Spectral Focusing Timing and Recombination Unit (SF-TRU)

For Multiphoton Imaging and Ultrafast Spectroscopy Applications

Newport's Spectral Focusing Timing and Recombination Unit (SF-TRU) is the second generation of the TRU family, specifically designed for dual-output laser sources, such as the Spectra-Physics InSight® X3+™ and InSight® X3™. The SF-TRU facilitates a variety of single- and dual-beam, multiphoton imaging and ultrafast spectroscopy applications, such as single- and multi-color two-photon fluorescence, second and third harmonic generation, coherent anti-Stokes Raman scattering (CARS), stimulated Raman scattering (SRS), pump-probe, transient absorption and others. Developed by scientists in the MKS Technology and Applications Center, the SF-TRU module enables hyperspectral CARS/SRS imaging with spectral resolution up to 5 cm^{-1}. High spectral resolution is achieved by employing spectral focusing with tunable-distance grating pairs, which, in contrast with fixed-length glass rods, allows matching the spectral resolution and the linewidths of the Raman lines of interest.

Inside the SF-TRU, each beam is equipped with a motorized ultrafast variable attenuator for power control. Additionally, each beam path has a telescope to fill the back aperture of the microscope objective and to focus the two beams in the same focal plane. The fixed-wavelength beam at 1045 nm is passed through a high-precision Newport DL125 motorized delay line stage and a resonant electro-optic amplitude modulator (EOM) for lock-in detection of SRS signal*. Each beam is passed through a grating pair with adjustable dispersion for controlling the chirps. The device allows simple switching from a single- to a dual-beam collinear setup, and from femtosecond to chirped picosecond pulses, without affecting alignment.

SF-TRU (lid removed)

Product Features

- Flexibly designed to work with dual-wavelength, dual-output laser sources, such as the Spectra-Physics InSight X3+ and InSight X3
- Includes grating pairs to enable spectral focusing
- Easily switch between single- to dual-beam, and fs to ps output modes, while maintaining beam alignment
- Includes two, motorized, Newport ultrafast variable attenuators with 0 – 2 OD (standard)
- Includes a resonant EOM* for SRS/CARS imaging
- Ultrafast dielectric mirrors (standard) in the tunable beam path
- Temporally and spectrally distortion-free
- Size (L x W x H): 30 x 18 x 7.75 in {76.2 x 45.7 x 19.7 cm} (excludes external controls and handles)

*EOM resonant frequency should be specified upon ordering

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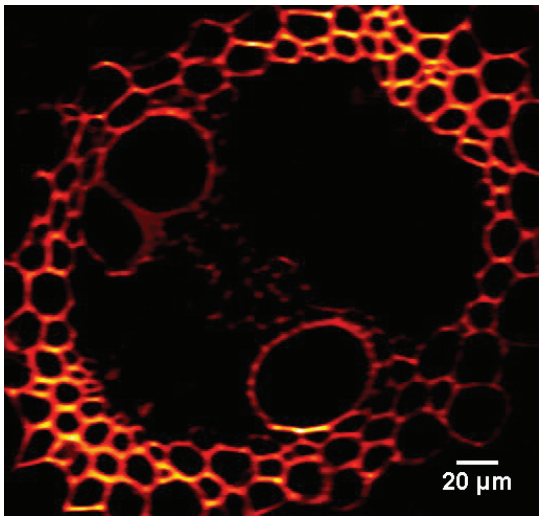
In the single-beam regime, entire tuning range (680 – 1300 nm) of the InSight is available. In the dual-beam, collinear femtosecond regime, it is possible to select the tunable laser wavelength from 750 nm to 980 nm, which, when overlapped with the fixed 1045 nm output, corresponds to a Raman shift range of 600 — 3800 cm^{-1} for CARS and SRS. In the dual-beam, collinear chirped picosecond regime, utilization of grating pairs reduces the tunable laser usable wavelength range to 790 – 910 nm, corresponding to a Raman shift range of 1300 – 3200 cm^{-1}. Within this range it is possible to probe 250 cm^{-1} wide windows just by moving the delay line stage and leaving the pump wavelength unchanged.



SRS image of corn stalk in the fingerprint region

Specifications

Regime	fs (without grating pair)	ps (with grating pair)
Fixed beam wavelength (nm)	1045	1045
Tunable beam spectral range (single beam, nm)	680 – 1300	790 – 910
Tunable beam spectral range (dual beam, nm)	750 – 980	790 – 910
Raman shift for CARS, SRS (cm^{-1})	600 – 3800	1300 – 3200
Fixed beam pulse width[1]	<260 fs	2.2 – 4.4 ps
Tunable beam pulse width	<120 fs	3.5 – 4.5 ps @ 800 nm 5.5 – 7.5 ps @ 900 nm
Fixed beam group delay dispersion range (fs^2)[1]	+12,000	–160,000 to –320,000
Tunable beam group delay dispersion range (fs^2)	provided by DeepSee inside the laser 0 to –25,000 @ 800 nm 0 to –17,000 @ 900 nm	provided by gratings –150,000 to –200,000 @ 800 nm –240,000 to –320,000 @ 900 nm
Raman linewidth for CARS, SRS (cm^{-1})	145	<7
Fixed beam throughput (pinhole-free silver mirrors)[2]	>85%	Additional 40% Loss
Tunable beam throughput (dielectric mirrors)	>80%	Additional 50% Loss
Tunable beam throughput (pinhole-free silver mirrors option)	>70%	Additional 50% Loss
Attenuation of tunable and fixed beams (OD)	0-2	
Output polarization of tunable and fixed beams[3]	S- (vertical) standard	
Delay line maximum speed/travel range	500 mm/s / 125 mm	
Fixed beam modulation frequency	2 – 4% range of EOM center frequency specified upon ordering	
Beam entrance/exit height	4.75 in (120.7 mm) / 4.44 in (112.7 mm)	

1. Pulse broadening in the fs regime compared to the laser output (<200 fs) is due to the EOM crystal dispersion.
2. Specifications only apply to the unmodulated beam. In case of modulated beam, the duty cycle should be taken into account.
3. Each beam is equipped with a 1/2 wave plate to independently control polarizations before exiting the SF-TRU.

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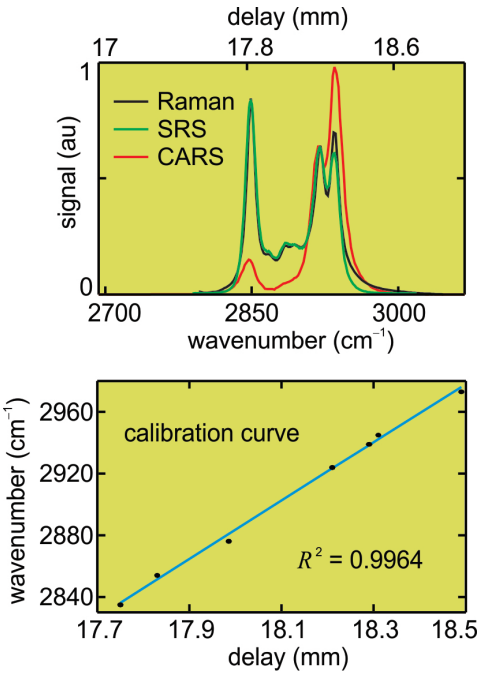
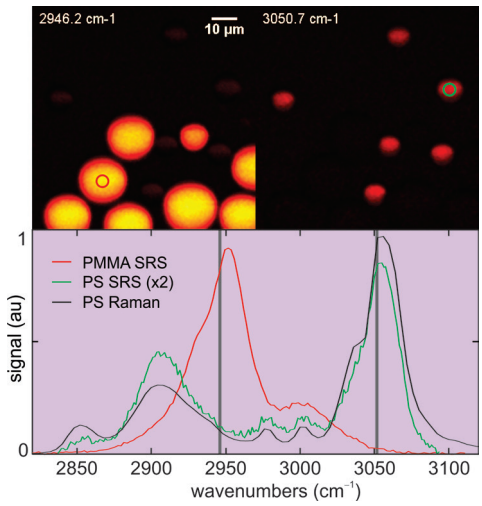


Top: SRS (green) and CARS (red) hyperspectral spectra of cyclohexane measured by SF-TRU in comparison with spontaneous Raman spectrum (black), showing excellent agreement between spontaneous Raman and SRS spectra.

Bottom: Delay-to-wavenumber calibration curve for hyperspectral imaging obtained from the Raman shift measurements of known peaks of different liquids.



Top: Hyperspectral SRS images of mixed polymethylmethacrylate (PMMA, large) and polystyrene (PS, small) beads. Two different slices from a stack of a hyperspectral scan are shown. Red and green circles indicate the regions of interest (ROI).

Bottom: SRS spectra of PMMA (red) and PS (green) beads measured from the hyperspectral scan in comparison with spontaneous Raman spectrum of PS (black). The vertical bars correspond to the Raman shifts of the frames shown on the top.

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For more information, visit
https://www.newport.com/f/tru-timing-and-recombination-unit

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