

# Testing Miller wavelength scaling of the second-order nonlinear coefficients of $\text{KNbO}_3$ , $\text{KTiOPO}_4$ , $\text{KTiOAsO}_4$ , $\text{LiNbO}_3$ , $\text{LiIO}_3$ , $\beta\text{-BaB}_2\text{O}_4$ , $\text{KH}_2\text{OP}_4$ , and $\text{LiB}_3\text{O}_5$

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**Abstract:** We combine our new measurements of nonlinear coefficients over a range of wavelengths with previous values to compare their wavelength variation with that predicted by Miller scaling. We conclude that Miller scaling is a good approximation in most cases.

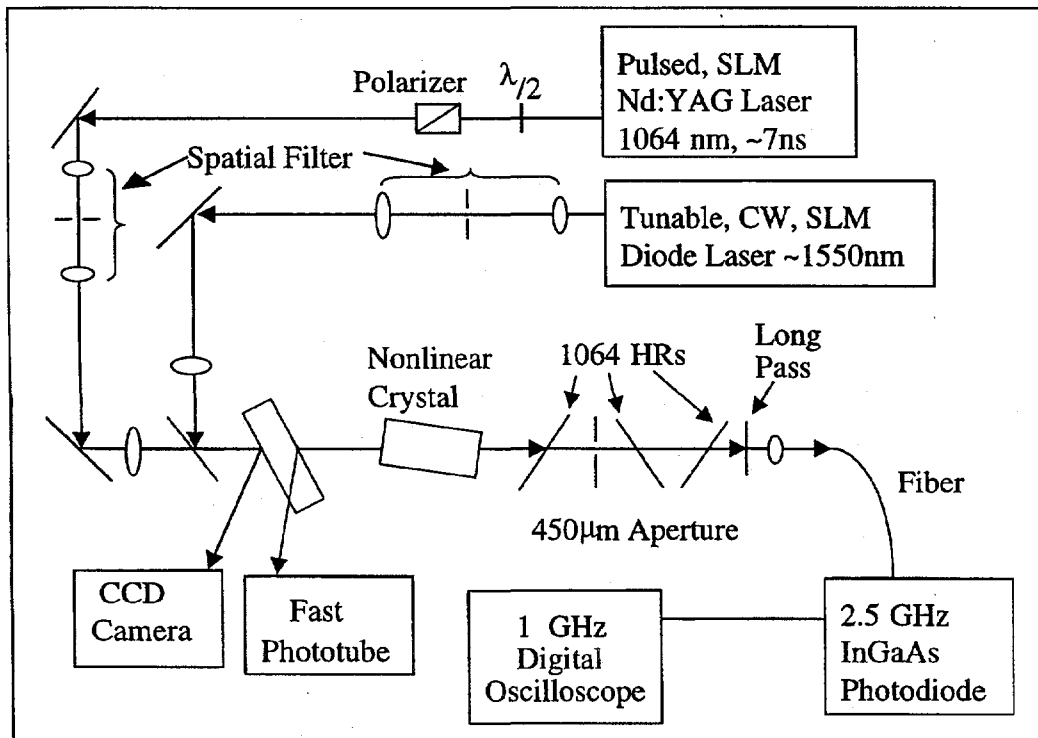
**OCIS codes:** 190.4720 Optical nonlinearities of condensed matter, 190.4400 Nonlinear optics, materials

Most second-order nonlinear coefficients have been measured using second harmonic generation of 1064 nm light, but because many applications involve other wavelengths it would be useful to have a method of scaling the coefficients with wavelength. An approximation known as Miller scaling is often used for this, but it is not well tested. This scaling states that for a given coefficient the ratio

$$\frac{d_{ijk}(-\omega_1 - \omega_2; \omega_1, \omega_2)}{\chi_{ii}(\omega_1 + \omega_2)\chi_{jj}(\omega_1)\chi_{kk}(\omega_2)}$$

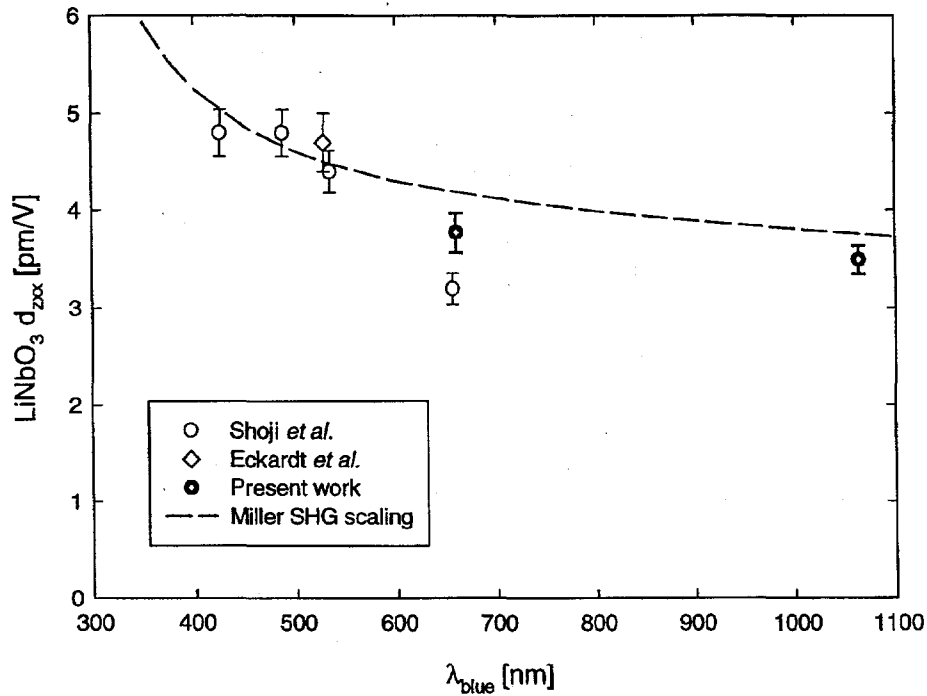
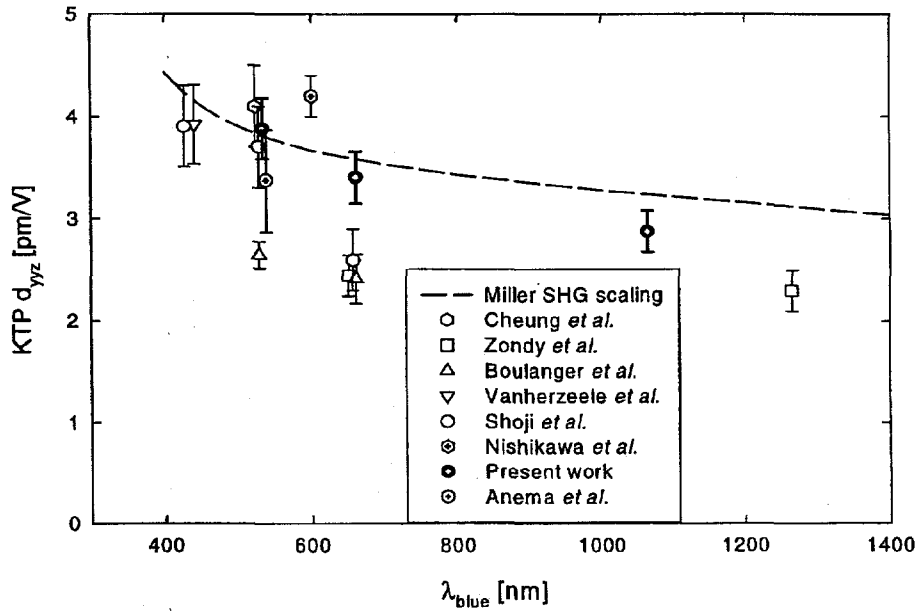
is constant. Here  $d_{ijk}$  is the second-order nonlinear coefficient, and the  $\chi$ 's are linear susceptibility tensor elements for polarization directions  $i, j, k$  ( $\chi_{ii}(\omega) = n_i^2 - 1$ ,  $n_i$  = refractive index).

For comparison with this scaling, we determined  $d$ 's for the crystals listed in the title by measuring parametric gain of 1550 nm light pumped by 1064 nm and 532 nm light, or by frequency doubling 806 nm, 980 nm, 1064 nm, and 1319 nm light. The figure below shows the experimental setup for the 1064 nm pumped gain measurements. The frequency doubling measurements used focused, low power cw lasers



and careful calibration of powers and focal parameters.

The figures below show examples of the wavelength dependence of two nonlinear coefficients. The first figure summarizes measurements of  $d_{yz}$  for KTP. The references for the various measurements are listed at



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the end of this paper. The dashed line indicates Miller scaling for second harmonic generation normalized to our best estimate of the value for doubling 1064 nm light. All data is plotted at the wavelength of the bluest of the three interacting waves. Although the scatter in the measured values is large, based on a critical assessment of all the measurements, we conclude that Miller scaling is a good approximation for his coefficient. The next figure summarizes the measurements of  $d_{xx}$  for lithium niobate. The scatter in this case is much smaller and obviously fits the Miller curve quite well.

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