Acoustic Measurements on NLCTA structures (Feb. 22 2000)
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Accelerometers were attached to each end of a 1.8M X-band structure in the NLCTA. The accelerometers were aligned to measure longitudinal waves along the structure, but were probably also sensitive to transverse waves. RF pressure, RF induced thermal expansion, and breakdown could produce acoustic waves.

Comparison of RF pressure and RF induced thermal expansion waves: Note that both RF pressure, and thermal effects would produce acoustic amplitudes which scale with power. We do a rough estimate:

The pressure from an electromagnetic wave is given by $2P/c$, with $P$ the power density (assuming ~100% reflection). This pressure is distributed over a depth proportional to the skin depth.

An electromagnetic wave will also heat material within the skin depth. The fraction of incident power absorbed by a conducting material is $r = \frac{k\delta}{4}$. For 11.424GHz, and copper, the skin depth is ~600nm, giving $4x10^{-5}$ absorption. The diffusion time in copper is given by $\tau = \frac{CL^2}{4\rho}$, or for copper, 8600 s/m². For our skin depth, that gives $3\text{ nsec} \ll \text{pulse width}$. The diffusion depth then is a few microns for our conditions. The temperature rise is $\Delta T = P_{abs}\frac{t}{K\rho C}$. This is $2.7x10^{-5}$ °K sec.$^{-1/2}$ W$^{-1}$m$^2$. This gives per incident watt $\Delta T = 1.1x10^{-9}$Pt$^{1/2}$. Using the coefficient of expansion of copper, and its stiffness, we get pressure $= 2x10^6$ Pascals/°K. Combining we get $2.1x10^{-3}$ Pascals sec$^{-1/2}$. W$^{-1}$ M$^2$. When we plug in 100 nanoseconds for a pulse length, we get $6x10^{-7}$ Pascals W$^{-1}$ M$^2$. This compares with the radiation pressure of $6x10^{-9}$ Pascals W$^{-1}$ M$^2$ for radiation pressure. For our pulse lengths, the thermal pressure is approximately 100X the radiation pressure.

Accelerometers: Sensitivity was 1V/G, from 2 Hz to 5KHz, with a resonant frequency of ~25KHz.
Measurement of Acoustic Delay

The structure was “tapped” at various locations. The time delay between the first signals observed on the acoustic detectors was measured. It was hoped that the impulse from a structure breakdown could be localized using this method.

Note that a wave speed of approximately 1900M/Sec was measured. The published shear wave speed for Copper is 2325M/Sec, the longitudinal wave speed is 4760M/Sec. We assume that even though the sensor was aligned for pressure waves, it is measuring shear waves.
Measurement of RF induced acoustic signal

The acoustic signal for normal RF (no breakdown) was very strong. This effect swamps any attempt to localize arcs, but is interesting. The output acoustic amplitude was measured with a AC voltmeter, sensitive to at least 20KHz.

The measured RMS error was 1.7MV, or about 1% of the measurement. This may have been due to errors in the RF power measurement.