MOSAIC LabVIEW Software

D. A. Bender, M. P. Hasselbeck, M. Sheik-Bahae
Department of Physics and Astronomy, University of New Mexico
Contact: dnbender@unm.edu *or* mph@unm.edu, www.optics.unm.edu/msbahae/
Last updated: Feb. 2005

MOSAIC is a LabVIEW program that monitors chirp present on femtosecond laser pulses from their interferometric auto-correlation (IAC) traces. This monitoring allows for real-time dispersion control of laser systems. MOSAIC traces display much higher sensitivity to chirp than a traditional IAC. The program can make real-time analysis using a digital oscilloscope and can also analyze existing IAC traces [1,2,3].

INITIAL INSTALLATION

- Double-click the file MOSAICv1.4.
- This is a beta test VI (Virtual Instrument) that was developed with LabVIEW 7.1. The user must establish a connection with a high-bandwidth digital oscilloscope using a VISA session. This can be done through the National Instruments Measurement and Automation Explorer program that is bundled with LabVIEW. If a GPIB card is already installed for another LabVIEW program that uses VISA, MOSAIC will make this resource accessible on the front panel of the VI under a pop up menu titled **VISA resource name.**
- When opening the program for the first time, the user may be asked to locate missing sub-VI's. These are located in the .llb library files. When exiting MOSAIC for the first time be sure to save changes by clicking "Yes to All." This ensures that when starting the program again, the user will not be prompted to relocate the necessary support VI's.
- The program requires a minimum oscilloscope record length of 2500 waveform samples. Longer record lengths will give cleaner MOSAIC traces but slow down the data acquisition rate.

USER CONTROLS

- **Data Source** selects between modes of operation. **TDS 500, 1k2k, 3k** and **PCI 5122** are options available to select the real-time interface that retrieves IACs from a digital oscilloscope. **Data file** allows the user to compute MOSAIC traces for previously saved IAC files. The user will be prompted for the file location when the program is run. The program accepts .dat or .txt files. **Column with IAC data** selects the column within the data file that contains the IAC signal. If you are analyzing data files that were created with the MOSAIC program, the IAC signal will be in column two for the Fourier tab and column 3 for the envelope tab.
- **Source** refers to the channel on the oscilloscope with the IAC signal. The default value is Channel 1.
- **Wavelength** is the center wavelength of the laser spectrum. This value is used to compute the pulse width (FWHM) assuming a hyperbolic secant profile. The default value is 800 nm.
- **Details** when this button is depressed the lesser-used controls of the MOSAIC program are hidden.

D. A. Bender, M. P. Hasselbeck, M. Sheik-Bahae
Department of Physics and Astronomy, University of New Mexico
Contact: *dnbender@unm.edu or mph@unm.edu, www.optics.unm.edu/msbahae/*
Last updated: Feb. 2005

- **Points defining a peak** allows the user to adjust the resolution of the fringe counting algorithm that analyzes the IAC. The minimum and default value of this control is 3. If the data is noisy, this number should be increased.
- **Threshold** determines how MOSAIC will analyze the IAC fringes. This value sets the minimum fringe amplitude of the normalized IAC; fringes below this threshold are ignored. The range of user control is between 0 and 1 and the default value is 0.5. **Threshold** is not a critical parameter and should be adjusted, if necessary, in response to noise on the waveform.
- **FWHM** is the calculated full-width half-maximum of a sech^2 pulse in femtoseconds.
- **Check for MOSAIC updates** pressing this button opens your Internet browser to the MOSAIC homepage. New versions of the program can be downloaded here.
- **Stop/Save** stops the program and asks the user if they wish to save the last IAC and MOSAIC trace displayed. If you choose to save, a dialog box is opened. Specify the file name and file type (.txt or .dat). MOSAIC will create a file with 3 columns of numbers. The first column is time (fs), the second is IAC signal, and the third is MOSAIC waveform. The length of the columns is set by the record length.
- **Fourier Domain Diagnostics**. This tab selects the Fourier domain interface. Controls are as follows:
    - If the IAC data is noisy or the record length is large (~50,000), increase the **points defining a peak** value to avoid detecting false peaks in the noise.
    - **σ-factor** adjusts the spectral width of the filter function. Increasing σ decreases the width of the filter in the frequency domain. This is not a critical parameter and can be adjusted so that $\tau_p\omega_o > \sigma \geq 1$, where τ_p is the FWHM of the pulse and ω_o is the laser angular frequency. The default value of σ is 5.00. The goal in MOSAIC analysis is to resolve the baseline shoulders that indicate the presence of frequency chirp.
    - **Suggested σ-factor** is a value of σ determined by the program that is likely to render a clean MOSAIC trace. Depending on the quality of the IAC, the suggested σ-factor may or may not give the best MOSAIC trace. It is a starting value and the user should experiment with this value and observe the effect on the MOSAIC waveform.
    - **Intensity order** displays the order of the detected IAC signal. The MOSAIC algorithm can determine the order of the autocorrelation with high accuracy. This value will be 2 for an ideal second-order detection scheme (i.e. the IAC signal goes as I^2).
    - **Zero delay correction** allows the program to correct for deviations from an ideal second-order response. When the correction is selected, the program automatically accounts for departures from I^2. With this option turned on, the **correction** will also be displayed. A value of zero means the detection scheme is behaving ideally. Use this feature with caution; see the TROUBLESHOOTING section below.

D. A. Bender, M. P. Hasselbeck, M. Sheik-Bahae
Department of Physics and Astronomy, University of New Mexico
Contact: *dnbender@unm.edu or mph@unm.edu, www.optics.unm.edu/msbahae/*
Last updated: Feb. 2005

- **Shoulder Height (%)** displays the height of the shoulder relative to the peak of the MOSAIC trace. An unchirped pulse would have a **Shoulder Height (%)** equal to zero.
- **FFT peak location** displays the location of the ω_o peak. This numerical value of the peak location should correspond to the visual location of the first peak. The lower plot is the filtered IAC spectrum.
- **Averaging mode FFT** selects between different averaging algorithms to apply to the power spectrum. The default is no averaging
- **Weighting mode** specifies the weighting mode used for RMS and vector averaging applied to the power spectrum.
- **Number of averages** specifies the number of averages that is used for RMS and vector averaging. If **weighting mode** is exponential, the averaging process is continuous. If **weighting mode** is linear the averaging process stops after the selected **number of averages** have been computed.
- **Window** specifies the time domain window to apply in calculating the power spectrum.
- **Restart averaging** resets the power spectrum when averaging is in use.
- **Peak hold** maintains the position of a peak in the power spectrum allowing for unstable signals to be averaged.

- **Envelope**. This tab selects the envelope interface. Some controls of this tab are identical to the **Fourier Domain Diagnostics** tab; a description of the duplicate controls is found in the **Fourier Domain Diagnostics** description above. The controls unique to the envelope tab are as follows:
  - **Cutoff frequency** selects the cutoff frequency used in the Chebyshev filtering scheme. The value of the cutoff frequencies must obey the Nyquist criterion:

$$0 \le f < \frac{1}{2} f_s$$

    where f is the cutoff frequency specified by the user and f_s is the sampling frequency. The cutoff frequency is automatically normalized to the sampling frequency; therefore, the numerical range of this control is (0,1/2]. The best MOSAIC traces are typically obtained when these values are equal. The user is encouraged to vary these values to produce the cleanest MOSAIC traces.
  - **Order**. Selects the order of the filter. The higher the order, the sharper the filter rolloff.
  - **Average**. Turning this feature on will allow the MOSAIC trace to be averaged. The number of traces averaged is selected by the user in the **# of waveforms to average** control. The minimum value for this control is

D. A. Bender, M. P. Hasselbeck, M. Sheik-Bahae
Department of Physics and Astronomy, University of New Mexico
Contact: dnbender@unm.edu *or* mph@unm.edu, www.optics.unm.edu/msbahae/
Last updated: Feb. 2005

two. The averaging feature works with both the corrected and uncorrected MOSAIC option.

- **Split correction.** When this function is on, MOSAIC is computed using noise compensation algorithms. In low signal-to-noise applications, splitting in the wings of the maximum and minimum traces in MOSAIC is visible.
- **View log scale** toggles between a linear and logarithmic y-axis scale on the MOSAIC trace.

TROUBLESHOOTING

The MOSAIC trace must touch the baseline near zero delay, even with a badly chirped pulse. If the center of the trace fails to reach the baseline or extends far below it, there is a problem with alignment, electronic bandwidth, or the nonlinear response of the detection system. An example of a distorted MOSAIC trace is depicted in Figure 1.

- Although the IAC waveform may look acceptable, optimum alignment of the autocorrelator is necessary to display a meaningful MOSAIC trace. MOSAIC requires high fringe visibility on the detector and this means that the interfering beams must be as parallel as possible. The presence of a multiple fringes at the detector indicates the autocorrelator is not optimally aligned. An ideal alignment will cause the interferometer output to transition from bright to dark as it is scanned. MOSAIC is highly sensitive to this alignment.

- Similar problems can occur if the electronic detection bandwidth is insufficient. MOSAIC uses the spectral components of interference at twice the temporal fringe frequency. Failure to provide adequate bandwidth from either the detector or oscilloscope (eg. programmed bandwidth limit, RC time constant at input connection, sample record length) may yield an unacceptable MOSAIC trace even though the IAC displays properly.

- If the detector deviates from an ideal quadratic response, the MOSAIC trace will appear distorted. The program has a correction feature to compensate for this problem; see **Zero delay correction** above. Users are encouraged to optimize alignment and response first; the auto-correct feature should be used as a last resort.

D. A. Bender, M. P. Hasselbeck, M. Sheik-Bahae
Department of Physics and Astronomy, University of New Mexico
Contact: *dnbender@unm.edu or mph@unm.edu, www.optics.unm.edu/msbahae/*
Last updated: Feb. 2005

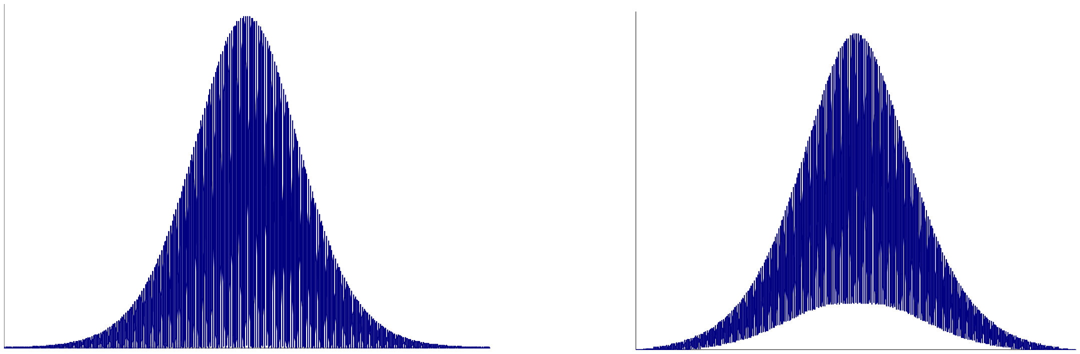

Figure 1. MOSAIC traces from a properly aligned autocorrelator (left) and a misaligned autocorrelator (right) using a chirp-free pulse. Serious distortion such as shown in the right figure may occur as the result of misalignment or insufficient electronic bandwidth.

References

[1] M. Sheik-Bahae, Opt. Lett. **22**, 399 (1997).

[2] T. Hirayama and M. Sheik-Bahae, Opt. Lett. **27**, 860 (2002).

[3] M. Sheik-Bahae , *Interferometric Auto-Correlator Using Third-Order Nonlinearity* U.S. Patent #6,108,085; (2000)

Visit www.optics.unm.edu/sbahae/research/mosaic/ for updates.