

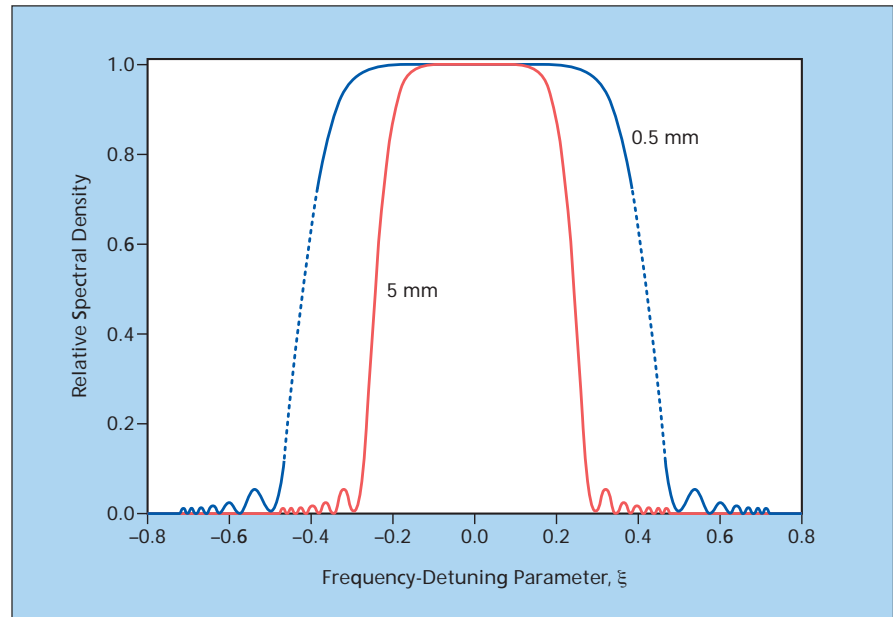
## Ultra-Broad-Band Optical Parametric Amplifier or Oscillator

Potential applications include wavelength-multiplexing communications and generating reference frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A concept for an ultra-broad-band optical parametric amplifier or oscillator has emerged as a by-product of a theoretical study in fundamental quantum optics. The study was originally intended to address the question of whether the two-photon temporal correlation function of light [in particular, light produced by spontaneous parametric down conversion (SPDC)] can be considerably narrower than the inverse of the spectral width (bandwidth) of the light. The answer to the question was found to be negative. More specifically, on the basis of the universal integral relations between the quantum two-photon temporal correlation and the classical spectrum of light, it was found that the lower limit of two-photon correlation time is set approximately by the inverse of the bandwidth. The mathematical solution for the minimum two-photon correlation time also provides the minimum relative frequency dispersion of the down-converted light components; in turn, the minimum relative frequency dispersion translates to the maximum bandwidth, which is important for the design of an ultra-broad-band optical parametric oscillator or amplifier.

In the study, results of an analysis of the general integral relations were applied in the case of an optically nonlinear, frequency-dispersive crystal in which SPDC produces collinear photons. Equations were found for the crystal orientation and pump wavelength, specific for each parametric-down-converting crystal, that eliminate the relative frequency dispersion of collinear degenerate (equal-frequency) signal and idler components up to the fourth order in the frequency-detuning parameter,  $\xi$ . [The degenerate frequency,  $\nu_0$ , of the signal or idler component is half the pump frequency. If the difference between the signal or pump component and the degenerate frequency is  $\nu$  (in which case the corresponding difference for the pump or signal component, respectively, is  $-\nu$ ), then  $\xi \equiv \nu/\nu_0$ .]



The Relative Spectral Density in SPDC was calculated for a suitably oriented pump beam in 5- and 0.5-mm-long BeSO<sub>4</sub> crystals for a degenerate wavelength of 923.8 nm.

As a result of the elimination of the relative frequency dispersion up to fourth order, an optical parametric amplifier consisting of such a crystal at the specified orientation and pumped at the specified wavelength can be designed to exhibit a relatively flat spectral-density-versus-frequency curve over more than an octave (see figure). Conveniently, the octave could be chosen to

include two wavelength bands — centered at 1,330 and 1,560 nm — that are used in optical communications. Hence, for example, the amplifier might be useful in a wavelength-multiplexing communication system using these two wavelength bands. In another potential application, by configuring this amplifier as a mode-locked oscillator, one could obtain a self-locked comblike spectrum that could serve as an excellent set of frequency references.

*This work was done by Dmitry Strelkov, Andrey Matsko, Anatoly Savchenkov, and Lute Maleki of Caltech for NASA's Jet Propulsion Laboratory. For further information, contact iaoffice@jpl.nasa.gov. NPO-41584*

## Particle-Image Velocimeter Having Large Depth of Field

This instrument could be used to monitor particle-laden flows.

Goddard Space Flight Center, Greenbelt, Maryland

An instrument that functions mainly as a particle-image velocimeter provides data on the sizes and velocities of flying opaque particles. The instrument is being developed as a means of characterizing fluxes of wind-borne dust particles

in the Martian atmosphere. The instrument could also be adapted to terrestrial use in measuring sizes and velocities of opaque particles carried by natural winds and industrial gases. Examples of potential terrestrial applications include moni-

toring of airborne industrial pollutants and airborne particles in mine shafts.

The design of this instrument reflects an observation, made in field research, that airborne dust particles derived from soil and rock are opaque enough to be