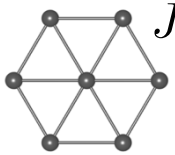
# Mourigal Lab Research: Quantum Magnetism

## Idea

magnetic material

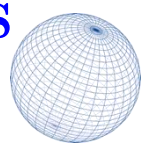
$\Leftrightarrow$ $\mathcal{H} = \sum_{(ij)} \hat{\mathbf{S}}_i J_{ij} \hat{\mathbf{S}}_j$ $\Leftrightarrow$

Heisenberg model



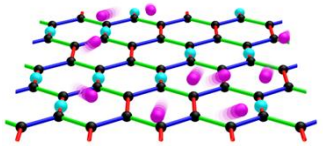

lattice-space

$\otimes$




spin-space

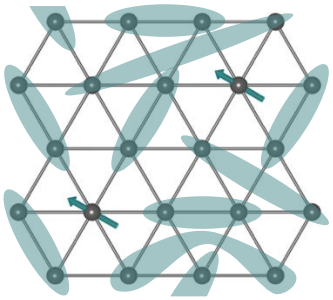
$\Leftrightarrow$



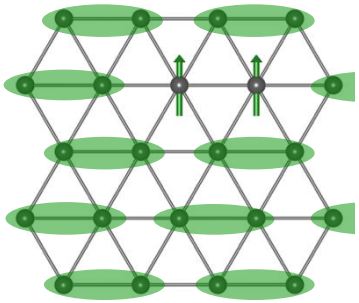
emergent quantum behavior

## Challenge

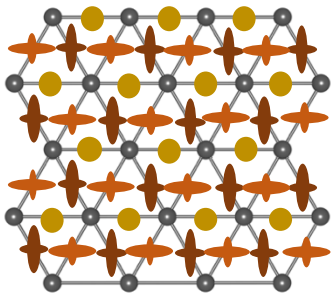
topological order — entanglement — local order — disorder



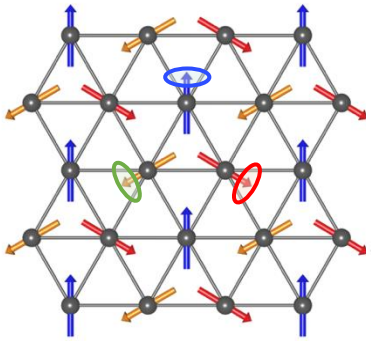
Quantum spin liquid



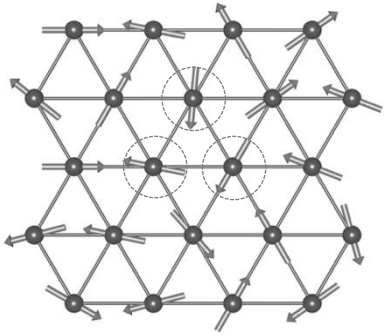
Quantum paramagnet



Quadrupolar order

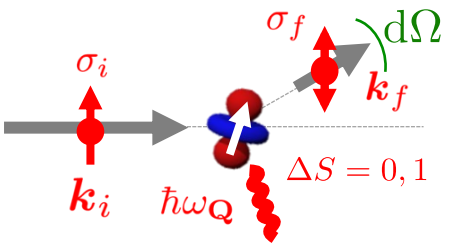


Dipolar order

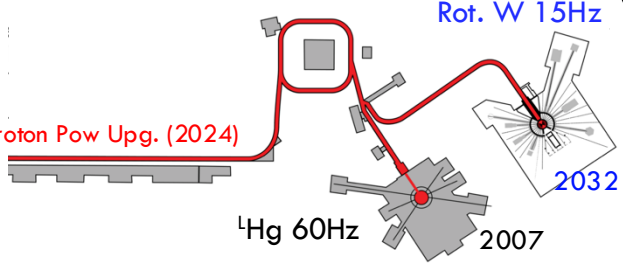


Paramagnet

## Approach

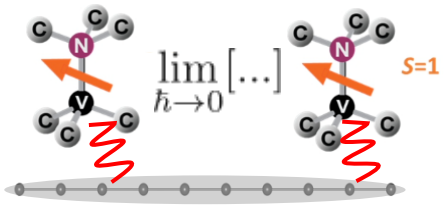



Inelastic neutron scattering




ORNL Spallation Neutron Source

## Applications?




Transduction of quantum information

# Undergraduate Research

## Course Information

- **Instructor:** Martin Mourigal (mourigal@gatech.edu)
- **Course Prefix and Number:** PHYS 4699 MM
- **Term:** Summer 2026

## Course Description

Undergraduate research conducted under the guidance of a faculty mentor. This course is a graded academic credit research course.

## Course Learning Outcome

- Communication
  - Uses and understands professional and discipline-specific language
  - Expresses ideas orally in an organized, clear, and concise manner
  - Writes clearly and concisely using correct grammar, spelling, syntax, and sentence structure
  - Demonstrates an ability to interpret, evaluate, and create visual representations of ideas
- Creativity
  - Shows ability to approach problems from different perspectives
  - Uses information in ways that demonstrate intellectual resourcefulness
  - Effectively connects multiple ideas/approaches
- Autonomy
  - Demonstrates an ability to work independently and identify when guidance is needed
  - Accepts constructive criticism and uses feedback effectively
  - Uses time well to ensure work gets accomplished
- Ability to Deal with Obstacles
  - Is not discouraged by setbacks or unforeseen events and perseveres when challenges are encountered
  - Shows flexibility and a willingness to take risks and try again

  - Troubleshoots problems and searches for ways to do things more effectively

- Intellectual Development
  - Recognizes that problems are often more complicated than they first appear
  - Approaches problems with an understanding that there can be more than one right explanation or even none at all
  - Displays insights into the limits of their knowledge and an appreciation for what isn't known

- Critical Thinking and Problem Solving
  - Uses a reflective and iterative approach to problem solving
  - Looks for the root causes of problems and develops or recognizes the most appropriate corrective actions
  - Recognizes flaws, assumptions, and missing elements in arguments

- Practice & Process of Inquiry
  - Demonstrates ability to formulate questions and hypotheses within the discipline
  - Demonstrates ability to properly identify and/or generate reliable data
  - Shows understanding of how knowledge is generated, validated, and communicated within the discipline

- Nature of Disciplinary Knowledge
  - Shows understanding of the criteria for determining what is valued as a contribution in the discipline
  - Shows awareness of important contributions in the discipline and who was responsible for those contributions
  - Reads and applies information obtained from professional journals and other sources

- Project Knowledge and Skills
  - Displays knowledge of key facts and concepts
  - Displays a grasp of relevant methods and is clear about how these methods apply to the research project
  - Demonstrates an appropriate mastery of skills needed to conduct the project

- Ethical Conduct
  - Shows understanding of the importance of principles of Responsible Conduct of Research (RCR)

## Required Course Materials

No textbooks or materials are required. Resources for research are determined in consultation with the instructor.

## Grading Policy

This course is graded on a letter grade basis.

The grade will be assigned based on agreed upon objectives commensurate with the difficulty and scope of the project, the number of credit hours, as well as the technical proficiency of the student. It is the joint responsibility of the instructor and the student to discuss expectations and how meeting or not the expectations affects the final grade. The grading process will be clearly articulated to the student to allow reasonable prediction progress towards the final grade throughout the semester.

## Attendance Policy

This course does not include scheduled class meetings. Undergraduate research students will participate in research activities on a weekly basis commensurate with registered credit hours and as discussed with faculty research mentors.

## Academic and Research Honesty/Integrity Statement

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review the Student Code of Conduct and the Academic Honor Code, especially Appendix A: Graduate Addendum to the Academic Honor Code.

Students are expected to perform research in an ethical and responsible manner.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Allegations of scientific or scholarly misconduct are handled in accordance with the procedures outlined by the Policy for Responding to Allegations of Scientific or Other Scholarly Misconduct.

## Core IMPACTS

Not applicable

## Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

## Student-Faculty Expectations

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulates some basic expectations that you can have of me and that I have of you. Additional information for research-related work is given in The Expectations of Advisors and Advisees. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

## Campus Resources

The Undergraduate Research Opportunities Program (UROP) provides resources and support for undergraduate research students and their mentors. Visit https://undergradresearch.gatech.edu/ or contact UROP at urop@gatech.edu for more information.