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\times10^6

Re \( \sim \) 3\times10^7

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.

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

Experimental Setup

LARMOR Beamline

Optical Path

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