Popular scientific paper

Evaluation of white-light generation as possible seed for a mid-infrared optical parametric chirped pulse amplifier

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Nowadays, mid-infrared (MIR) light with wavelength range from 2 μm to 10 μm (1 μm $=10^{-6}$ meter) has provided excellent views of atoms, molecules and solids and opened up many applications, such as the observation of atmospheric reactions and non-invasive surgery. Those achievements are attributed to a development on absorption spectroscopy where the specific absorption of radiation as function of wavelength due to light-matter interaction is used to characterize atoms and molecules. Because a large number of molecules exhibit strong absorption lines in the MIR region, the MIR absorption spectroscopy has big advantages in compare with other spectral ranges. For example, water molecule has only very strong absorption lines near 3 μm, which allows biomedical applications, such as tissue surgery and imaging on dermatology. In addition, mid-infrared source is highly significant for ultra-short pulse generation.

We aim at the generation of MIR pulses from a near-infrared pump at 1.03 μm. The MIR generation is based on difference frequency generation (DFG), a nonlinear optical process where two beams beat (or interact) in nonlinear materials to generate another beam with a optical frequency at the difference between the two beams. Simply put, two bluer color lights can mix to create redder colors in some particular conditions.

In our project, by beating the 1.03-μm pulsed laser light with 1.5-μm light in nonlinear materials, the output 'color' of the different frequency will be around 4 μm. The light at 1.5 μm is called signal, which the thesis work focuses on to generate. The signal wave can be generated based on another set of light-matter (nonlinear) interactions between a laser pulse at 1.03 μm and a medium, which results in a broadband radiation, the so-called supercontinuum emission as seen in Figure 1 [**1**].

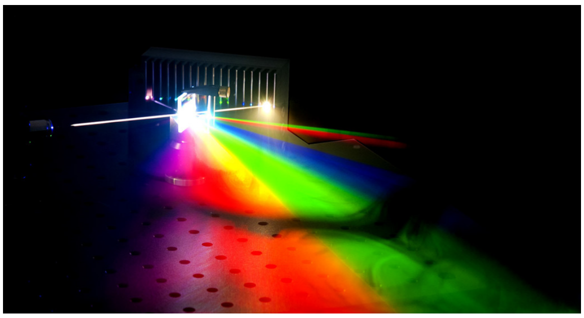

Figure 1: The supercontinuum light propagates through a optical grating after which various frequency components (colors) diffracted to different directions are displayed. In fact, all the visible colors seen above is a very short spectral segment of the broadband spectrum. Unlike solar radiation, tungsten bulb, and rainbow, these colors are correlated to each other and interfere constructively in time. As a result, they together exhibit high instantaneous power and ultra-short duration.

Several materials have been experimentally investigated for the supercontinuum generation. The results show that YAG (yttrium aluminium garnet), KGW (potassium gadolinium tungstate) and YVO_4 (yttrium orthovanadate) are the best performers, with high generation efficiency as well as large laser power tolerance. Numerical simulations of the main interaction processes are to some extent confirmed by our results.

Supercontinuum will not only allow a promising way to generate MIR pulses, but also itself is a highly useful technology that already has been directly implemented in industry and medicine since the last decade. Our study will permit a deeper understanding of the whole physical processes as well as limitless possibilities to further develop it in many other fields.

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