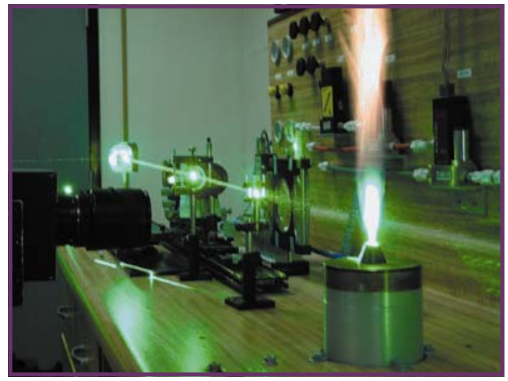
Advantages of Dual Head Laser System for High Speed PIV

Particle Image Velocimetry (PIV) is a well-established measurement technique for characterizing the flow of water and air. The PIV technique has evolved over the years with the PIV camera being the driving component for change. The commonly used CCD camera has gained sensitivity and dropped in price.



FSU Combustion Laboratory

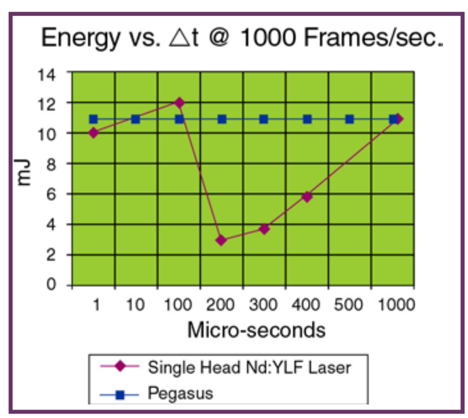
A new camera development over the past two years, the introduction of CMOS cameras, has allowed PIV systems to capture information at much higher flow rates resulting in much higher resolution of flows with respect to time. CMOS cameras can capture images at rates of 1000's of frames per second while their CCD counterparts operate at 10's of frames per second, recently reaching 100-200 frames per second. The availability of high-speed cameras allows researchers using PIV to capture high-speed transient flow phenomena such as found in combustion, vortex shedding and other turbulent flows.

New Laser Light Sources for High Speed PIV

Traditional PIV lasers have two laser heads packaged as one that operate in the 10's of Hz, compatible with the requirements of today's CCD cameras. The introduction of kilo Hertz CMOS cameras for high speed PIV or time resolved PIV, has generated a need for laser light sources that can operate at a CMOS camera's higher frame rate of 1000's of frames per second.

Initially, high repetition rate, high power, *single head*, diode pumped lasers were adapted to high speed PIV. These lasers were originally developed for materials processing and as pump sources for ultra fast femto-second scientific lasers. Specialized, *dual head* high repetition rate, high power lasers, designed specifically for high speed PIV, such as Pegasus-PIV from New Wave Research, were only recently introduced. A dual head high-speed laser, like Pegasus, was introduced to address the shortcomings of single head lasers adapted for high speed PIV.

Flexible Time Between Laser Pulses (△t)



PIV requires precise timing between the first and second laser pulses (△t) to calculate flow speeds. Inter-pulse timing may vary from less than one microsecond to many milliseconds depending upon the speed of the flow. To accommodate a short △t single head laser systems are usually "double pulsed" by releasing part of the energy stored in the laser rod for the first pulse and then releasing the remainder of the energy in the second pulse. This technique works for a limited range of time of △t's, typically 1 – 150 us for Nd:YLF systems. While this is adequate for many high-speed airflow applications, a longer △t is required for many high-speed water flow applications. A dual head system, such as Pegasus, has no such limitation. Each head may be fired independently with pulse spacing of a few hundred nano-seconds to many milli-seconds or even seconds. This allows PIV experiments to be designed for a wide range of air and water flows without regard to the △t limitations of the laser.

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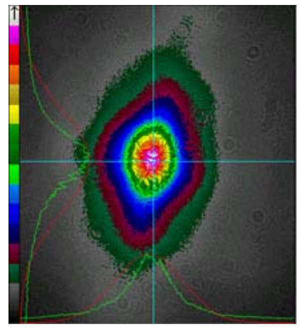
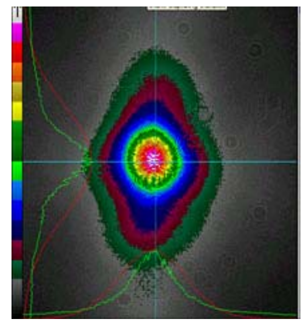
Uniform Beam Quality and Pulse Width From Both Laser Pulses



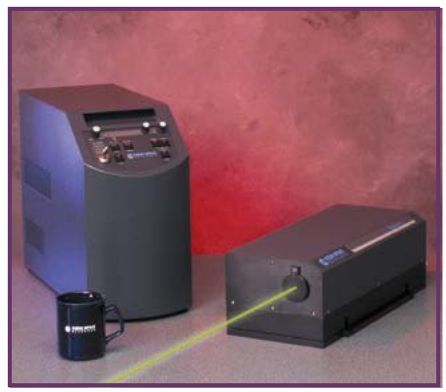
Pegasus Laser #1 Beam



Pegasus Laser #2 Beam

A second limitation of "double pulsed" single head lasers, is the beam quality with respect to the first and second pulse. In a single head laser the second pulse tends to have a "hole" or weak spot in the center of the beam. This is due to the fact that the first pulse tends to deplete the high gain, center portion of the laser rod with the first pulse. Since the energy in the center of the rod is depleted there tends to be a "hole" in the second pulse when it exits the laser head. There is no such "hole" or a weak spot in the center of the second pulse or a longer pulse width for the second pulse since the second pulse comes from a different laser head in a dual head system. In addition, the pulse width of the second pulse is about twice as long as the pulse width of the first pulse. This can be a problem in high-speed airflows that require a very short △t. The uniform beam from both heads allows better cross correlation resulting in a more accurate flow representation because both sets of images are illuminated nearly equally by the two separate heads.

Small Size — Easy to Use



Most PIV experiments require a temporary set up of equipment. When the experiment is completed, the equipment may be moved to a new PIV experiment often in a different laboratory. The small size of Pegasus allows PIV equipment to be moved to the experiment rather than the experiment moved to the PIV equipment. Pegasus is easy to set up and easy to use. Connect the electrical umbilical from the power supply to the laser head and the cooling hoses from the chiller to the laser head. Turn the system on, wait for the water temperature to stabilize and operate the laser as required. Repetition rate and energy level may be changed at any time as required by the experiment without any other adjustments. Pegasus may be operated manually or by computer.

Summary

The introduction of Pegasus, a dual head, high speed laser system for time resolved PIV allows high speed measurements to be made as easily as traditional PIV measurements. The dual head design of Pegasus allows flexibility between pulses (△t) allowing a wide variety of PIV flows to be studied. Dual heads assures uniform beam quality allowing successful cross correlation and reliable results. The small size of Pegasus and its ease of use permit PIV experiments to be set-up quickly allowing users to focus on characterizing air and water flows and not on operating the equipment.

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