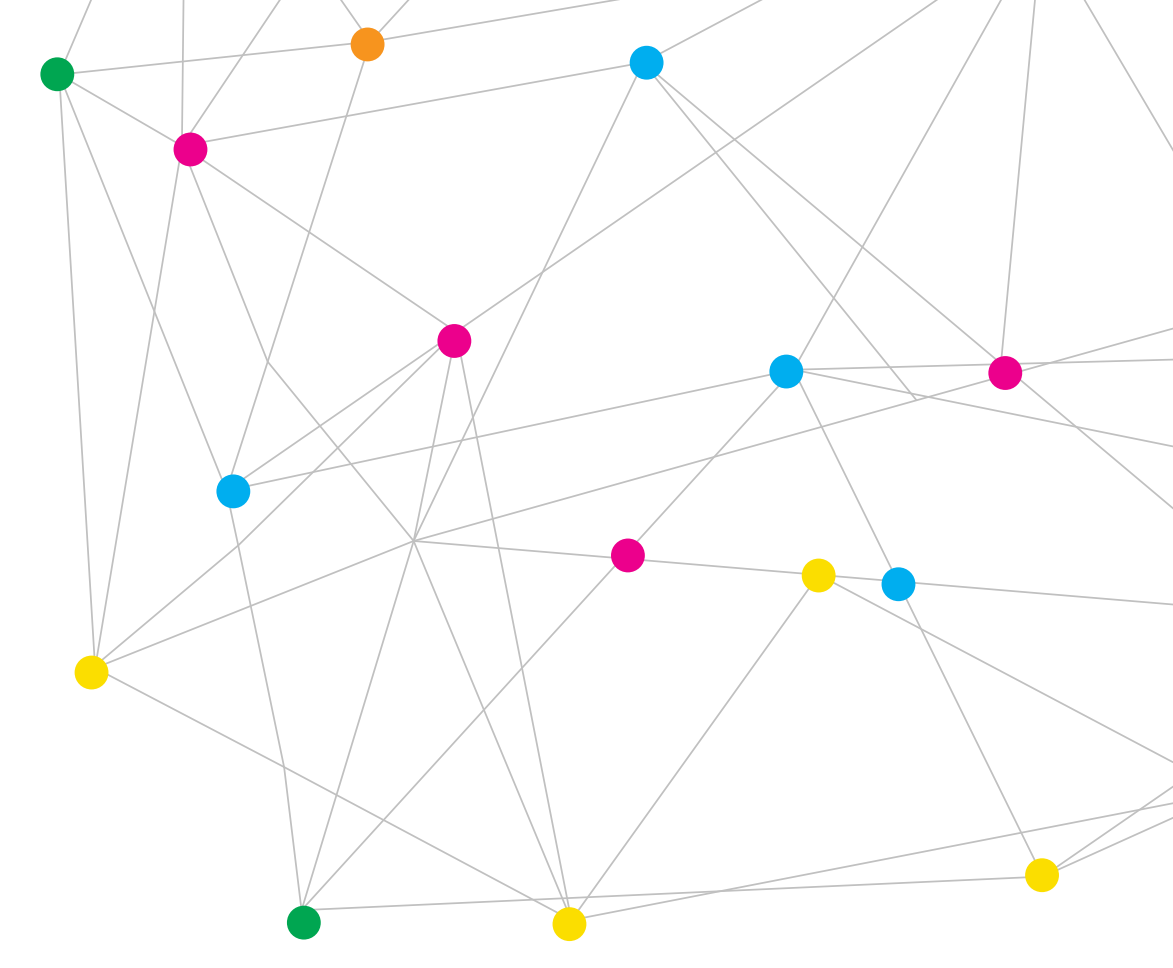


PARTICLE IMAGE VELOCIMETRY (PIV)

QUANTITATIVE FLOW VISUALIZATION



Particle image velocimetry is a laser-based imaging technique that combines the accuracy of non-intrusive point measurements with the global flow imaging capability of flow visualization to obtain time-resolved, instantaneous velocity information over an extended region of the flow.

Measurement Region

- + Small tracer particles are added to the flow
- + Light is scattered from the tracer particles in the light-sheet
- + The measurement region, called Field of View (FoV), increases with pixel resolution:*

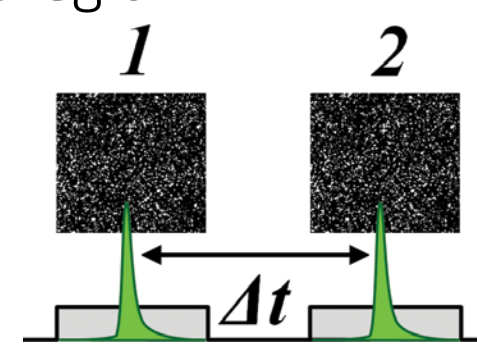
$$FoV = \frac{P_1 \cdot P_2}{M}$$

* P_1 = Pixel resolution of the camera P_2 = Size of Pixels M = Magnification of the Camera Lens



Illumination

- + A laser beam is formed into a light-sheet using a combination of lenses
- + The light-sheet is pulsed, "freezing" the location of particles in the planar measurement region
- + The laser pulses are separated by a known time (Δt)

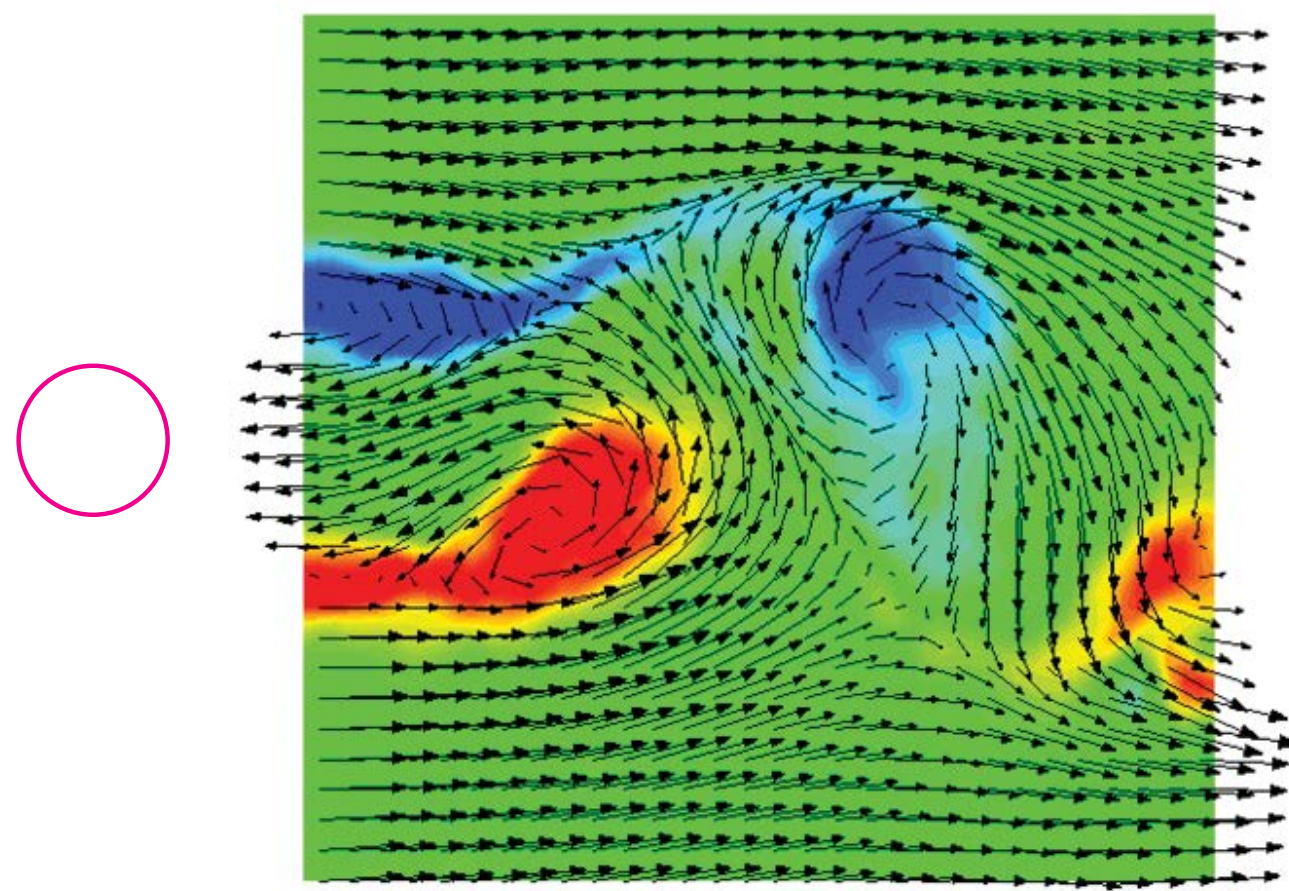


The Camera System

- + A camera captures an image of the particles in the light-sheet
- + The magnification (M) is determined by the camera lens
- + Two images are taken - one corresponding to each laser pulse
- + Images are transferred to a computer for processing
- + Spatial resolution increases with magnification
- + Temporal resolution increases with image capture rate

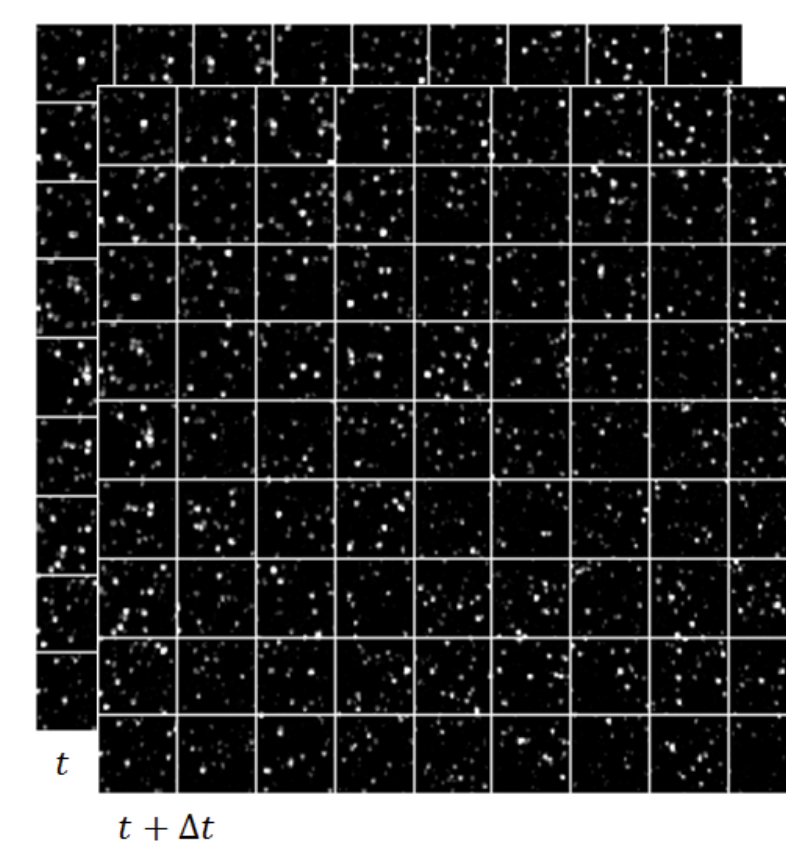
PIV Results

- + Instantaneous planar velocity vector fields
- + Higher-order quantities such as vorticity, shear stress, Q-criterion, and turbulent energy
- + A sequence of images can provide temporal flow characteristics (flow evolution)

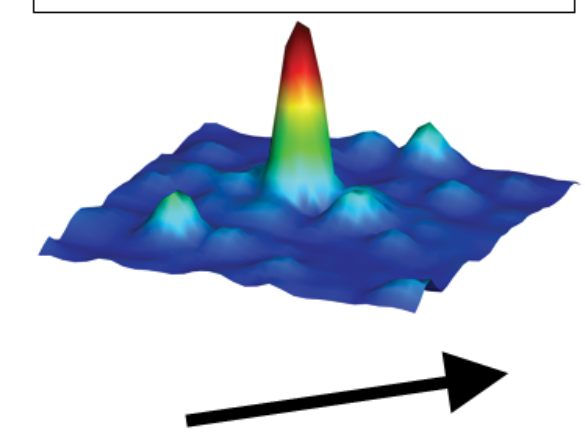


Processing Algorithms

- + Images are divided into many small "interrogation windows"
- + Particle motion (Δx , Δy) between images is determined through cross-correlation
- + Velocity is found by dividing the particle displacements by the time between pulses



$$c(\Delta x) = \int I_1(x) I_2(x + \Delta x) dx$$



$$u = \frac{\Delta x}{M \Delta t}$$

$$v = \frac{\Delta y}{M \Delta t}$$

- + The process is repeated for all interrogation windows to obtain the instantaneous velocity field

Extensions of the Technique

- + StereoPIV - Two cameras at oblique angles can be used to obtain 3D velocity information in a plane
- + Volumetric 3-Component Velocimetry (V3V) - Three cameras are used to determine 3D velocity fields in a volume
- + A high speed camera and laser can be used to obtain time resolved velocity fields



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