HECAL: A cryostat for calibration of hot wires.

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1. Introduction: helium for fundamental turbulence
   A few experiments at CEA/SBT
      SHREK
      HEJET

2. Hot wire anemometry

3. HECAL, measurements
Introduction: research on turbulence

Description of the cascade process still under discussion: intermittency (at small scales) not yet understood.

Models assume infinite Reynolds => interest of HELIUM
Helium properties make it the ideal fluid for fundamental studies.
Examples: (1) the SHREK experiment
Examples (2) the Hejet experiment

The jet is generated by the expansion of the liquid helium which is set in movement by a rotating pump, and cooled via a copper heat exchanger.
Measuring velocity fluctuations: Hot Wire Anemometry

\[ \frac{L}{\eta} \propto Re^{3/4} \]

\[ \Rightarrow \text{Need for very small sensors (}\eta \sim \text{few } \mu\text{m)} \]

Hot wires are the most widespread (and efficient) sensors for measuring the turbulent fluctuations of the velocity,

Principle: convective flux cools the wire & changes its resistance

But: small hot wires are not available commercially

\[ \Rightarrow \text{Developments at CEA Grenoble for:} \]

- Small (micron size) sensors
- Reliable sensors.

\[ \Rightarrow \text{technique of Wollastone hot wires} \]

\[ \Rightarrow \text{Calibration ?} \]
A few equations…

Energy balance :

\[ m C \frac{dT_w}{dt} = R_w I^2 - \pi l k_f (T_w - T_a) Nu \]

King’s law: \[ Nu = a + b Re^n_w ; \quad n=0.5 \]

dependence of Resistance with Temperature

\[ \frac{m C}{\alpha R_0 (A - I^2 + BU^n)} \frac{dR_w}{dt} + R_w = \frac{A + BU^n}{(A - I^2 + BU^n)} R_0 \]

\[ \Rightarrow \text{Need for calibration} \]
\[ \Rightarrow \text{Determination of the time constant} : \quad \tau = \frac{m C}{\alpha R_0 (A - I^2 + BU^n)} \]
HECAL: Calibration of hot wires
Calibration (continued)
Time constant measurement (CCA operation)

As expected, the time constant decreases as the velocity increases.

<table>
<thead>
<tr>
<th>Velocity (m/s)</th>
<th>Time constant (µs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>22.6</td>
</tr>
<tr>
<td>4.4</td>
<td>20.7</td>
</tr>
<tr>
<td>5.6</td>
<td>18.6</td>
</tr>
</tbody>
</table>
Conclusions, more work…

The Hecal provides a calibration tool to characterize hot wires used in Cryogenic facilities. It works in He-I as well as in He-II

Hot wires exhibit a different behavior in He-II

• Need for a higher current in He-II to get the same resistance
• Calibration curve does not fit King’s law, but is sensitive to velocity
• However, time constant depends also on velocity in He-II

Heat transfer in He II is totally different from what happens in He-I

=> More experiments in HeCal for different He-II temperatures, with different heating currents and velocities.
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Thank you for your attention....