Measuring dispersion in nonlinear crystals beyond detectors' spectral range

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Proper characterization of nonlinear crystals is essential for designing single photon sources.

Here we show a technique for dispersion characterization of a nonlinear material by making use of phase matching in the process of parametric down conversion. Our method is demonstrated on an exemplary PPKTP (*periodically poled potassium titanyl phosphate*) crystal phase-matched for 396nm to 532nm and 1550nm.We show a procedure to determine the dispersion in the range of (390,1800) nm by using only one spectrometer for the UV-visible range.

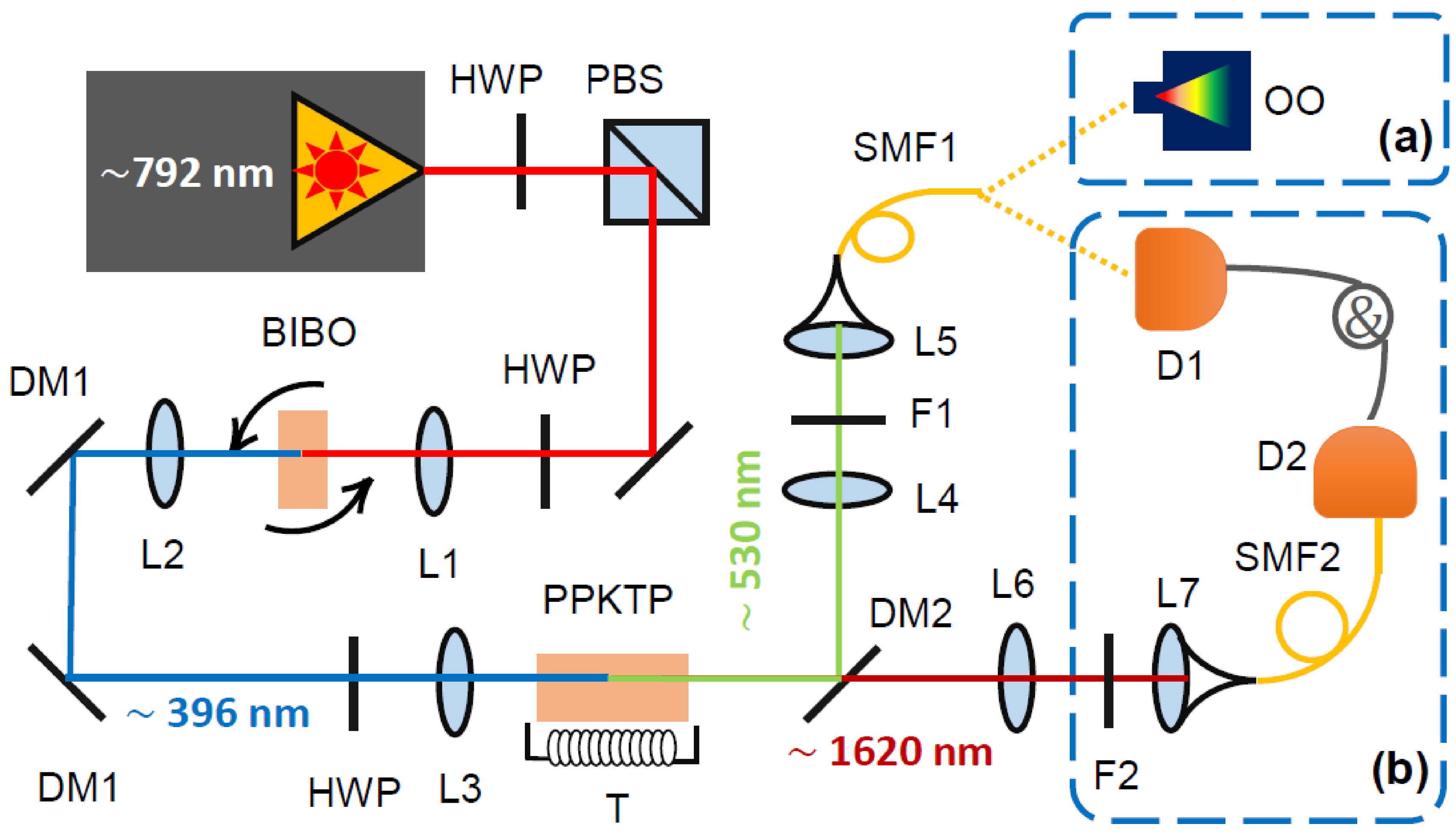

***Fig. 1. Experimental setup**, consists of: tunable Ti:Sapphire pulsed laser, HWP – half-wave plate, PBS – polarization beam splitter, L1, L2 – lenses, BIBO – nonlinear crystal, DM1 – dichroic mirror, L3 – lens, PPKTP – nonlinear crystal, T – temperature controller, DM2 – dichroic mirror, L4 – lens, F1 – set of filters, L5 – aspheric lens, L6 – lens, F2 – long-pass filter, L7 – aspheric lens. **Detection setups**: a) OO – commercially available spectrometer, b) D1, D2 – single photon detectors.*

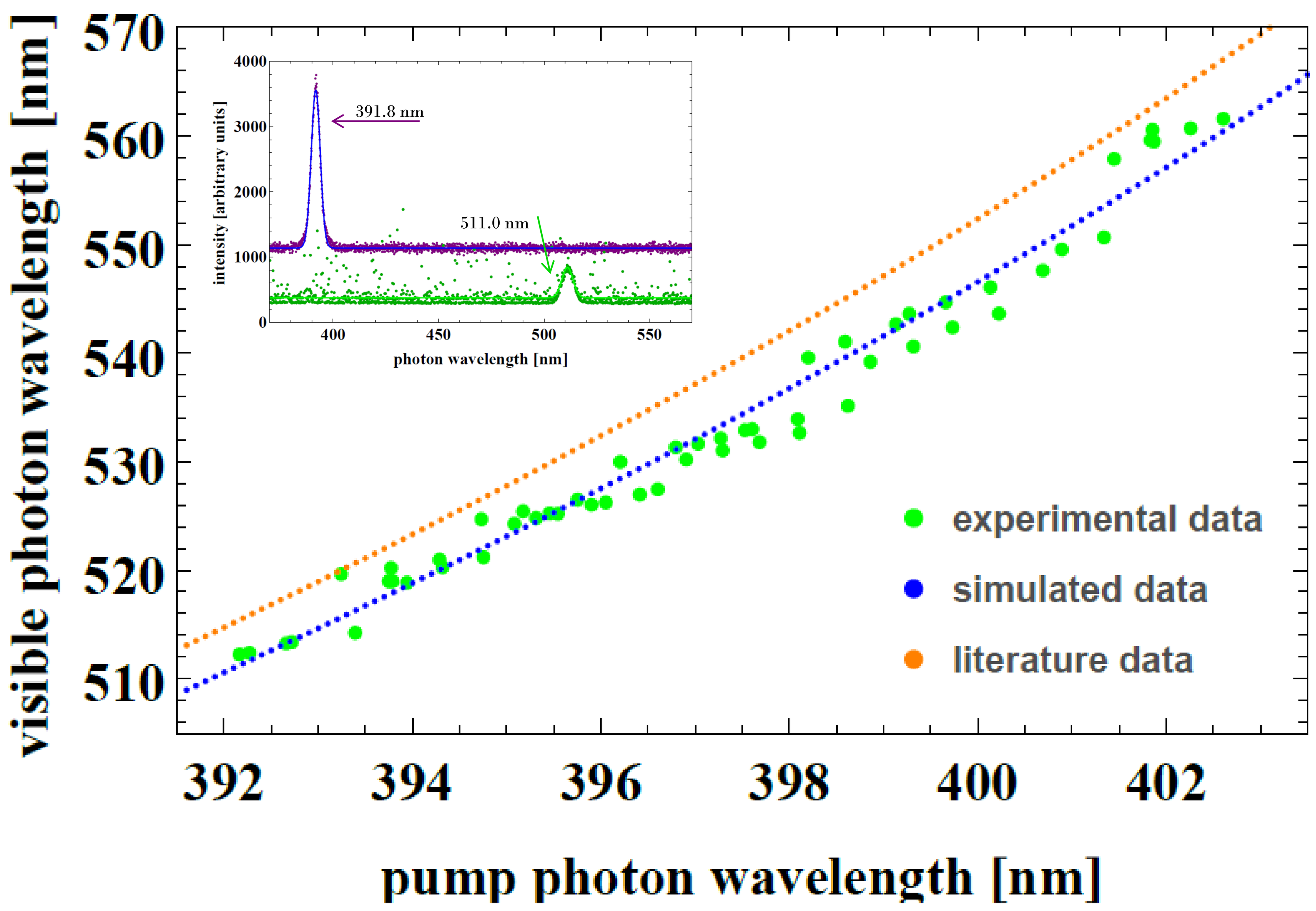

***Fig. 2. Experimental results**, visible photon wavelength dependence on the pump wavelength. **Inset:** an exemplary measurement of a visible photon spectrum.*

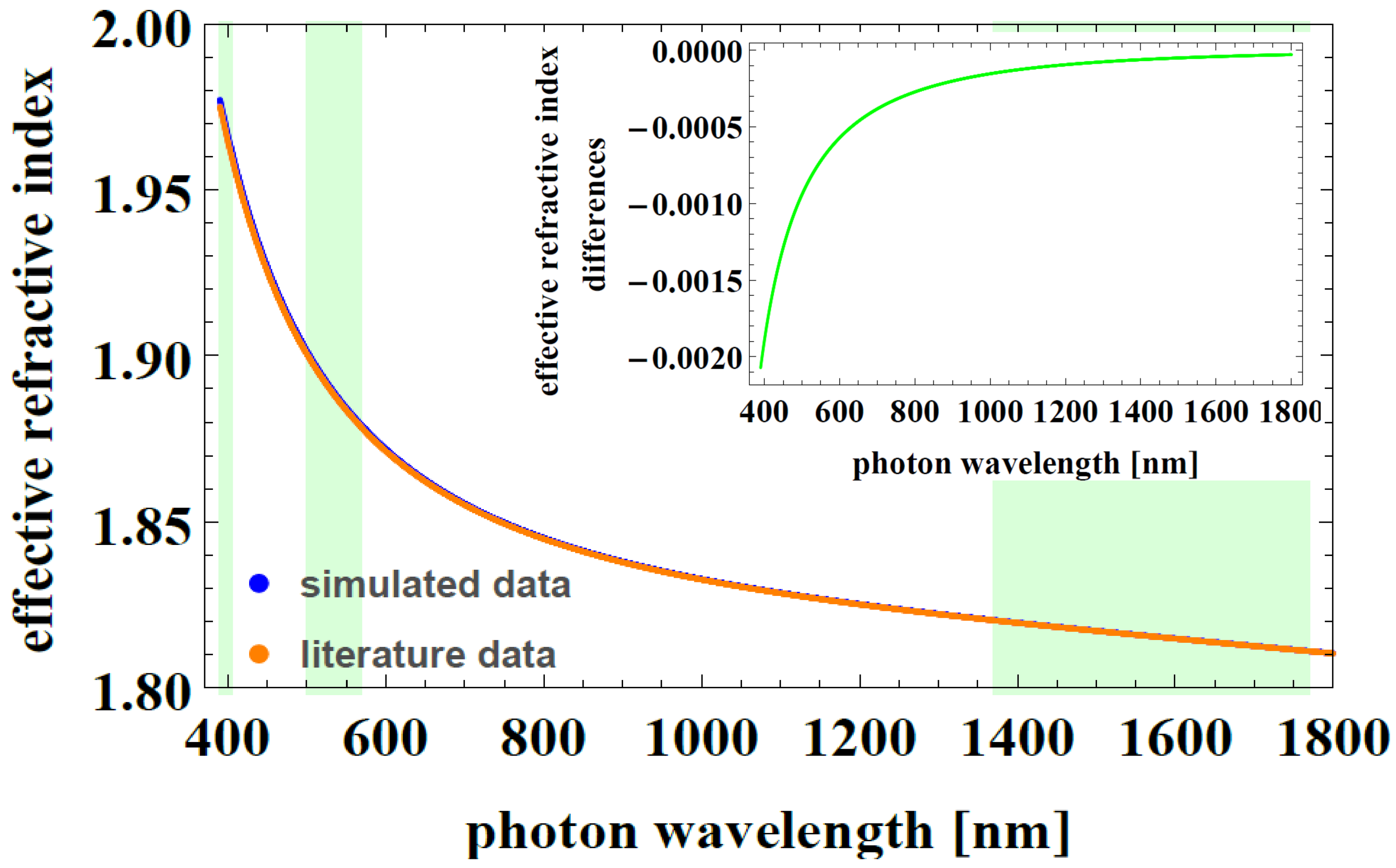

***Fig. 3. Effective refractive index.** Shaded fields correspond to areas with the quasi phase matching condition fulfilled. **Inset:** differences between literature and simulated data.*

Experimental results

The pump photon wavelength is set in the range of (392, 403) nm for crystal temperature equal to 304.8 K. For each of the settings a spectra of the visible photon and pump photons are measured. The central wavelengths of both the photons are depicted in Fig. 2 (green dots). An exemplary spectrum measurement is shown as an inset.

Theoretical modelling

The main goal of modelling is to obtain effective refractive index in nonlinear crystal by determining the Sellmeier coefficients (a, b_i, c_i). It is given by

$$n_{eff}^2(\lambda) = a + \sum_i \frac{b_i\,\lambda^2}{\lambda^2 - c_i}.$$

In the SPDC proces the quasi phase - matching is given by

$$\Delta k = k_{p\perp} - k_{s\perp} - k_{i\perp} - \frac{2\pi}{\Lambda} = 0.$$

This relations allows us to determine all three photons' wavelengths, by measuring only two of them. Also, it allows to extract Sellmeier coefficients for the photon which is not measured directly.

Our algorithm consists of the following steps:

1. choose some initial (literature) coefficients,
2. check the phase matching condition, calculate photon wavelengths,
3. compare obtained wavelenghts with experimental ones, change slightly coefficients and return to step 2.

The experimental, literature and simulated data is shown in Fig 2. The goodness of fit to the experimental data for literature effective refractive index is equal to $\chi^2 \cong 5.44$, whereas for our simulated one is $\chi^2 \cong 1.72$.

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