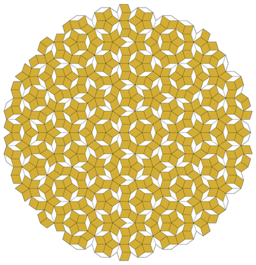
Probing the quantum realm

Charles Brown
Assistant Professor

Charles Brown, member of the Yale Quantum Institute, has expertise in the generation and measurement of quantum matter in liquid and gas form. He leads an experimental group at Yale that focuses on trapping atoms at nano-Kelvin temperatures in optical lattices to explore how geometry and topology affect emergent properties in exotic quantum materials. Brown is also a part of the ALPHA collaboration, using his knowledge of superconducting magnets to aid in the axion search.

Brown was awarded the Air Force Research Laboratory Young Investigator Program Award and National Science Foundation (NSF) CAREER awards for his work exploring the physics of quantum quasicrystals. .

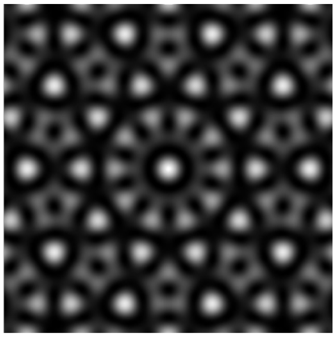


A Single/Few/Many Body Quantum Physics Lab

The Brown Research Group aims to study single-, few-, and many-body quantum physics by conducting quantum simulation experiments. A quantum simulation experiment is the use of a simpler quantum system to realize the behavior of a more complex quantum system, for the purpose of understanding the complex system's ordered phases and dynamics. The Brown group uses trapped quantum degenerate gasses to perform a wide range of exciting quantum simulation experiments.

Axion Longitudinal Plasma HAloscope (ALPHA)

ALPHA is looking for a theorized particle called the axion, which is candidate for dark matter that, if detected, would provide important clues to the nature of dark matter and the constitution of the mass content of the universe. ALPHA, which will be located at Yale's Wright Lab, will build on the success of the HAYSTAC experiment and search for even higher mass axions by employing a novel axion detector called a plasma haloscope. ALPHA will comprehensively investigate how new experimental ideas using plasmas can be used to detect the axion.



Ultracold Atoms in an Optical Quasicrystalline Potential

A quasicrystal is an aperiodic crystal with a rotational symmetry that is mathematically forbidden in a periodic crystal. One related example is found in the Penrose tiling, which exhibits local five-fold rotation symmetry, a symmetry that cannot exist in a system with translation symmetry. The standard mathematical analysis techniques used to understand the behavior of periodic crystals does not work for quasicrystals due to a lack of translation symmetry. Quasicrystals are thought to exhibit anomalous and, potentially, topological transport properties that are thus difficult to understand analytically.

In the Brown Group, we trap degenerate quantum gasses of lithium in a two-dimensional optical potential that exhibits five-fold and ten-fold rotation symmetries, thus creating a quantum quasicrystal with a deep connection to the Penrose tiling. We explore the effects of geometry and topology in the quantum behavior of Penrose-like quasicrystals and how these effects lead to exotic transport properties.