Optical parametric amplification in gas-filled hollow core capillary for the generation of tunable pulses in the infrared

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Ultrashort pulses in the **near-infrared (NIR)** to **mid-infrared (MIR)** are widely used for laser matter interaction experiments, e.g. the relaxation process of carrier semiconductors and chemical dynamics at the femtosecond and attosecond time scale [1,2]. Many different approaches based on nonlinear processes or laser devices can be found to generate pulses in theses spectral ranges. Recently, **four wave mixing (FWM)** based parametric amplification in **gas-filled hollow core capillary (HCC)** has been used to create a tunable source of ultrashort pulses. For example, pulses can be generated in the visible with an energy at the 10 µJ level [4] and in the near infrared at ~1.4 µm with an energy of 5 µJ and a pulse duration of 45 fs [5]. Here, we present an implementation of a scheme to generate tuneable pulses from the NIR to the MIR toward a high-power level.

The general principle of the FWM process relies on the combination of two pulses: a strong pump and a weak signal which co-propagate in a gas filled HCC. According to the phase matching condition, a part of the pump energy is transferred from the pump to the signal and an idler is created. In our experiment, this process was driven by pulses from a 1 kHz, Ti: Sapphire laser (800 nm, 120 fs) in combination with a weak continuum tunable from 420 to 650 nm (the signal) obtained by focusing a part of the 800nm laser into a 5 mm thick Sapphire plate. The relative delay between the pump and the seed pulses was controlled by a translation stage. Both beams were focused in a 30 cm long argon filled HCC with an inner core diameter of 150 µm. In parallel, we firstly achieved numerical simulations to predict the optimal pressure when the three waves propagate in the fundamental modes. From the computed total phase mismatch (Figure 1.a), we determine that tunable pulses in the near/mid infrared with high gain can be obtained from a pressure < 2 bar. Figure 1.b-c shows the experimental spectrum for a pressure of ~2 bar and an energy in the capillary of 146 µJ, when the pump pulse and the continuum signal are temporally overlapped. The tunability was obtained by changing the relative delay between the signal and the pump with the translation stage. In this condition, the idler is found to be tuneable from 1µm to 1.3 µm. Others simulations and experiments are in progress to extend the bandwidth toward the mid-infrared.

a) b) c)

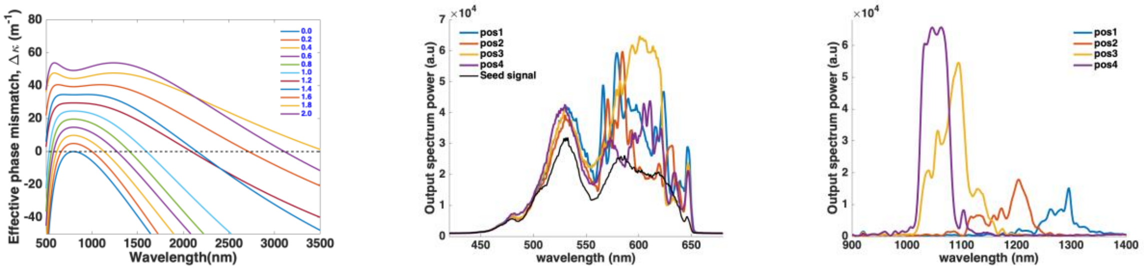

Fig. 1 *(a) Total phase mismatch in a Ar filled HCC. The core diameter is 150 µm. The pressure is tuned from 0.5 to 2 bar. The pump energy is 250 uJ.at 800nm b) Continuum spectrum (black line). Amplified spectrum for several delays, (color lines). c) Infrared spectrum generated by the FWM for a pressure of 2 bar.*

To summarize, we have shown that FWM based parametric amplification in gas filled hollow core capillary is an efficient method to generate tuneable pulses in the infrared band with a promising potentiality to reach the mid infrared.

References

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