Cold Atom Laboratory

"The Coolest Spot in the Universe"

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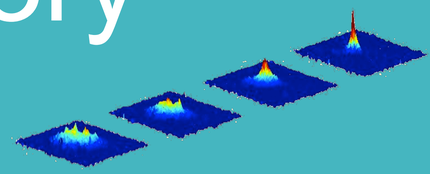
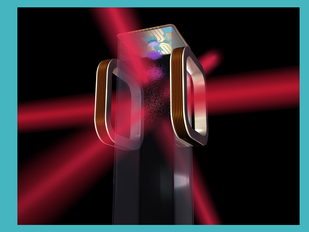
coldatomlab.jpl.nasa.gov





Mission Overview

ISS Utilization

- CAL is a multi-user ultra-cold atom facility that will enable research in a temperature regime and force free environment that is inaccessible to terrestrial laboratories
- Due to gravity, laser cooling experiments on Earth are typically limited to short observation times and temperatures that only begin to explore the wave nature of atoms
- In the microgravity environment 20 sec interaction times and 1 picokelvin temperatures are achievable, unlocking the potential to observe new quantum phenomena
- Facility designed for use by multiple investigators and be upgradable/maintainable on orbit
- Investigation scientists selected by NASA as part of a competitive NRA
- CAL will be a pathfinder experiment for future quantum sensors based on laser cooled atoms
- **Launch Readiness December 2015, Up to 5 years On Orbit ISS Utilization**

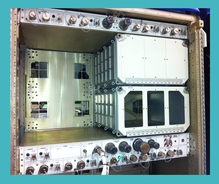
CAL Science Observations

- Study ultra-cold quantum gases in the microgravity of the International Space Station
- Study dual species degenerate gases, both Bose-Bose and Bose-Fermi in microgravity
- Study ^{87}Rb, ^{41}K and ^{40}K , and interactions between mixtures with residual kinetic energy below 100 pK with free expansion times greater than 5 seconds
- Study the properties of quantum gases loaded into optical lattices; in the presence of external magnetic fields tuned near interspecies or single-species Feshbach resonances
- Demonstration of Delta-Kick Cooling and Evaporative Cooling in a space environment

Launch and Installation

Delivered to NASA JSC in December 2015

April 2016 Launch in a pressurized cargo vehicle



Installation into EXPRESS Rack with Sequence Control Operation from JPL

Docking with ISS

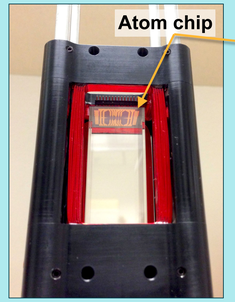
Current Investigation

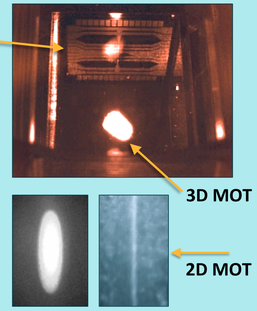
Development of Ground Testbed Laser Cooling Facility at JPL

- Leverages COTS hardware for rapid development and results
- Evaluation of various laser technologies (ECDL, DBR, DFB) and fiber coupling schemes
- Characterization system performance and dependencies
- Validation and verification of instrument requirements
- Test subsystem hardware and components
- Serve as ground based experiment during mission operations

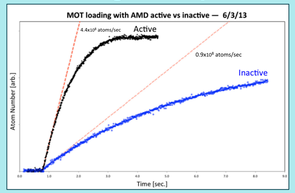
CAL Ground Test Bed

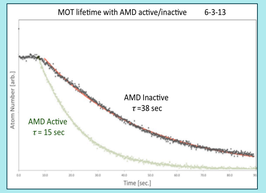
Lab model assembled, including 2D MOT source and 3D MOT

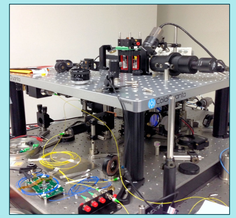




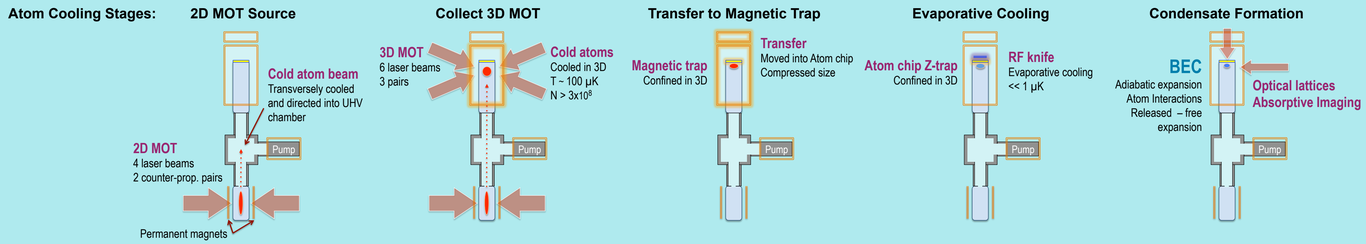
Magneto-Optical-Trap Measurements







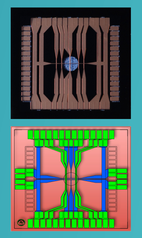
Laser Cooling — Formation of the Ultra-Cold Quantum Gas: The Bose Einstein Condensate (BEC)



Technology

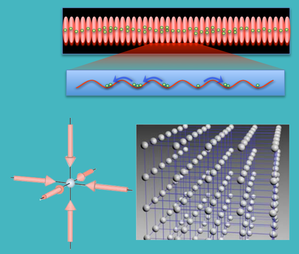
The Atom Chip

- Compound silicon and glass substrate technology enables both magnetic and optical control of ultra-cold atoms.
- On-window wires enable simultaneous magnetic trapping and optical manipulation.

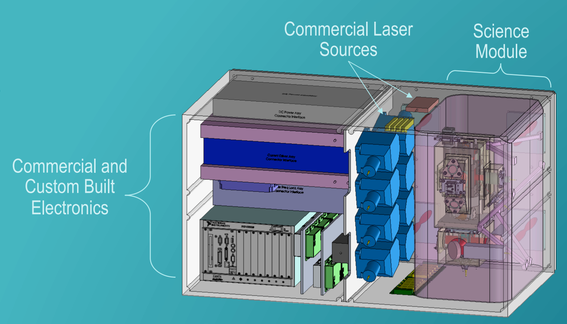


Optical Lattices & Cold Atoms

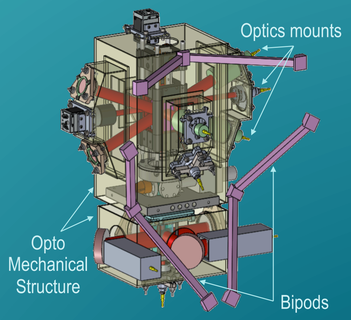
- Counter-propagating light beams form an interference pattern
- Cold atoms are trapped at intensity maxima (for light tuned to the red side of resonance or minima for light tuned to the blue side of resonance)
- Atoms on a single site interact with one another and tunnel to neighboring sites



Instrument Description



Instrument Configuration



Science Module
(magnetic shield not shown)

- Leverage COTS hardware and software for rapid development and results
- Convective cooling via fans and liquid heat exchangers
- Fiber-optic coupled lasers to simply optic-mechanical design

Contact Info

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