

Cryogenics Symposium

Day 1 – Thursday March 31, 2011

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|----------------------------------------|---------------------|
| 1. Evaporative Cooling- | Sahar Mirshamsi |
| 2. Peltier Effect | Bobby Bond |
| 3. Dewar's Flask and Cryogenic Storage | Roberto Gomez-Perez |
| 4. Cooling Computers | Brady Nash |
| 5. Vortex Tube Cooling | Joseph Smales |
| 6. Pulse Tube Refrigeration- | Scott Petersen |
| 7. Food Processing and Storage | Gabriel Dilanji |

Evaporate Cooling

Sahar Mirshamsi

- **Science of Evaporate cooling, basic ideas:** Evaporative cooling is based on a physical phenomenon in which evaporation of a liquid (usually water) into surrounding air cools an object or a liquid in contact with it.
- **Evaporative Coolers:** Also known as swamp coolers, sump coolers or desert coolers are most commonly found in homes and small businesses located in dry hot climates.
- **"Badgir", a traditional windcatcher in Iran:** The dry and warm wind will pass over a pond with a fountain gets cool and wet through evaporation.
- **Cooling Towers**
(If it does not make the talk longer than 8 minutes)

Peltier Effect

- Materials used to make Thermoelectric coolers
- Figure of Merit
- Improving Figure of Merit
- Disadvantages
- Advantage
- Applications of Thermoelectric Cooling
- Common Devices

Sources (not all):

- <http://www.electronics-cooling.com/2006/11/effect-of-improved-thermoelectric-zts-on-electronic-module-coolability/>
- http://www.tec-microsystems.com/EN/Intro_Thermoelectric_Coolers.html

Dewar's Flask and Cryogenics Storage outline

INTRODUCTION

Sir James Dewar
Modern applications
Gravity Probe B
Thermos

Dewar's Flask

Original
Materials
Pictures
Development
Seal
Fill
Out gassing
Gaskets

Use
Modern designs
Pictures

Other Storage Devices

Different types
Liquid cylinders
Tanks
When these devices were created
Differences in use compared to Dewar's flask

Conclusion

Computer Cooling

Brady Nash

- Heat Buildup and Hardware Damage
- Types of System Cooling & Implementation
 - Air Cooling
 - Liquid Submersion
- Types of Spot Cooling & Implementation
 - Passive/Active heat-sinks
 - Water cooling
 - Heat Pipes
 - Phase-change cooling
 - Liquid nitrogen cooling
- Overclocking & Cooling Cautions

Vortex Tube Cooling Outline

Joseph Smales

- Brief History
 - Invented: 1933 Georges J. Ranque
 - Design improved & Large publication: 1947 Rudolf Hilsch
- Theory as to how it works:
 - Compressed air → vortex motion → hot out / reverse flow → cool out, opposite hot
 - Pressure differences and conservation of angular momentum
 - C.L. Stong
 - J. J. Van Doornik
- Basic design considerations
- Efficiency
 - Data tables from various manufacturers
- Applications
 - Poor efficiency: good for "spot" cooling
 - Cooling electrical cabinets
- Possible demo
- Clicker Question

pulse tube refrigeration

- Slide 1: Introduction**
Basic overview of pulse tube refrigeration
How it uses acoustics and involves no cold moving parts
- Slide 2: Beginning Research**
NASA origins for space applications: lower mass and longer life
Originally abandoned due to discouraging results
Phase shift discovery opened topic back up
- Slide 3: Picture Description**
Using a picture of a pulse tube refrigerator, I'll go over the components of the diagram
How it is a Stirling-type
- Slide 4: Individual Components**
Compressed gas traveling through system
Explain regenerator and heat exchangers
- Slide 5: Comparison to other refrigerators**
No need for displacer
Efficient (very little interference)
Can only reach temperatures around 1 K
- Slide 6: Current Uses**
Very popular in space applications (telescopes)
Ben and Jerry's Interest in thermoacoustic
Semiconductor fabrication
- Slide 7: Future possibilities**
Most effective at very low temperatures (not good for room temperature applications)
Combining dilution refrigerators and pulse tubes can achieve mill and micro K temperatures without prohibitive cost
Infrared detection, telecommunication filters

Food Processing and Storage Gabriel Dilanji

- To be continued

Cryogenics Symposium Day 2– Tuesday April 5, 2011

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|-----------------------------------------|----------------|
| 1. Superfluidity | Kristin Zych |
| 2. SuperSolid | Icon Mazzaccar |
| 3. Vortex State-type II superconductors | Joshua Arlund |
| 4. Superconducting Magnets | Lana Muniz |
| 5. Nuclear Demagnetization Cooling | Roman Ciapurin |
| 6. CDF Cryo System | Matt Snowball |
| 7. Quantum Computing | Adam Butler |

Superfluidity Outline

- Discovery**
-when, by whom
- Properties**
-lambda point, viscosity
- Theory**
-Bose/Fermi statistics
- Applications**
-superconductors
- Recent developments**
-supersolids

Supersolids

- What is a supersolid and what are its characteristics?
- Motivation for the existence of a supersolid:
 - "Speculations on Bose-Einstein Condensation and Quantum Crystals" by D.N. Chester, *Phys Rev A* (1970)
- How is it possible to measure superfluidity?
 - Torsional Oscillator
 - What would signal its existence within the data?
- Kim and Chan's experimental data confirming the existence
 - "Probable observation of a supersolid helium phase" by Kim and Chan, *Nature* (2004)
- Controversy over experimental data
 - Certain processes eliminate the characteristics that signaled superfluidity
 - Experimental data that support its nonexistence
- Alternate explanation for what is occurring at low temperatures
- Chan and Kim's reaction to experimental data against their case
- Future for Supersolids?
 - Possibilities in optical lattices
 - "Dynamical Creation of a Supersolid in Asymmetric Mixtures of Bosons", *Phys Rev Letters* (2009)
 - Maybe it does not exist at all.

Vortex State in type II superconductors

- What is a superconductor
Type I and Type II differences
transition (sharp or gradual)
penetrating magnetic field
- What is the vortex state
penetrating flux lines
vortex superconducts
Core size
how many are present
distribution
- Uses of vortex states

Superconducting Magnets – Outline

Introduction – What is a superconducting magnet?
 History – Heike Kamerlingh Onnes, George Yntema, and type-II superconductors
 Materials and Operation – How a superconducting magnet works. Persistent mode.
 Advantages/Disadvantages – Comparison to regular magnets.
 Applications
 - MRI/NMR
 - Particle Accelerators

Nuclear Demagnetization

- History, what is it, temperature ranges
- Magnetism in materials
- Principles: entropy cycle (main focus)
- Nuclear vs paramagnetic salts
- Laboratory setup (main focus)
- Limitations, external fields, H/T
- Multiple stages, improved technologies

CDF Cryo System Outline

- What is CDF
 - Where is it? What does it do?
 - Why does it need to be cold?
 - How cold does it get?
- Cryo Systems
 - What are the main components?
 - Where is the helium stored?
 - What is the refrigeration cycle used?
 - Refrigerator diagram
 - Heat exchange system
 - Expansion Engine used, how fast is it?
 - Liquefaction of Helium
 - How do they monitor the system?
 - How do they measure temperature in the system?
 - Controlling the system



Download

Quantum Computing

- What is quantum computing
 - How is it different from regular computers
 - Quantum bit
 - Quantum Gates
 - Quantum Circuit
 - Why is it better
 - Faster
 - Capable of modeling quantum systems
 - Quantum Cryptography
- History of Quantum Computing
 - Feynman
 - Shor's factorization algorithm
- Why Cryogenics
 - Needs to be superconducting
 - Only exhibits quantum behavior near absolute zero
- Obstacles
 - Error Correction
 - Scalability
 - Hardware architecture
 - Nuclear Magnetic Resonance
- Future of Quantum Computing
 - Progress is being made
 - Currently there are computers that use a few qubits, within a few years, the number of qubits is expected to increase significantly

- http://www.cs.nice.edu/~tsaha/teaching/QBF/210/news/2005_09_18.htm
- <http://www.nytimes.com/2010/11/09/science/09compute.html>
- Quantum Computing by Josef Gruska
- <http://plato.stanford.edu/entries/qt-quantcomp/#Rel>

Cryogenics Symposium

Day 3– Thursday April 7, 2011

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|--------------------------------|----------------|
| 1. Laser Cooling of Solids | Pedro Quintero |
| 2. A short introduction to BEC | Xiaochang Miao |
| 3. Solitons in BEC | Yitzak Calm |
| 4. Sperm/Egg Preservation | Alessa Bastron |
| 5. Cryo-Surgery | Nirish Shukla |
| 6. Cryo-Ablation | Peter Boulos |

Laser cooling of solids

1. History
2. Anti-Stokes fluorescence
3. Basic Principles
4. Experimental Setup
5. Cryocooler Applications

[1] S.A. Egorov and J.L. Skinner, On the theory of multiphonon relaxation rates in solids, J. Chem. Phys. 103, 1535 (1995).