lengths readily available from semiconductor diode lasers. The dominant pumping mechanism is sequential two-step excitation; the first at 792.1 nm populates a long-lived intermediate state and the second at 840 nm takes population from this level and excites the upper $^4S_{3/2}$ laser level. With 200 mW of pump light, 1 mW of cw output at 549.6 nm was obtained using very conservative 1% output coupling. The laser transition terminates 218 cm^{-1} above the groundstate, limiting laser action to $T \leq 77K$. For $YLiF_4$: Er^{3+} (1%), upconversion laser operation was obtained with a single cw pump source at 802 nm. Here resonant cooperative energy transfer efficiently populates $^4S_{3/2}$ from two excited Er^{3+} ions in the intermediate $^4I_{11/2}$ level. The laser output consists of narrow pulses of about 80 ns duration and repetition frequency of ~200 kHz. The lasing threshold was 80 mW and with only 0.5% output coupling, the output power was 5 mW for an input of 200 mW of near-ir pump. In these upconversion lasers the energy of the output photons is almost 80% of the sum of the two pump photons. A number of other materials are under investigation to further optimize the performance of these novel lasers, with the possibility of operation at higher temperatures and perhaps even shorter wavelengths.

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Nondiffracting beams

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Recently workers at the University of Rochester have undertaken both theoretical and experimental investigations of the properties of nondiffracting beams.[1,2] In their ideal form, these beams represent a class of fields having transverse intensity distributions that are unaltered as they propagate in free space. Although not achievable in their ideal form (the field distribution would need to be perfectly mapped over an infinite plane), many interesting results have been obtained with these beams under the restriction of finite aperture. Investigation of the power transport efficiency and depth of field obtainable with these beams has revealed some interesting trade-offs in their utilization.

When the time dependence is factored from the electromagnetic wave equation, the spatial distribution of a field is determined by the Helmholtz equation. The simplest nondiffracting field solution of the Helmholz equation is the zero order Bessel function of the first kind. This mode can have a sharply-defined central maximum with a full-width at half-maximum (FWHM) as small as a wavelength, independent of propagation distance. Although these exact solutions are only scalar modes of the Helmholtz equation, exact nondiffracting vector modes also exist and are closely approximated by the scalar solutions for spot sizes greater than a few wavelengths.

Experiments with finite aperture approximations to the ideal Bessel modes have demonstrated that they can possess remarkable (although finite) depth of field. Beams with spot sizes of 60 μm have been propagated for approximately 1 meter in the laboratory without any measurable spreading of the FWHM, a feat that is impossible with a Gaussian field distribution. Although Bessel beams have a tremendous advantage over Gaussian beams in maintaining their transverse intensity profile, the power transport efficiency of a Bessel beam is approximately the same as that of a Gaussian beam. This seemingly contradictory result is a consequence of the fact that the Bessel beam, while possessing a very sharply peaked central maximum and non-spreading FWHM, has a large fraction of its energy contained in the tail of its intensity distribution (which decays inversely with radical coordinate).

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Ultrafast all-optical glass fiber switches

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The promise of achieving ultrarapid all-optical signal processing is attracting considerable interest. Many of the necessary components have been available for some time, including lasers that produce subpicosecond pulses, optical fiber waveguides that support tremendous bandwidths, and optical materials that have nonlinearities with femtosecond response. A missing component, until recently, has been an all-optical switch that could operate at ul-