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Five-beam Fabry-Perot velocimeter*

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Introduction

Velocimetry is useful in diagnosing many properties of high-explosive (HE) systems. The shock pressure of the detonation wave in HE is often measured by noting the velocity of an interface between the HE and a known material. Properties of the equation of state (EOS) of an explosive can be measured in a cylinder event using a combination of velocimetry and other diagnostics. Point-initiated explosions driving large plates give additional information regarding HE EOS. Hemispherical booster shots give quantitative data pertaining to booster performance. Velocimetry is used routinely to measure the performance of detonators. Velocimetry will be a particularly effective tool in cylinder shots, flat plate, and booster shots to determine the effects of aging on the EOS of explosive components in stockpile devices.

Background

Most velocities of interest in explosives research are in the range of a few to several km/sec. The simplest and least intrusive method of diagnosing velocity in this range utilizes the Doppler shift of light reflected from a moving target. The light is then passed through a sensitive wavelength discriminator to measure the Doppler shift of the return light. The standard wavelength discriminator used at LLNL is the Fabry-Perot interferometer. Figure 1 shows schematically a typical Fabry-Perot velocimeter setup.

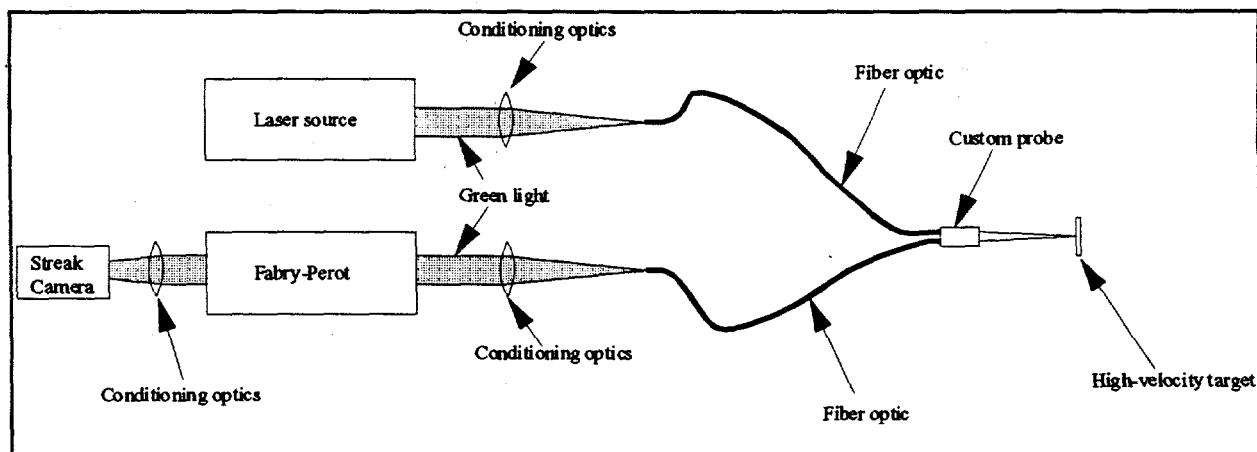


Fig. 1. Schematic layout of typical Fabry-Perot velocimeter. The laser source is normally an Argon ion or Nd:YAG laser operating at $\lambda \approx 500$ nm. The probe is a custom LLNL design optimized for maximum returned light and depth of field. The fiber optic transport allows the probe to be conveniently placed in relation to the target.

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Two points, in particular, must be addressed with this system. First, the laser power and optical delivery system efficiency must allow the probe to collect sufficient light for analysis. Usually, the high-velocity target of interest is diffuse at rest and becomes more diffuse as movement progresses - particularly for an explosive experiment. This diffuse target gives a low quality reflection, making it difficult to collect sufficient light for analysis. The velocimeter described here utilizes a powerful laser, coupled with an efficient distribution and collection system to address this issue. The second issue to address is the property of the velocimeter of Fig. 1 that precludes observing spatial information. The Fabry-Perot system described above only allows velocity to be obtained at a single spatial point. Many experiments require that the velocity be known at several points. We address this issue by integrating several probes into the velocimeter.

Description of the Velocimeter

The velocimeter described here (designed by Goosman) will be used in conjunction with the explosives firing tanks in the High Explosives Application Facility (HEAF) at LLNL and is very similar to three other velocimeters at the LLNL Site 300 (LLNL's explosive test site) and at the Nevada Test Site (NTS). The firing tank allows explosions with the equivalent of 10 kg of TNT and is operational today. The velocimeter will allow up to five channels of velocity data to be recorded for a single event and should be operational near the end of 1996. The fiber optic transport system will allow independent targeting of each channel for spatial flexibility. Independent triggering and a dedicated streak camera with variable record length for each data channel will give temporal flexibility. A frequency-doubled Nd:YAG laser producing an output beam of $\lambda = 532$ nm will be used as the laser source for the velocimeter. This custom laser will be similar to the lasers used at Site 300 and NTS and will produce over 1 kW of power for 80 μ s. An active feedback system ensures that the intensity will be constant in time over the duration of the pulse. The laser beam will be split five ways with one fifth of the beam directed to each probe. The fiber-coupled probes are used currently with the Site 300 velocimeter and were designed to give maximum efficiency and depth of field. The fiber delivery system has been carefully matched to give maximum transmission with little distortion of the data. The total cost of the velocimeter is expected to be approximately \$1.2M, with funding provided from several sources. High-speed rotating-mirror camera diagnostics are also available for use on experiments in the 10 kg firing tank.

Conclusion

Once operational, the velocimeter will provide valuable data regarding performance of HE in stockpile devices. The use of the HEAF firing tank will provide significant cost savings over open firing facilities (Site 300). It will also free up Site 300 for the larger explosive events that it was designed to handle.