3D LDV MEASUREMENTS IN OSCILLATORY BOUNDARY LAYERS

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OSCILLATORY FLOWS AT THE BOTTOM OF THE SEA:
Getting to understand the processes of interaction between fluid and sediment.
THE OSCILLATORY BOUNDARY LAYER

Bottom → Shear → Turbulence → upward propagation → boundary layer

\begin{align*}
\text{Outer, inviscid region} & \quad u = U = f(\omega t) \\
\text{Inner, viscous region} & \quad u = f(z, \omega t) \\
\text{(boundary layer)} & \quad \tau = f(z, \omega t)
\end{align*}

From Jensen (1988)

Exp. Y6: Smooth bed. \(Re_w = 1.7 \times 10^5\)

Smooth bed, \(Re_w = 3.0 \times 10^5\) From Carstensen et al. (2010)
PREVIOUS EXPERIMENTAL WORK

OSCILLATORY FLOW EXPERIMENTS
Previous studies

Jonsson (1980)
Hino et al. (1983)
Sleath (1987)
Jensen (1988)
Kamphuis (1975)
Pedocchi (2009)

MORE ROUGH
MORE TURBULENT
RESEARCH GOAL

- Characteristics of the mean flow and turbulence in the **laminar-turbulent transition** of the oscillatory boundary layer with **smooth** bed.
Experimental setup: fixed, flat, smooth, PVC floor

Setup team: Andy Waratuke, Andrew Rehn, Nicholas Möller, CEE shop
CHALLENGE: LDV SYSTEM IN 3D CONFIGURATION

- Closed section
- Limited optical access
- Under pressure
- Window thickness
- Refraction
- Traversing 2 probes
- Alignment
- Bubbles
- Reflections
- Seeding particles
3D LDV TRAVERSING WITH 2 PROBES

Focal distance **changes** for top probe when traversing up

Focal distance **is preserved** for top probe when traversing up

CROSS-SECTION VIEW

Submersible probe

Water container
FOCAL DISTANCE CORRECTION: WATER CONTAINER
RESULTS: MEAN VELOCITY

U velocity contours:

- Symmetry both half-cycles
- Phase lead inside boundary layer
- Non-sinusoidal velocity inside boundary layer

Exp. X6: Smooth bed, \( \text{Re}_w = 6.4 \times 10^5 \)
RESULTS: TKE

TKE contours:

• Dominated by \( U \) contribution
• Good symmetry
• Peak turbulence near the bed
• Phase lead with \( U_{om} \)
• Upward propagation in time
• Upper limit of boundary layer thickness

Exp. X6: Smooth bed, \( Re_w = 6.4 \times 10^5 \)