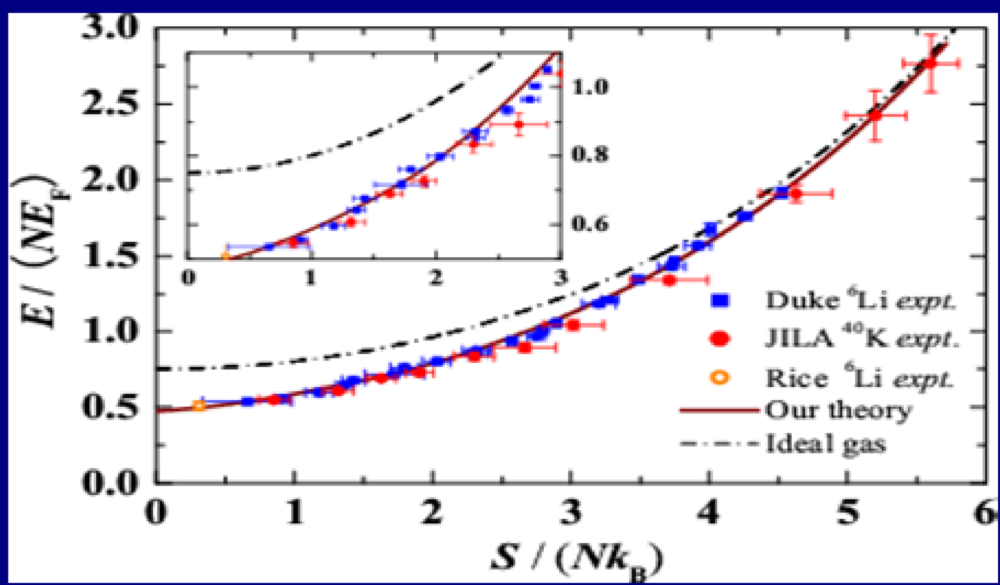
Theoretical Physics – 2013 PhD Topics

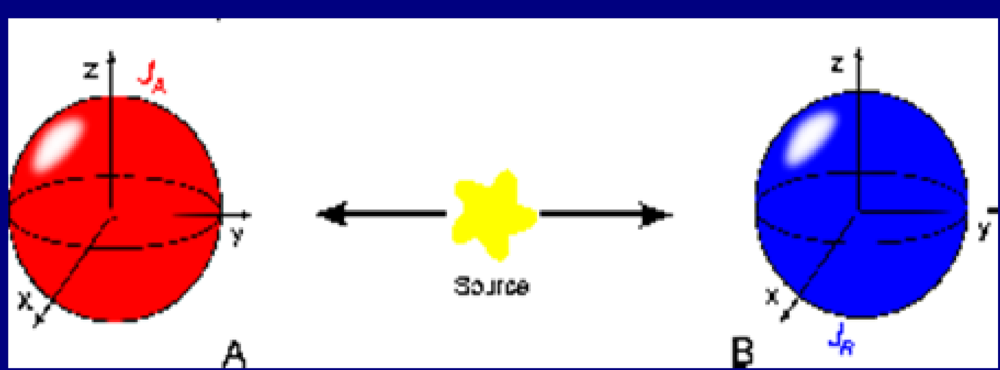
Modern problems in theoretical physics are wide-ranging. Here we focus on topics ranging from ultra-cold atoms to genetics, computational science, quantum information, condensed matter, and the foundations of quantum mechanics. Many are linked to SUT experimental work.

See: http://www.swinbune.edu.au/feis/caous//theory

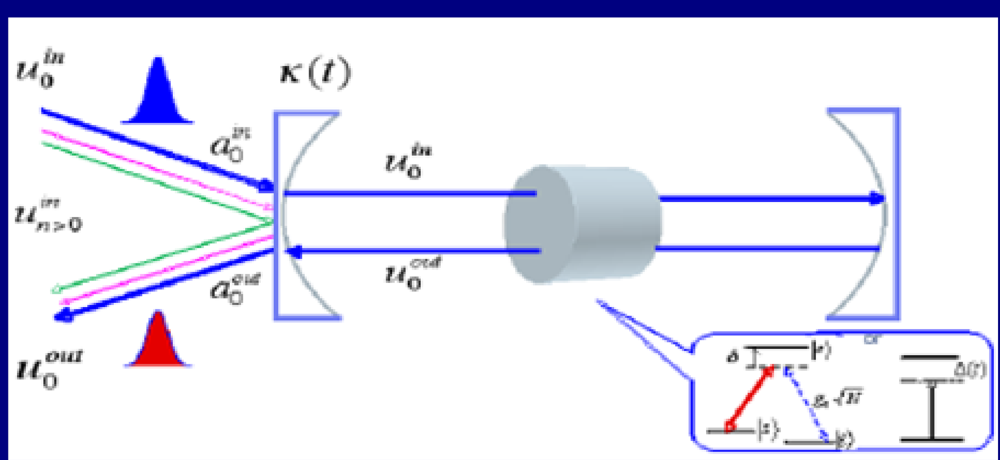
SUT PHYSICS: INTERNATIONAL TOP 100
TOP 2 IN AUSTRALIA (Jiao-Tong List, 2012)
Swinburne University of Technology
Centre for Atom Optics & Ultrafast Spectroscopy



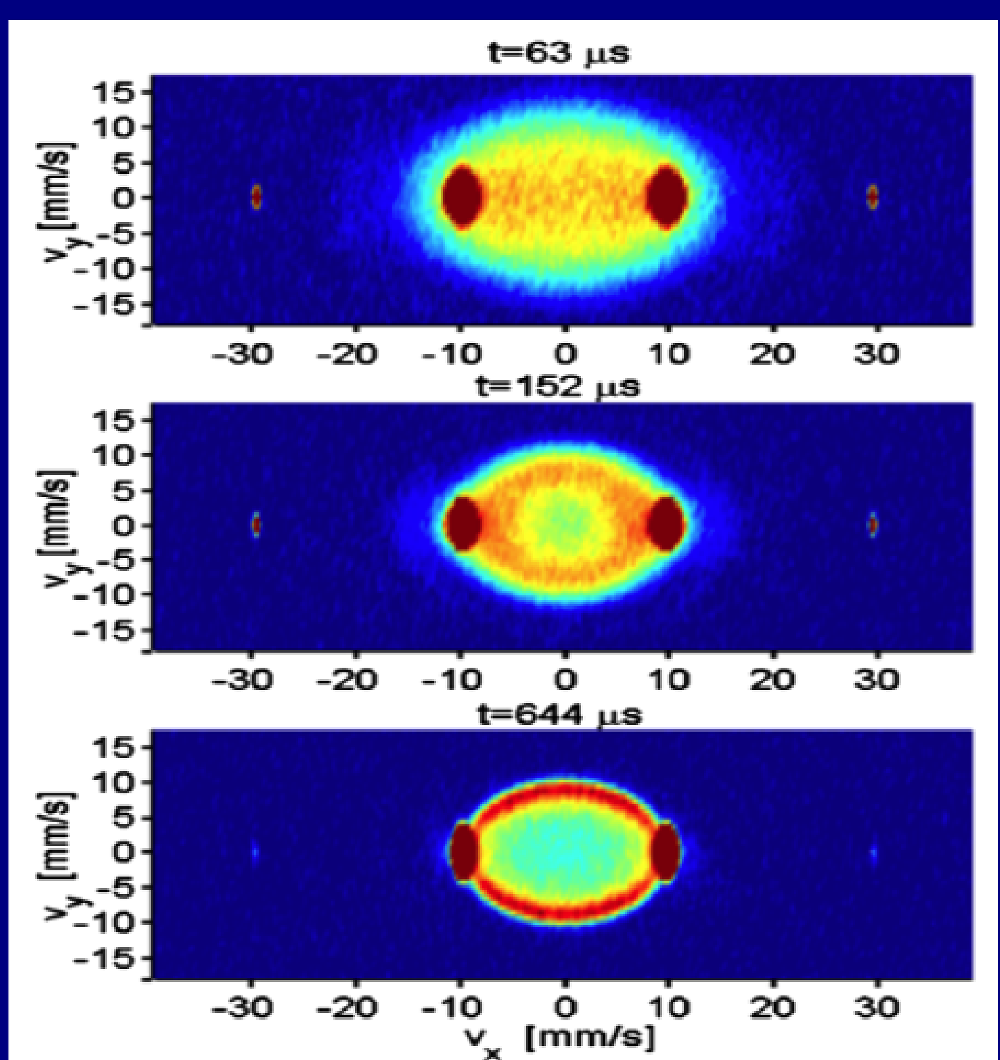
Nature Physics **3**, 469 (2007). This is the first published evidence for universality, comparing different strongly interacting Fermi gases.



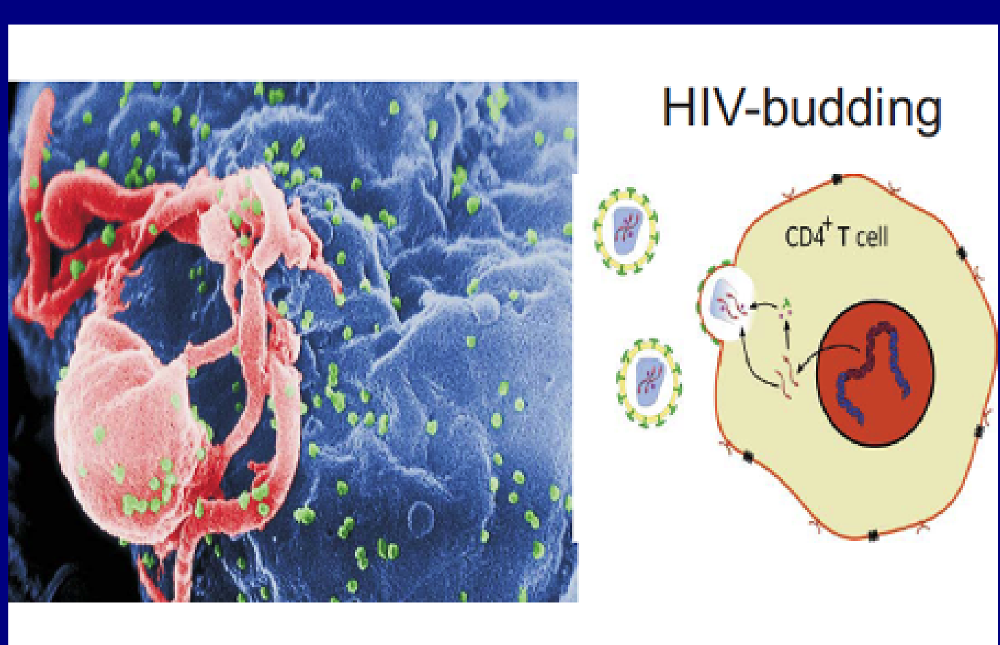
Rev. Mod. Phys. 81, 1727 (2009).



Quantum memory Phys. Rev. A 79, 022310 (2009)



Colliding BEC quantum dynamics: Phys. Rev. Lett. 98, 120402 (2007) (an Editor's Suggestion)



Ultracold Fermi Gases

Our research program is motivated by rapid experimental developments in degenerate Fermi gases. These experiments are controlled at an unprecedented level and are well described by quantum many-body models. The program involves themes designed to develop fundamental knowledge of the quantum physics, and to provide theoretical guidance to experiments at Swinburne University.

* Quantitative strong-coupling theory of ultracold Fermi gases
* Low dimensional physics of multi-species Fermi gases
* Entanglement, correlations, and coherent manipulations of ultra-cold Fermi gases.
* Few-body physics and virial expansions

Entanglement & Nonlocality in Quantum Mechanics

The well-known 1935 paper of Einstein et al (EPR) led to the famous Bell theorem, which rules out local realism – a result that has been called "the most profound discovery of science" . The Schrodinger cat paradox raises an even more important issue - how to reconcile quantum with classical realities at the macroscopic level. Modern physics technologies are now making these paradoxes experimentally accessible. Specific research topics include:

* The Bell and EPR paradox in macroscopic systems
* Signatures of macroscopic superpositions and entanglement

Computational Physics & BEC

Atom lasers, or Bose-Einstein condensates (BEC) exist at temperatures below one nano-Kelvin - a billion times colder than interstellar space. High-precision interferometry applications are being studied experimentally at Swinburne University. We employ computational techniques to complement the theoretical studies elsewhere in the group. We are developing new algorithms based on phase space representations for simulating quantum and classical many-body systems.

Theory projects on quantum noise properties of BECs and Fermi gases are:

* Quantum Brownian motion and interferometry in a BEC
* Quantum phase space dynamics for multi-mode Fermion systems.
* High spin topological phases in BEC.

Genetics and Bioinformatics

As a cross-disciplinary application, mathematical genetics is one of the most rapidly growing fields of science, bridging the gap between theoretical physics and biology. New gene sequencing technology is unleashing floods of new genetic data in many areas, requiring sophisticated models to understand and analyse genetic drift and genetic correlations. Our research focuses on viral evolution and genetics.

* Genetic correlations in RNA virus evolution

Deadline: May 31, 2013
Full scholarships available
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