OPAL

Femtosecond

Synchronously Pumped

Parametric Oscillator

Spectra-Physics

The Solid State Laser Company™

Opal: The First Synchronously Pumped Parametric Oscillator

The Spectra-Physics Opal® is a synchronously pumped parametric oscillator (SPPO) that delivers tunable femtosecond pulses from 1.1 to 2.25 microns. Opal enhances the versatility of the Tsunami™ ultrafast Ti:sapphire laser by extending its output into the infrared. In addition, Opal also provides frequency-doubled access to the "missing" visible region not accessible by Ti:sapphire alone.

Opal features all solid-state construction for maximum reliability and ruggedness. It is a highly compact, turnkey instrument, consisting of a small optical head and a separate electronics control module. All operation and wavelength tuning is automatically controlled by the built-in computer which can be interfaced to other equipment via a RS-232 or GPIB interface.

Temperature Tunability

The main purpose of Opal is to provide tunable ultrafast pulses in the infrared by parametric generation of two longer wavelength photons from a single shorter wavelength photon. This process is essentially the reverse of frequency mixing. The two new wavelengths are termed the signal and idler outputs, where the signal refers to the shorter of the two newly formed wavelengths.

Efficient optical parametric conversion requires a phase matching condition which is dictated by the angle and temperature of a non-linear crystal, in this case LBO. In the Opal, the crystal angle is fixed and the temperature is scanned to achieve a remarkably simple wavelength adjustment. Once the Tsunami wavelength is set, the signal and idler wavelengths can be adjusted from 1.1 to 2.25 microns using the push-button control or via the computer interface. Thanks to recent developments in dielectric mirror design and fabrication, this very broad spectral range can be covered using two incident wavelengths from Tsunami and just two sets of Opal cavity optics.

The Opal Advantage.

- Wide continuous spectral coverage: synchronized signal and idler outputs deliver wavelengths from 1.1 to 2.25 µm
- Simple to scan or set wavelength: automated tuning delivers on demand
- Ultrafast pulses: mode-locked output pulses less than 130 femtoseconds
- High output power: more than 200 mW at 1.3 µm and 1.5 µm
- Simple to operate: menu driven electronics/control module with no need to tune pump laser

Automated Cavity-Length Matching

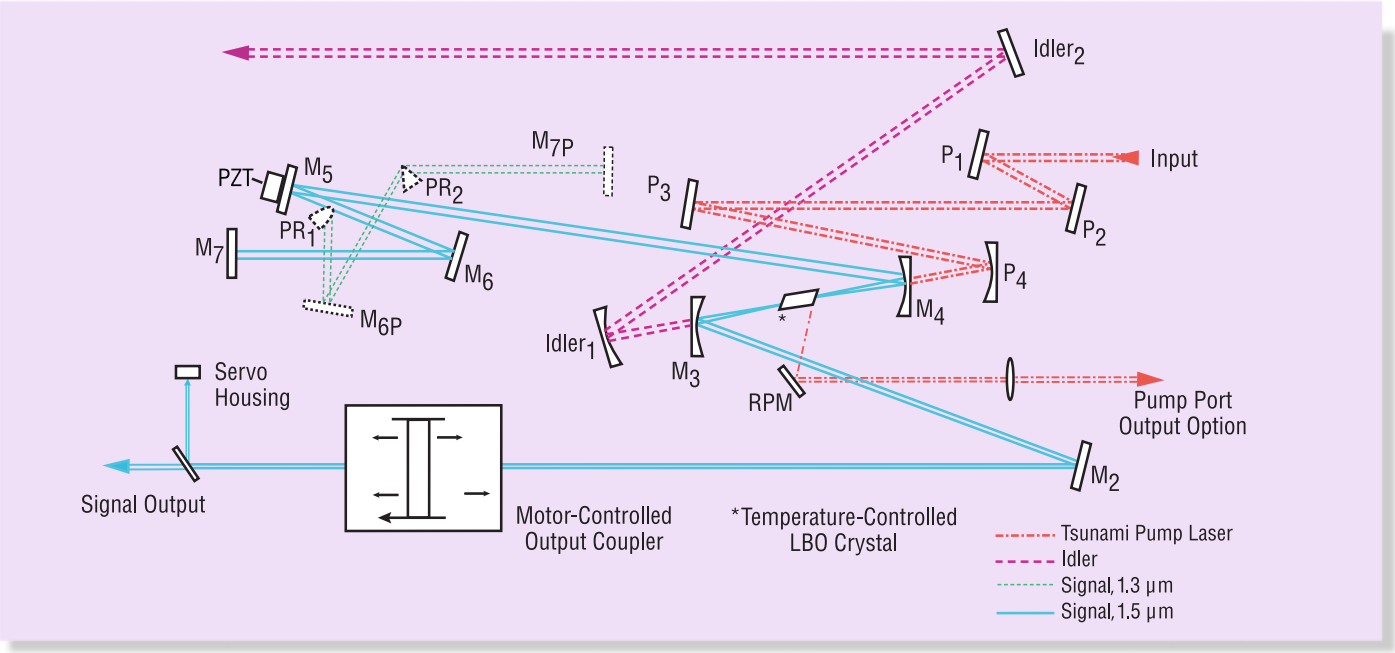
The Opal is a synchronously pumped device—the pump pulses from the Tsunami must arrive at the LBO crystal at exactly the same time as the signal pulses circulating the Opal cavity. This means that the cavity round trip time must be the same as the repetition rate of the Tsunami. Since different wavelengths travel at different velocities, the Opal cavity length must be adjusted as its output wavelength is scanned. Unlike any other commercial OPO, this is a fully automated, transparent function in the Opal. Consequently, the pump, signal and idler pulses are all synchronized. This feature provides the user with the capability of performing multi-wavelength pump-probe experiments with femtosecond time resolution. In addition, the Opal can be used to generate mid-IR wavelengths by difference frequency mixing these outputs in a non-linear crystal.

Hands-free Operation and Wavelength Tuning

Because temperature and cavity length stabilization are both automatically controlled through the microprocessor in the electronic module, Opal provides the capability for fully automated-wavelength scans. A user-friendly, back-lit LCD panel allows access to a variety of control menus which provide setup and scan information, output power, wavelengths, and other operational parameters. Automated wavelength scans over 50 to 100 nm are initiated with no manual intervention required. Opal is still the only femtosecond source to offer this type of simple wavelength access and control. This allows the user to focus attention entirely on the experiment and data acquisition, rather than on the laser source.

Opal Applications.

- Semiconductor research and spectroscopy
- Cavity ring-down spectroscopy
- Fiber optics and optical communications
- Vibrational overtone spectroscopy
- Time-resolved spectroscopy
- Multiple wavelength pump-probe experiments



Opal cavity layout (includes prisms when using short wavelength mirror set).

Millennia and Tsunami—
The Ultimate Pump Combination

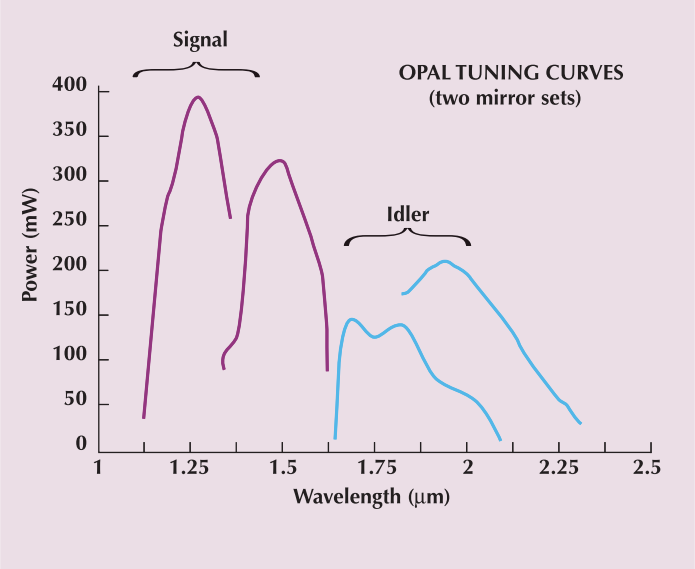
To achieve optimum performance, a synchronously pumped oscillator requires a pump source with high stability, high peak power, and excellent beam characteristics, including beam pointing stability. It must also deliver a constant pulse repetition rate to minimize cavity length adjustments. In the case of a synchronously pumped parametric oscillator such as Opal, the non-linear effect is very short lived, and the pump laser requirements are even tighter. The Spectra-Physics Tsunami meets these requirements.

The Tsunami is an ultra-stable Ti:sapphire laser that delivers over 2 watts of power with a TEM_{00} output profile, when pumped by a 10 watt Millennia laser. It delivers sub-100 fs pulses at an 80 MHz repetition rate. The invar-based resonator design guarantees minimum deviations in repetition rate that can result from temperature variations. Operational simplicity and reliability are enhanced by the inherent stability of the Millennia pump laser. This solid-state green (532 nm) laser efficiently delivers 10 watts of low noise TEM_{00} output from the industry's smallest platform, reducing electricity costs, eliminating the need for cooling water, and minimizing the use of valuable lab space. These combined features make Opal the most stable, easiest to use OPO on the market. For scientific applications requiring infrared wavelengths, Opal provides what no other OPO can—*simplicity*!

Opal Performance and Specifications

Output Characteristics	Opal Performance	
	1.3 µm at 775 pump	1.5 µm at 810 pump
Average Power[2]	> 250 mW	> 200 mW
Pulse Width[2,3]	< 130 fs	< 130 fs
Tuning Range[4,5]	1.10–1.35 µm	1.35-1.60 µm
Repetition Rate (Nominal)	80 MHz	
Noise[6]	< 0.2%	
Stability[7]	< 5%	
Spatial Mode	TEM_{00}	
Beam Diameter @ $1/e^2$ points	< 2.0 mm	
Beam Divergence, full angle	< 1.0 mrad	
Polarization	Horizontal (> 100:1)	

1. *Specifications subject to change without notice and only apply when pumped at 775 or 810 nm, 2 W, <80 fs, by a Spectra-Physics Tsunami/Millennia system.*
2. *Specifications apply to operation at wavelength noted.*
3. *A $sech^2$ pulse shape (0.65 deconvolution factor) is used to determine the pulse width.*
4. *Corresponding idler output wavelengths are also accessible at 1.8–2.25µm and 1.63–2.00 µm, respectively. Power levels are typically 50% of the signal.*
5. *For operation below 1.18µm, 750 nm pump or lower is required.*
6. *Rms, measured in a 10 Hz to 1MHz bandwidth.*
7. *Percent power drift in any 1-hour period after an 1-hour warm-up and less than 3° C temperature change.*



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Printed in U.S.A. 1/03
000B-0189S