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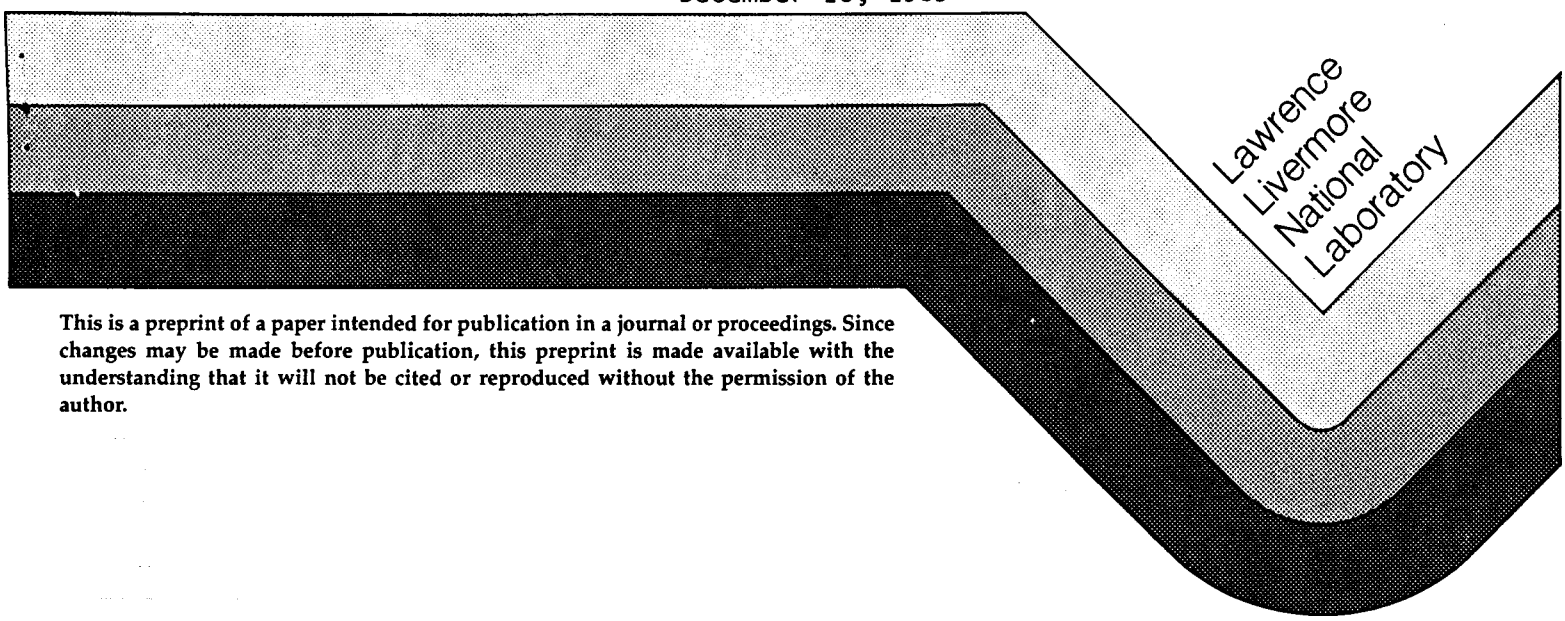

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The thermo-optic coefficients of deuterated l-arginine phosphate indicate temperature-insensitive phase-matching directions for second-harmonic generation. We present direct measurements that partially agree with these predictions, and provide an explanation of the discrepancies between predicted and measured behavior.

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Efficient frequency conversion of high power laser radiation requires materials that possess significant nonlinear coefficients, high damage threshold, and the capability to phase-match, with reasonable angular bandwidth, the interaction between the fundamental and harmonic waves. Deuterated L-arginine phosphate (d-LAP) is a very promising new crystal for use in harmonic frequency conversion devices for Nd^{3+} lasers.[1] In addition to having a larger nonlinearity than KDP, d-LAP possesses another property that is quite attractive for high average power applications: the existence of temperature-insensitive phase-matching directions. In general, biaxial materials, such as d-LAP, are far more likely to demonstrate temperature-insensitive phase-matching directions than uniaxial crystals, such as KDP. Biaxial materials must satisfy far less stringent relationships between refractive indexes and thermo-optic coefficients than uniaxial materials in order to exhibit this property. For efficient high average power frequency conversion, careful management of the thermal loading of the conversion crystal is essential.[2] The presence of phase-matching directions with large thermal bandwidth greatly eases the requirements for crystal temperature control.[3]

In the principle planes, the reported thermo-optic coefficients of d-LAP[1] predict relatively large changes in the phasematching angle as a function of temperature for both type I and II phase-matching processes. Furthermore these rates of phase-matching angle change have opposite signs in the two principle planes. This behavior indicates the existence of temperature-insensitive phasematching directions.

Utilizing a modelocked, Q-switched Nd^{3+}:YAG laser and a very high quality, spherically shaped sample of d-LAP mounted in a goniometer, we measured directly the change in phase-matching angle as a function of temperature in the principle planes. The values we have obtained, shown in Table 1, from this procedure directly indicate the presence of temperature-insensitive directions for type I phase-matching of second harmonic generation of 1.064μm light. Using this same apparatus, we have also accurately mapped the entire phase-matching locus for both type I and II second harmonic generation. By fitting these locus maps to a very simple analytical approximation, we have been able to predict the approximate location of the temperature-insensitve directions for type I phase-matched second harmonic generation.

Although our measurements do indicate temperature-insensitive phase-matching directions in the type I second harmonic generation locus, the values we measure for the rate of change of phase-matching angle with respect to temperature in the principle planes disagree significantly with the predictions made from the early thermo-optic data[1]. Furthermore, our direct measurements indicate that there are no temperature-insensitive phase-matching directions for type II second harmonic generation. The source of this discrepancy lies in the highly anisotropic thermal expansion of d-LAP,

which requires the thermo-optic coefficients obtained from minimum deviation measurements be corrected for thermally-induced changes in the prism angles of the samples.

References:

1. D. Eimerl, S. Velsko, L. Davis, F. Wang, G. Loiacono, and G. Kennedy, "Deuterated L-Arginine Phosphate: A New Efficient Nonlinear Crystal," IEEE J. Quantum Electron., vol. QE-25, no. 2, pp. 179–193, Feb. 1989.
2. D. Eimerl, "High Average Power Harmonic Generation," IEEE J. Quantum Electron., vol QE-23, no. 5, pp. 575-592, May 1987.
3. D. Hon, "High Average Power, Efficient Second Harmonic Generation," in Laser Handbook, vol. 3, ed. M. L. Stitch, (North Holland Publishing Company, Amsterdam, 1979), pp. 421-484.

Table 1. Measured values of the rate of change of phase-matching angle with respect to temperature in the principle planes.

	measured value of $d\theta_{PM}/dT$ (μrad/°C)	
nonlinear process	α–β plane	α–γ plane
Type I SHG	+248 ± 4	–38.3 ± 1.9
Type II SHG	+237 ± 4	+30.9 ± 2.0