum world, is a hefty task in itself, but the success of the molecular motor has allowed a bit of control for the future.

"So that's the key here," said Hla.

"It's not just building things, it's that we are in control [of the motor]. ✨"

## Ginetom Diniz Receives First NQPI Outstanding Dissertation Award

NQPI would like to announce that, after consideration by a selection committee, Ginetom Diniz has been designated as the first recipient of the Outstanding Dissertation Award, which includes a \$500 prize. The topic of Diniz' dissertation is electronic and transport properties of carbon nanotubes.



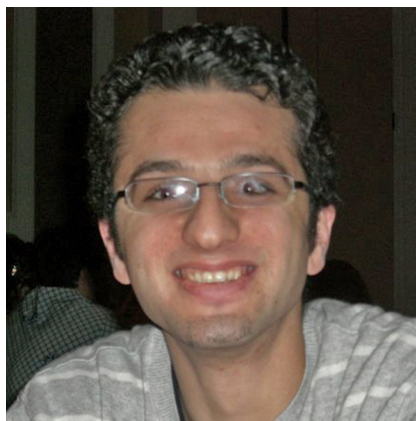
Ginetom Diniz

In order to compete for this award: i) the student must work in one of NQPI's groups, and the dissertation ii) must fall within the scope of NQPI research, iii) must be submitted in its final form to OU's Graduate College within the academic year under consideration, and iv) must be

nominated by a dissertation committee member who is an NQPI member. Nominations for next year's award should be submitted via email to the NQPI Business Manager and Event Coordinator, Kay Kemerer at kemereb@ohio.edu by Sept. 6, 2013. ✨

## Asmar's Article Receives Physical Review B Editors' Suggestion

Mahmoud Asmar, an Ohio University Ph.D. student and his adviser, Sergio Ulloa, an OU physics and astronomy professor, submitted the paper entitled *Rashba spin-orbit interaction and birefringent electron optics in graphene* in August 2012 to the American Physics Society. The article was published in February by Physical Review B.



Mahmoud Asmar

Editors' Suggestion.

The article exploits an analogy between geometrical optics and electron trajectories. Asmar believes that a major factor for the publication's highlighting is its use of relativistic quantum mechanics in the semi-classical limit.

Physical Review B will publish a total of 5,900 articles in 2013. Certain articles are marked with an Editors' Suggestion icon, which are those that the editors find of particular interest, importance or clarity. Asmar's article received the highly esteemed

"We have a one-to-one analogy between kinds of currents and light, so in the same way that we can manipulate light, lenses and prisms or other types of things, we can manipulate currents through different interfaces," Asmar said. ✨

## Botte, from page 1

Instead of sitting for dialysis for a period of time, a sensor could monitor urea levels in the patient's blood, determining the length of time the dialysis is actually needed.

"It is very stressful for a person to take an hour of their day to go to dialysis treatment so... can we shorten it to 15 minutes or do we need to lengthen it? It's all based on how much urea they have in their blood," Botte said.

Botte has also developed technology that allows graphene to be synthesized from coal. Graphene is currently made from graphite through a very expensive process. With uses in batteries, phones, touch screens and much more, graphene is a valuable material.



Gerardine Botte with her award from the National Academy of Inventors.

From ammonia electrolysis to urea sensors to graphene synthesis from coal, Botte's inventions project the possibilities of the future. Botte considers her recognition by the NAI to be a recognition of universities' roles in innovation and economic development because, besides being an inventor, she is also a professor who values the university environment.

"I love the fact that I am in a university environment that supports this type of innovation and approach. I love to see the faces of the students when they are engaged in these types of projects—the way they get excited because they know they are contributing to something big and that has no price." ✨

## Sandler, Ulloa Study, Collaborate in Berlin

NQPI members Sergio Ulloa and Nancy Sandler have traveled from Ohio University to Berlin for a sabbatical that will last until July. They have been accompanied by several students as well as a postdoctoral researcher. Both Ulloa and Sandler have collaborated with their two hosts, Piet Brouwer and Felix Von Oppen.

Ulloa has continued work he began in Ohio to better understand the properties of topological insulators.

"A topological insulator is peculiar [in] that if you cut it, then at the interfaces, that you make ... a surface. That surface becomes conducting," Ulloa said.

Sandler is currently working with the accompanying Ohio postdoctoral researcher and students on a variety of topics, ranging from the role of correlations in disordered systems to the role of curvature and ripples on graphene samples shaped as rings.

"With the postdoctoral researcher we are finalizing a couple of projects on the effect that a magnetic impurity has on the properties of bilayer graphene, and also when one of the graphene layers is sitting on top of a metal that has electrons moving with relativistic corrections to their motion," said Sandler.

Both Sandler and Ulloa agree that studying abroad exposes students to many opportunities. "They're getting a taste of what the real world is," said Ulloa. ✨

Writing and design by Emma Dean.  
Editing by Dr. Horacio Castillo,  
Kay Kemerer and Angie Faller.  
Please email [nqpi@ohio.edu](mailto:nqpi@ohio.edu) with comments.