

MIIPS™ application notes What can you do with MIIPS™?

Experimental Search Space Mapping for Optimizing Selective Nonlinear Excitation

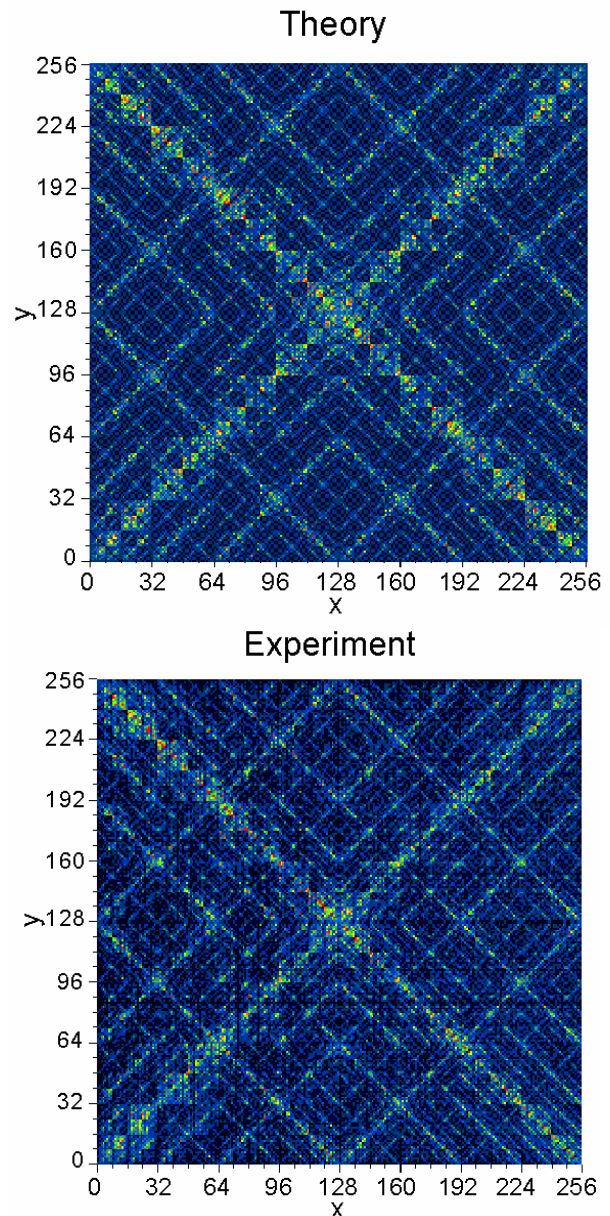
Selective nonlinear excitation is important for many kinds of spectroscopy, in which a single process is to be optimized while unwanted processes are suppressed. The use of a ultrabroad bandwidth (10 femtoseconds or less) source for selective excitation, rather than a nearly monochromatic source, has the advantage of higher efficiency, due to its shorter duration. Pulse shaping can be used to provide selective excitation at any wavelength or range of wavelengths within a broadband laser's spectrum, without changing the pulse's fundamental spectrum. A broadband pulse can therefore behave like a tunable femtosecond laser source, but one that does not change the way it travels through a microscope system as it tunes, and that can be tuned simultaneously to multiple wavelength ranges.

The difficulty in producing selective excitation is choosing the pulse shape that optimizes excitation at one wavelength in a pulse's nonlinear spectrum while suppressing excitation at all other wavelengths. The figure at the right shows one approach: exhaustive experimental evaluation of a set of pulse shapes to learn about general trends. The results of this evaluation are displayed via search space mapping, which transforms phase functions into coordinates in a 2D map. An experimental map for maximizing S/B at the center wavelength of the zeroth order spectrum (which governs stimulated Raman scattering) is shown, along with theory. Note that this excellent agreement between theory and experiment is possible only if the spectrum of the experimental laser pulse can be precisely and reproducibly predicted. The maps reveal that symmetry is the most important parameter for maximizing S/B; the optimal pulse shapes (shown in red) appear along the diagonals, where symmetric phase functions are located in a search space map. Further theoretical and experimental investigation confirms this insight.

References:

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Search space maps showing optimization of signal at the center of the second-order spectrum (used for SHG and two-photon excitation). Red denotes pulse shapes producing the highest Signal/Background ratio, while black shows lowest Signal/Background. Figure courtesy of the Dantus Research Group.

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