CAREER: Probing Antiferromagnetic Spintronics with Nitrogen-Vacancy Centers in Diamond

Chunhui R. Du, Georgia Tech Research Corporation

Project goal:

Probing the intriguing science of emergent spin transport and dynamic behaviors in antiferromagnetic materials by nanoscale quantum sensing and imaging techniques.

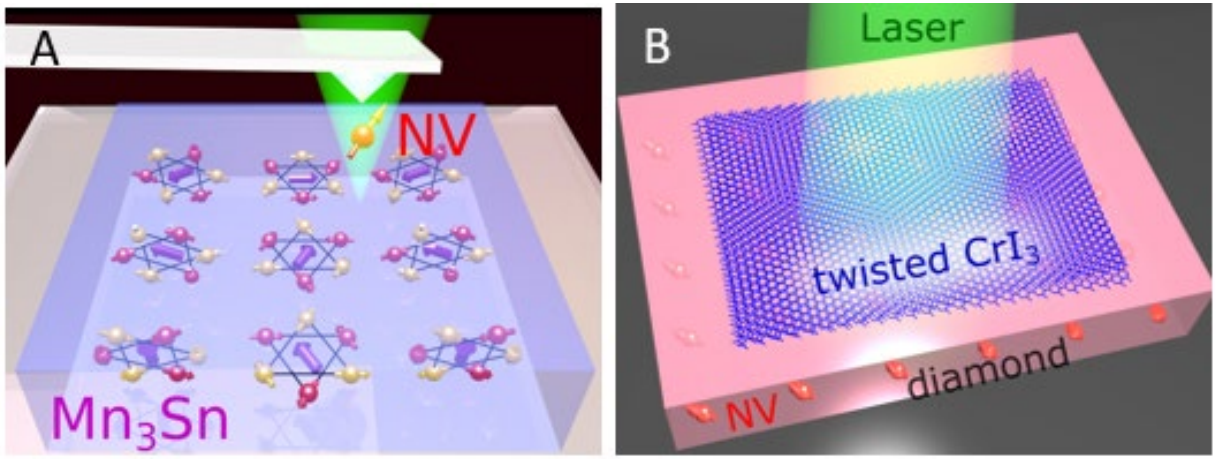
Major findings this year:

- Nanoscale magnetic imaging of local spin dynamic properties of an antiferromagnetic Weyl semimetal [1].
- Nanoscale imaging of magnetic domains and fluctuations of twisted van der Waals antiferromagnet CrI_3 [2].
- Nanoscale imaging of layer-dependent magnetism and spin fluctuations in atomically thin van der Waals antiferromagnet $CrPS_4$ [3].

Impact and importance:

Our findings contribute to the understanding of antiferromagnetic spintronics, which could bring novel functionalities for developing next-generation information technologies. The quantum sensing platforms developed in our work can be extended naturally to other material systems with vanishingly small net moment that are challenging to access by conventional magnetometry techniques.

[1] S. Li et al., *Nano Letters* **23**, 5326 (2023).
[2] M. Huang et al., *Nature Communications* **14**, 5259 (2023).
[3] M. Huang et al., *Nano Letters* **23**, 8099 (2023).



(A) Schematic of magnetic imaging of a non-collinear antiferromagnet Mn_3Sn film using nitrogen-vacancy (NV) centers in diamond.

(B) Schematic illustration of NV wide-field imaging measurements of magnetic domains and fluctuations of twisted van der Waals antiferromagnet CrI_3.

DMR-2342569

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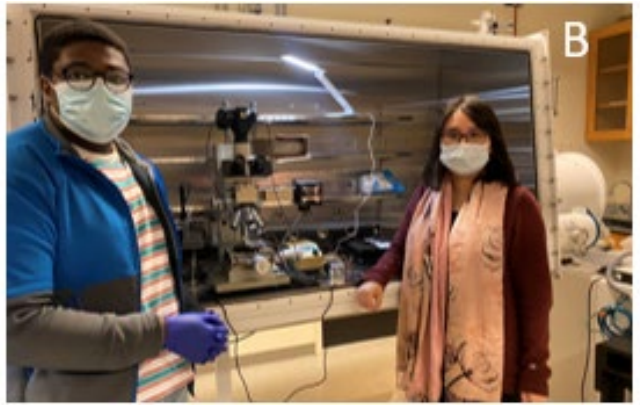
Integration of education with research activities:

The PI designed a curriculum for a project-oriented laboratory course. Students are provided with ample opportunities for using state-of-the-art experimental tools, writing research proposals/papers, and developing their academic presentation skills.

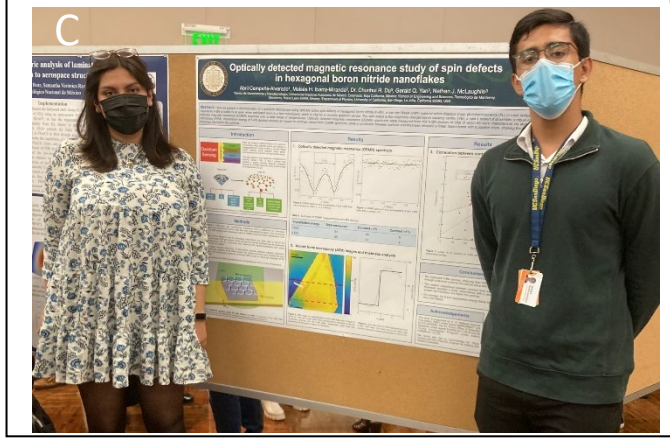
Increase the diversity in research participation:

- The PI offers significant opportunities for under-represented minority students to gain lab research experience via this project. PI recruited an African-American undergraduate student **Dziga Djugba** to conduct research projects on two-dimensional materials and diamond magnetometry measurements.
- The PI serves as a faculty mentor of Cal-Bridge program to create a pathway for students from the underrepresented groups to enter the Ph.D. programs in physics.
- The PI serves as a faculty mentor for ENLACE bi-national summer research program and she hosted a pair of undergraduates to participate in cutting-edge research.

(A) PI Du delivered a lecture on the topic of "Quantum technology" as a part of laboratory course.



(B) PI Du interacted with undergraduate student Dziga Djugba working on setting up a glove box to fabricate two-dimensional magnetic devices.



(C) Undergraduate students Abril Campana Alvarado and Moises Humberto Ibarra Miranda present a poster on their quantum sensing research project at ENLACE closing ceremony and symposium.