High Resolution Validation of Next Generation Turbulent Flow Models Using Neutron Beams, Laser Fluorescence, and Liquid Helium

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**Objectives**

Demonstrate particle tracking velocimetry (PTV) using neutron beams to create metastable He molecules in superfluid helium

Apply technique to map extremely turbulent fluid flow around models with specific geometries

**Background**

Reynolds Number

\[ Re = \frac{VL}{\nu} \]

\( V \) = velocity

\( L \) = characteristic length

\( \nu \) = kinematic viscosity

Modern turbulence data acquired in 1980’s

\( Re \sim 3 \times 10^6 \)

\( Re \sim 3 \times 10^7 \)

\( Re \sim 10^9 \)

**Our Approach**

We are conducting a proof of principle experiment in which we are able to map the temporal evolution of 3D velocity fields that achieve up to \( Re \sim 10^8 \) for large volumes.

This is achieved via the neutron capture by \(^3\)He atoms and optical excitation using high-power lasers that cause the helium to fluoresce.

These tracers only track the normal fluid phase (> 1K) and do not perturb the flow.

**Experimental Setup**

LARMOR Beamline

Optical Path

**Results**

4 successful experimental cycles at ORNL’s High Flux Isotope Reactor (HFIR)

Proved that this reaction can be observed and captured using an ICCD camera

**Future Development**

- Currently improving experimental design and fully automating testing in order to operate continuously with little intervention
- Heat flush technique used to generate counter flow
- Observe flow around specific geometries
- Compare results to turbulent flow models and validate Direct Numerical Simulations (DNS)
- Create user facility at ORNL