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EASISchool2 on Cryogenic Applications

Paris-Saclay / Grenoble

This is almost the end !

- **Day 1 – Medical Applications**

1. *To achieve the ISEULT magnet performance requirement, what are the selected superconducting material conductor and cooling technology?*

   NbTi + "double bath" pressurized superfluid He

2. *What did magnetic inductance Iseult magnet reach and why is it remarkable?*

   11.7 T and it is very close to the superconducting-normal limit

3. *What are the medical applications using cryogenics presented during the school ?*

   MRI, MEG with SQUID + Proton therapy

4. *What is the advantage of using superconducting coil for MRI?*

   Increase of spatial and temporal resolution

5. *What is the "bain Claudet" ? What are its advantages compare to saturated HeII bath ?*

   "Double" bath HeII with no subatmospheric operation, improved electrical insulation, gain in thermal performances and temperature margin before reaching Tlambda

- **Day 1 – Accelerator technologies**

1. *Which are the material property needed to build a SRF cavity?*

   The highest transition temperature, lowest surface resistance, good thermal & mechanical properties

2. *In which range of application SRF cavities are the best option with respect to the normal conducting one?*

   CW high current applications

3. *If you would like to accelerate electrons which cavity geometry will be best suited?*

   Elliptical

4. *What is the Kapitza resistance ? What are its consequences in cryogenics ?*

   Adding an extra temperature difference at the wall to be taken into account with HeII cooling.

- **Day 2 – Superconducting magnets**

1. *What are the peculiar HeII properties ? What represent the Paschen curve ?*

   Low effective viscosity, very high specific heat and very high conductivity.

   Electrical breakdown versus voltage, pressure and conductor distance

2. *What are the present superconducting materials for accelerator magnets ?*

   NbTi-NbSn

3. *What is the most used combination of superconductors/cryogen nowadays?*

   NbTi/Liquid Helium

4. *What is the main difference in cooling technique between Atlas and CMS and why?*

   Forced flow for Atlas and natural circulation for CMS because Atlas is principally horizontal oriented and CMS vertically oriented

5. *What is the principle of a Thermosiphon of CMS?*

   Mass unbalance between the feeding and return branches creating flow

- **Day 2 – Cryogenics for future**

1. *What is a cryogenic PHP ? What are its performances compare to other devices ?*

   Two-phase at saturation heat pipe and they offer potential larger heat transfer capacities than other thermal links

2. *What kind of insulation is proposed in GTT LNG tanks ?*

   Double membrane system with thin Invar foils or corrugated stainless steel + aluminum foil and wood

3. *What are the main differences between EML (Electromagnetic levitation), EDL (Electrodynamic levitation) and SML (superconducting magnetic levitation) for maglev technologies?*

   EML =Electro-magnet (static) EDL = Foucault's induced current (movement needed), SML = flux trapping

- **Day 4 – Space and Aerospace applications**

1. What is the only available heat transfer process in space ? Radiation
2. What are the three main cooling technologies for sub-kelvin operation and their lowest achievable cooling temperature ? ADR ~mK, dilution ~40mK, sorption down ~100mK
3. What are the main fluids used in dilution fridges? He 4 and He 3
4. What is the main concept of ADR (adiabatic demagnetization refrigerator) ? What is it based on? What are the ADR advantages ?
   Magneto-caloric property of material. Magnetization/demagnetization phase to produce cold down to ultra-low temperature. No motion part
5. What is the turbo-Brayton cycle ?
   Recuperative cycle with centrifugal compressor and expander with a recuperative heat exchanger, an after-cooler and a cold end heat exchanger
6. What coating is used for radiative shield made of solid materials ? Gold
7. What is the best solution for propellants ? LOx/LH2

- **Day 5 – Large-scale refrigeration and liquefaction**

1. What are the main differences between refrigerators and liquefiers ?

   Large heat exchangers for refrigeration and large extracted cooling power for liquefaction

2. What are the main objectives for cryogenic storages and distribution lines ?

   To achieve the best thermal efficiency

3. What are the safety risks of cryogenic liquid operation if not correctly designed?

   Pressure rise and explosion (*see TI « Safety in cryogenics BE 9814 » for design recommendation*)

4. What are the H2 singularities ?

   Normal H2 (75% ortho + 25% para), ortho-H2, para-H2. Conversion ortho-para required during liquefaction

5. What are the efficiency advantages of the turbo-Brayton systems ?

   Carnot efficiency > 40% achievable over a very large turndown (0-100%) with almost constant efficiency

Thanks all for your participation