

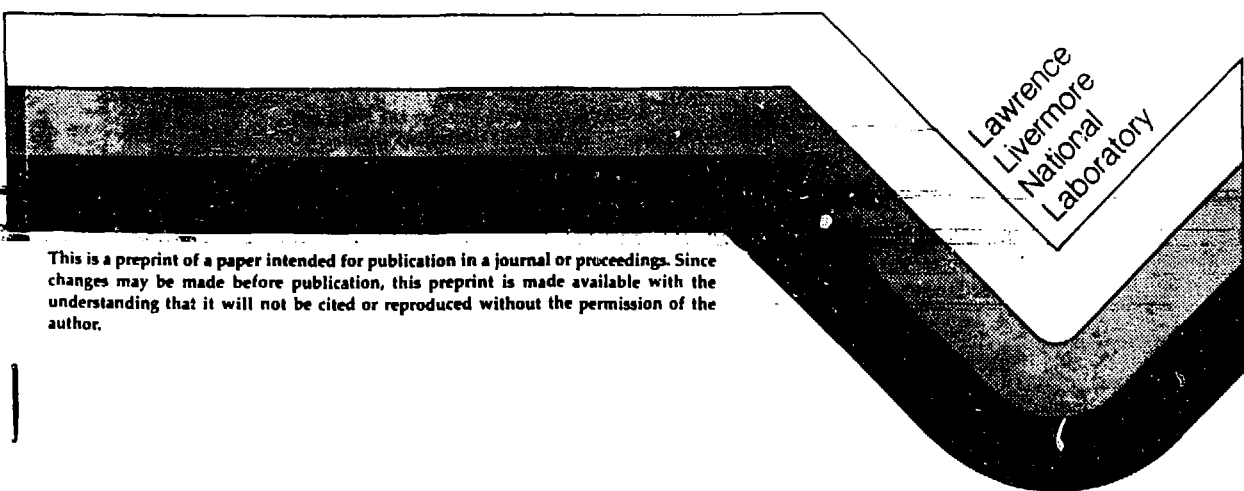
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LASER-HETERODYNE INTERFEROMETRY
WITH STREAK CAMERA DETECTION

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ABSTRACT

The spatial interference pattern between a cw laser local oscillator and a pulsed laser (40-80ns pulsewidth) is recorded by an electronic streak camera. Analysis yields time dependent wavefront and frequency chirp characteristics of single laser pulses.

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Wavefront and frequency characteristics of pulsed lasers are of interest in many applications, including laser oscillator design, beam propagation, and atom-field interactions. We have used a frequency-stabilized cw ring dye laser as a local oscillator (frequency jitter < 1 MHz) in an optical heterodyne interferometer to characterize a pulsed dye laser with baseline pulsewidths of 40-80ns. Streak camera detection of the heterodyne interferogram enabled us to obtain both spatial and temporal information from a single pulse.

Local oscillator light was delivered to the interferometer (Figure 1) through a single mode fiber whose collimated output served as both a frequency and wavefront reference. The frequency-difference $\Delta\nu$ between the two lasers was tuned in the range of 0-300 MHz, resulting in a spatial interference pattern with fringe velocity proportional to $\Delta\nu$. A conventional heterodyne detector using a fast photodiode¹ aided in monitoring $\Delta\nu$ while a gated intensified camera (gatewidth < 100 ns) was used to view the fringes within a single laser pulse. With the camera synchronized to the laser system, the two dimensional spatial interference pattern was viewed at video rates with increasing fringe visibility as $\Delta\nu$ approached zero.

The wavefront along a single spatial slice of the beam was monitored as a function of time during the pulse by imaging the interfering wavefronts onto the narrow slit of an electronic streak camera (200ps resolution) which was read out with a low noise CCD camera. Several waves of tilt were

introduced between the beams to produce nominally straight carrier fringes perpendicular to the entrance slit of the streak camera. The streak record yields fringes having a slope dx/dt that are proportional to the instantaneous frequency difference between the two lasers.

Figure 2 shows typical data from a strongly pumped single-mode pulsed dye laser. Streak data fringe centers were hand-digitized with a video cursor and then fit with fourth order polynomials. Assuming a spatially uniform wavefront, the instantaneous frequency is obtained directly from the fringe slope as shown in Figure 3 for each fringe. The temporal profile for this pulse was approximately triangular in shape with 85% of the pulse energy contained in the first 35ns.

The data have also been reduced along slices in the spatial domain (at fixed time) by Fourier transform fringe analysis techniques² to detect changes in the wavefront during the pulse. This information, as well as that derived from two dimensional polynomial fits in the x-t plane, can be used to test models of wavefront behavior in the presence of chirp.

1. The photodiode-based system was provided by R.W. Wyeth, M.A. Globig, and M.A. Johnson (LLNL).
2. D.J. Bone, H.-A. Bachor, and R. J. Sandeman, Appl. Opt. 25, 1653 (1986).

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FIGURE CAPTIONS

- Figure 1 Heterodyne-interferometer system with streak camera readout. The two laser beams are overlapped on the recombination beam splitter to produce spatial interference fringes. An image plane of the laser system is relayed to the two cameras shown.
- Figure 2 Digitized fringe centers (dots) obtained from the streak camera record with associated fourth order polynomial fit (lines). Fringe spacing is one wave.
- Figure 3 Frequency chirp derived from the polynomials of each fringe in Figure 2 under the assumption of a plane wavefront throughout the laser pulse.

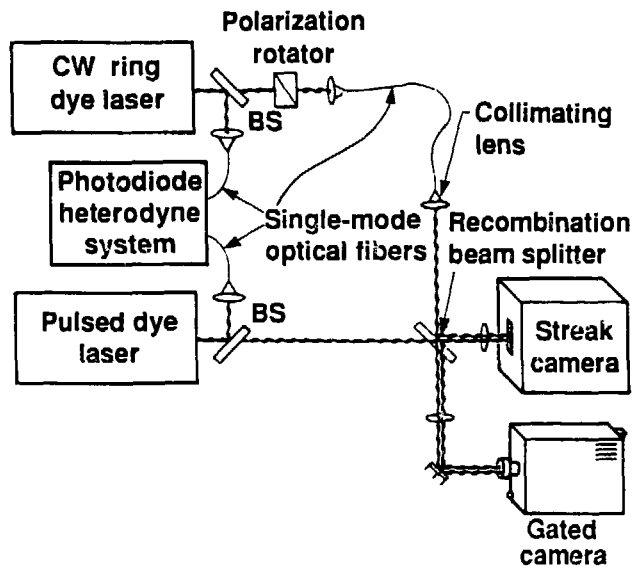


Figure 1

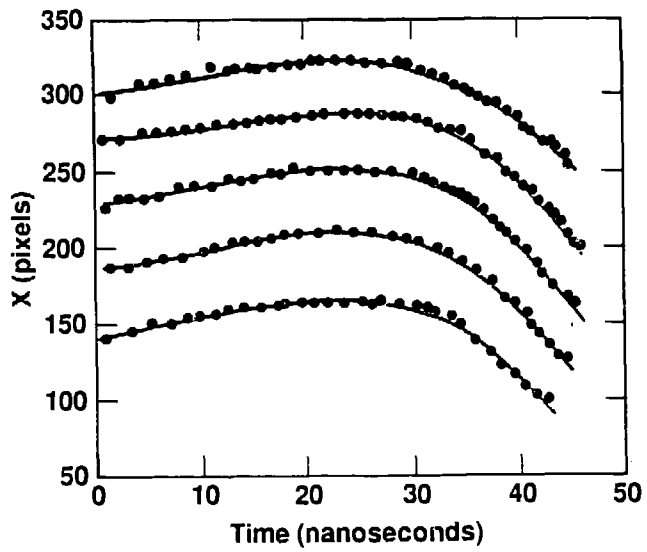


Figure 2

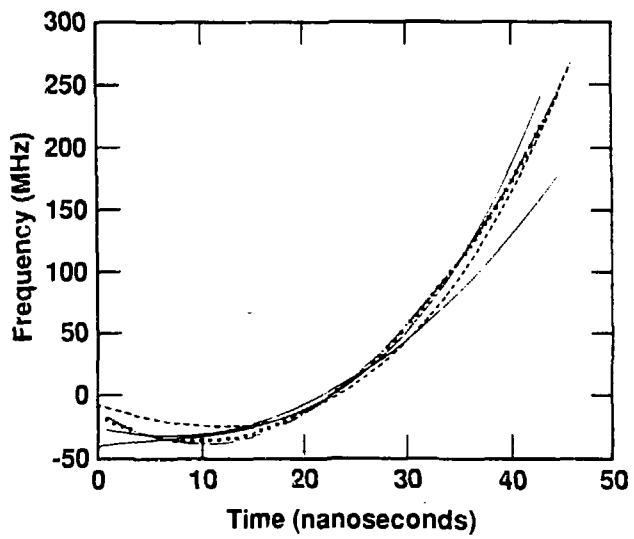


Figure 3