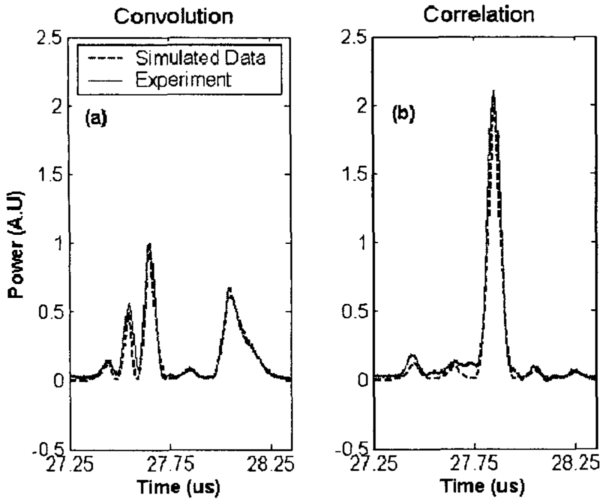

CMU2 Fig. 2. Echo output of programmed 5-bit bi-phase Barker code pulse shaper probed with same code producing (a) convolution when the probe is the time forward and (b) correlation with the probe is time reversed.

trol, we programmed the sequence first with return to zero (resolution limited) binary amplitude coding (Fig 1a) and then with binary phase (0, π) coding (Fig 1b). The nulls in the output of the bi-phase representation correspond to the phase flip of the data. The unusual modulation on the envelope for repeated bits is due to our detectors low-bandwidth limit. The output also experiences coherence decay as the time delay increases, but adjusting the relative amplitude of the programming chirps can compensate for this decay.

To test the ability of this method to perform correlations and convolutions, we programmed the bi-phase 5-bit Barker code (1,1,1,–1,1) as delays into the material. We probed the grating with time-forward and time-reverse version of the code, which yielded the operations of convolution and correlation, respectively. The experimental outputs are shown in figure 2, along with the theoretical convolution and correlation.

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CMU3 Invited **4:15 pm**

An Optically Smart X-Band Antenna Array

Dana Z. Anderson Edeline Fotheringham, Jacques H. Loui,† Darko Popovic,† Paul Smith,† Stephania Romisch,† and Zoya Popovic,† Department of Physics and JILA, †Department of Electrical and Computer Engineering, University of Colorado, Boulder, CO 80309, U.S.A., Email: dana@jila.colorado.edu

We demonstrate an optical processor that extracts the principal components of the spatiotemporal signals incident on an X-band antenna array. The entire system, including the microwave receiver and optical processor is packaged in a 33 cm × 45 cm by 15 cm briefcase and consumes less than 50 W of continuous power. The adaptive receiver system can be used, for example, to mitigate multipath interference effects, and can separate one received signal from another even though their power spectra may entirely overlap.

The receiving antenna is a 10 GHz antenna lens array that preprocesses the input signals by mapping incoming signal direction to position along a focal arc. Signals received by two detectors on the focal arc are down-converted to a 140 MHz IF and then placed on an optical carrier using a two-channel optical phase modulator made of a single crystal of lithium niobate. The optical source is a 150 mW diode-pumped single frequency solid-state laser. To prevent spurious signal correlation the optical carrier must be eliminated from the signal-bearing optical beams. This is with a two-beam coupling interaction in a photorefractive crystal. Separate measurements of the carrier suppression show up to better than 70 dB carrier reduction. A photorefractive oscillator that we refer to as an "auto-tuning filter" processes the carrier-suppressed output of the modulator. The oscillator uses two photorefractive crystals, one to provide gain and one to enhance mode competition. The auto-tuning filter extracts the largest principal component from the incoming spatially and temporally modulated optical beam. One output of the filter is thus the largest principal components and the other output contains the remaining principal component(s).

The filter output that carries the largest principal component is detected with a photodiode and is further amplified. The current system is designed with frequency modulated (FM) signals at the IF in mind. Demodulation of FM encoded signals takes place after the optical detection.

A pair of 10 GHz transmitters with horn antennas is used to characterize and demonstrate the prototype. The test signals are derived from two compact disc players; they are first up-converted to the IF and then imposed on 10 GHz carriers. The two microwave signals are received and processed by the system. The demodulated audio output drives a loudspeaker. Under the appropriate circumstances only the stronger of the two audio signals appears. Component and end-to-end system measurements give quantitative indicators for the usefulness of optical processing in wireless communications.

CMU4 **4:45 pm**

Broadband Operation of a Radio Frequency Spectrum Analyzer Based on Spectral Hole Burning

Ivan Lorgeré, Vincent Lavielle, Jean-Louis Le Gouët, Laboratoire Aimé Cotton, bâtiment 505, Campus Universitaire, 91405 Orsay Cedex, Email: jean-louis.legouet@lac.u-psud.fr

We recently demonstrated the principle of radio frequency spectrum analysis based on the engraving of multiple monochromatic gratings in a Spectral Hole Burning (SHB) material.[1] This device is considered for applications in RADAR and sub-millimeter wave astronomy. In the first experiment, the frequency scanning procedure limited the bandwidth to 35 MHz. With a new broadband setup we have achieved an instantaneous bandwidth of 2.5 GHz and demonstrated the spectral zooming capability of the analyzer.

A set of monochromatic gratings is engraved in a SHB material. Each grating diffracts a single spectral component, with a resolution ultimately determined by the homogeneous line width of the SHB medium. A large number of gratings can coexist within the inhomogeneous width of the absorption line. By varying the engraving laser frequency in synchronism with the angle of incidence, one associates a specific diffraction angle with each specific spectral component. Therefore, the different spectral components of an incident polychromatic probe beam are diffracted and simultaneously retrieved in different directions. The grating set works as a spectrometer that is expected to exhibit MHz resolution and tens of GHz bandwidth.

The SHB process on the $^3H_4 \leftrightarrow {}^3H_6$ transition of Thulium ions embedded in a YAG crystal offers the expected bandwidth and resolution. As illustrated on Fig. 1, beams #1 and #2 perform the engraving. The laser frequency is swept over a 2.5 GHz interval in synchrony with the angular scan of beam #1. With the counter propagating box configuration, the phase-matching condition remains satisfied as beam #1 direction is varied.

Since the burnt spectral holes are rapidly erased by the spontaneous return of the ions to their ground state, one continuously refreshes the