

EXPLORING THE QUANTUM UNIVERSE

HUGH CHURCHILL MAKES A BIG IMPACT ON AN ATOMIC SCALE

By AMP Staff

If you're among the millions of Marvel fans who have watched Ant-Man, you likely have gained a broad (if fantastical) definition of quantum physics. Hollywood sheds a glamorous spotlight on the science, but ARA Academy Member Dr. Hugh Churchill warns us to temper the high expectations.

"Quantum information science and engineering is in danger of being overhyped, and some would say already has been," he said with a wry smile. "But there are some specific, real ways in which quantum technologies could provide advantages over current technologies."

Churchill, an associate professor of physics at the University of Arkansas, ought to know. He is internationally recognized as a leading researcher on the topic. He heads a team that investigates how the physical properties of materials (for example, the performance of a transistor material) change when reduced to the atomic scale in one or more directions. The change in material properties is then employed to address challenges in quantum technologies with applications like machine learning. Hype notwithstanding, the practical applications of this research are significant.

"The applications are various, but two that stand out are smarter artificial intelligence and faster discovery of new medicines," explained Churchill. "Smarter AI could be achieved because quantum computers can solve certain problems much more quickly than regular computers, and the medical application could occur because medical drugs are big molecules, and big molecules will eventually be simulated more efficiently on quantum computers."

So, why haven't we already conquered the quantum universe? The biggest reason is the time-consuming process of creating the materials that Churchill wants to study, and then fabricating electronic devices using those materials. Recently, Churchill's team engaged in a collaboration between the University of Arkansas and Montana State University called the MonArk NSF Quantum Foundry. This is a research center funded by the National Science Foundation and jointly operated by the UA and MSU.

"We're using robots and artificial intelligence to dramatically accelerate the creation and characterization of atomically thin

two-dimensional materials and devices, such as qubits, which are the building blocks of quantum computers," said Churchill. "Our goal is to eventually become fast enough that we can satisfy not just our own internal research needs, but also serve a large national network of collaborators who would like rapid access to the quantum materials and devices produced by the Foundry."

If MonArk is successful, Arkansas could become a global resource for quantum devices based on 2D materials. In all the excitement surrounding robots and atomically thin 2-D materials, it is easy to miss Churchill's other contributions to society: a COVID-busting air filter that is cheaply and easily constructed. How did a quantum physicist get involved with an "actual size" project?

"The electronic devices we make in my lab are really tiny, only a few atoms thick, so if a speck of dust lands in the wrong spot, it can destroy the device," Churchill said. "Most of my career has been spent working in cleanrooms that maintain extremely clean air that's free of suspended dust particles that could ruin a device. When it was discovered early in the pandemic that COVID can be transmitted over long distances through the air, and when I learned of these portable air filters about a year ago, it seemed obvious to me that cleaning the air could be a good additional layer of protection that sidesteps the debates around masks and vaccines."

Churchill and his partners with StartUp Junkie and the Arkansas Research Alliance launched CleanARAir to bring this simple and inexpensive solution to Arkansas' classrooms and beyond. You can learn more at CleanARAir.com.

In the meantime, although Churchill may insist that expectations are set too high for quantum breakthroughs, the benefits continue to impress.

"Of course, the immediate, practical outcome is that our research has created more than a dozen high-tech jobs for our researchers and staff," he said. "We are developing a highly skilled group of trainees with expertise that converges a broad range of advanced technologies such as semiconductors, robotics and artificial intelligence. While some of them will likely go on to research careers elsewhere, I expect others to translate that expertise to the benefit of Arkansas companies."

Discovery Economics is a monthly feature highlighting the work of the ARA Academy of Scholars and Fellows, a community of strategic research leaders who strive to maximize the value of discovery and progress in the state. ARA recruits, retains, and focuses strategic research leaders to enhance the state's competitiveness in the knowledge economy and the production of job-creating discoveries and innovation. Learn more at ARAlliance.org. 



Dr. Hugh Churchill