Development of a two-color picosecond OPO, pumped by a Nd:YAG laser mode locked using a nonlinear mirror, for DR-SFG spectroscopy

A.A. Mani, L. Dreesen, C. Humbert, P. Hollander, Y. Caudano, P.A. Thiry, A. Peremans
Laboratoire de Spectroscopie Moleculaire de Surface, Belgium
Surface Science 502–503 (2002) 261–267

Abstract

We set up a doubly-resonant sum frequency generation (DR-SFG) spectrometer based on the use of an all-solid-state flash-lamp-pumped Nd:YAG laser that synchronously pumps two parametric oscillators. Pulses as short as 12 ps FWHM are generated by mode locking a Nd:YAG oscillator using a frequency doubling nonlinear mirror combined with a two-photon absorber. The available pump power is shared between a $LiNbO_3/AgGaS_2$ optical parametric oscillator (OPO), tunable from 3800 to 1100 cm^{-1} and a BBO OPO tunable from 410 to 2600 nm. Spectral resolution and pulse are 2 and 3 cm^{-1} in the infrared and visible spectral ranges, respectively. First DR-SFG spectra of self-assembled monolayers on Au are presented.

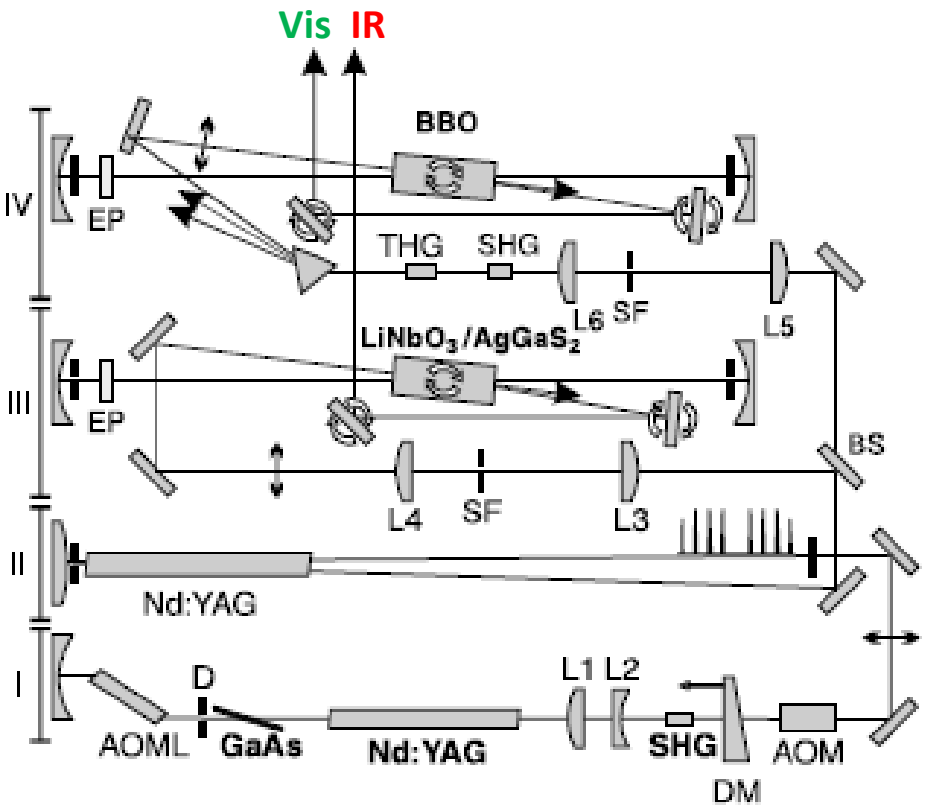
Keywords: Laser methods; Non-linear optical methods; Sum frequency generation

Zaure 2014.08.09

Introduction

- DR-SFG can detect possible electron transitions in the visible spectral region and possible interferences between substrate and adsorbed layer.
- DR-SFG spectroscopy requires tunable laser beams with short light pulses in the IR region and in the visible.
- OPO is used for generating frequency tunable laser beams delivering short pulses.
- Achieved a new passive mode-locking technique based on a FDNLM combined with passive-negative feedback.
- The merits of the setup: photochemical stability, short response time (12.5 ps), applicability to a wide spectral range, simplicity and self-starting mode locking .

The two-color tunable laser system



AOML: Acousto optic mode locker
D: diaphragm
L1and L2= telescope
SHG: SHG crystal
DM: dichroic mirror
AOM: Acousto-optic modulator

BS: beam splitter
L3 and L4= telescope
SF: spatial filter
EP: etalon plate
L5 and L6= telescope
THG: third harmonic crystal

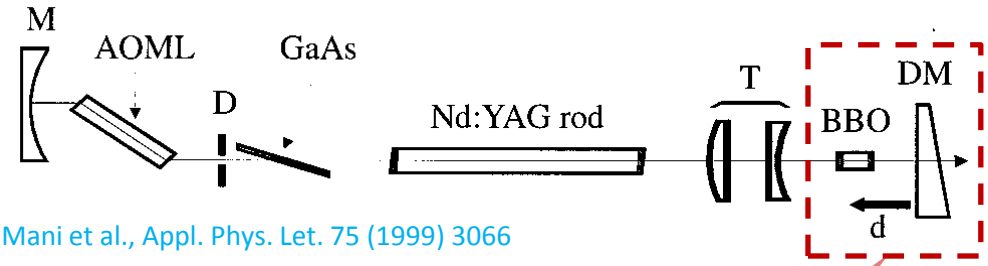
⇒ **OPO for the visible spectral range**

⇒ **OPO for the IR range**

⇒ **Double-pass optical amplifier**

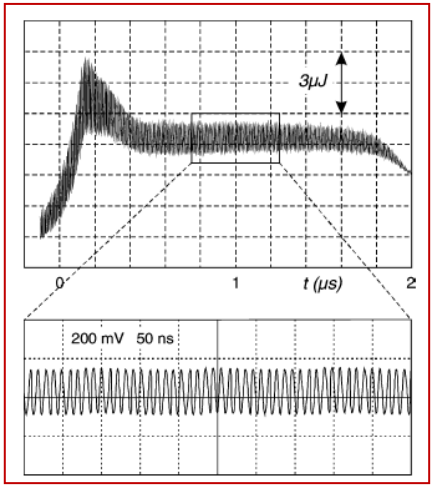
⇒ **Picosecond laser optical oscillator**

All-solid-state flash-lamp-pumped Nd:YAG laser



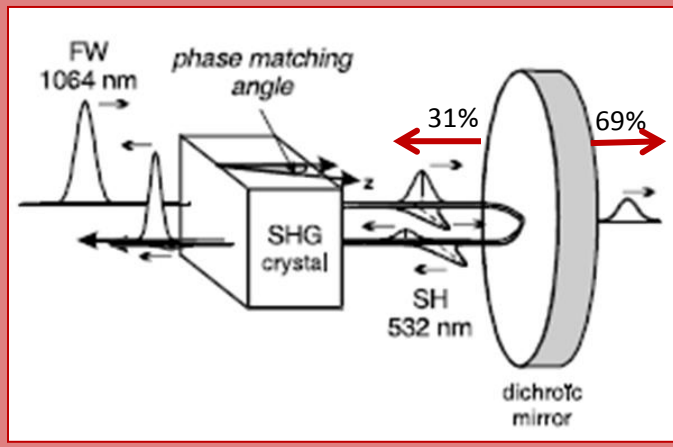
Mani et al., Appl. Phys. Let. 75 (1999) 3066

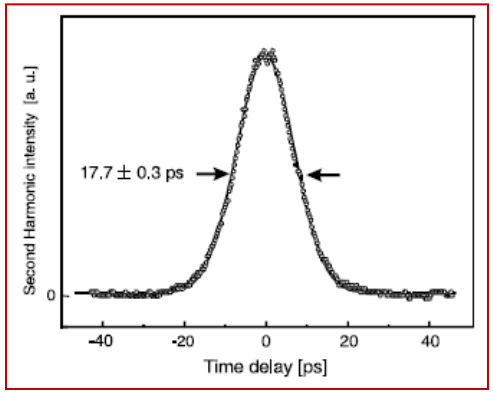
Nd:YAG oscillator configuration: AOML = acousto-optic mode locker; M = high reflectivity curved mirror (R = - 10 m); DM = dichroic mirror; T = telescope; D = diaphragm.



A typical envelope of the YAG oscillator pulse train, recorded on a 50 MHz oscilloscope

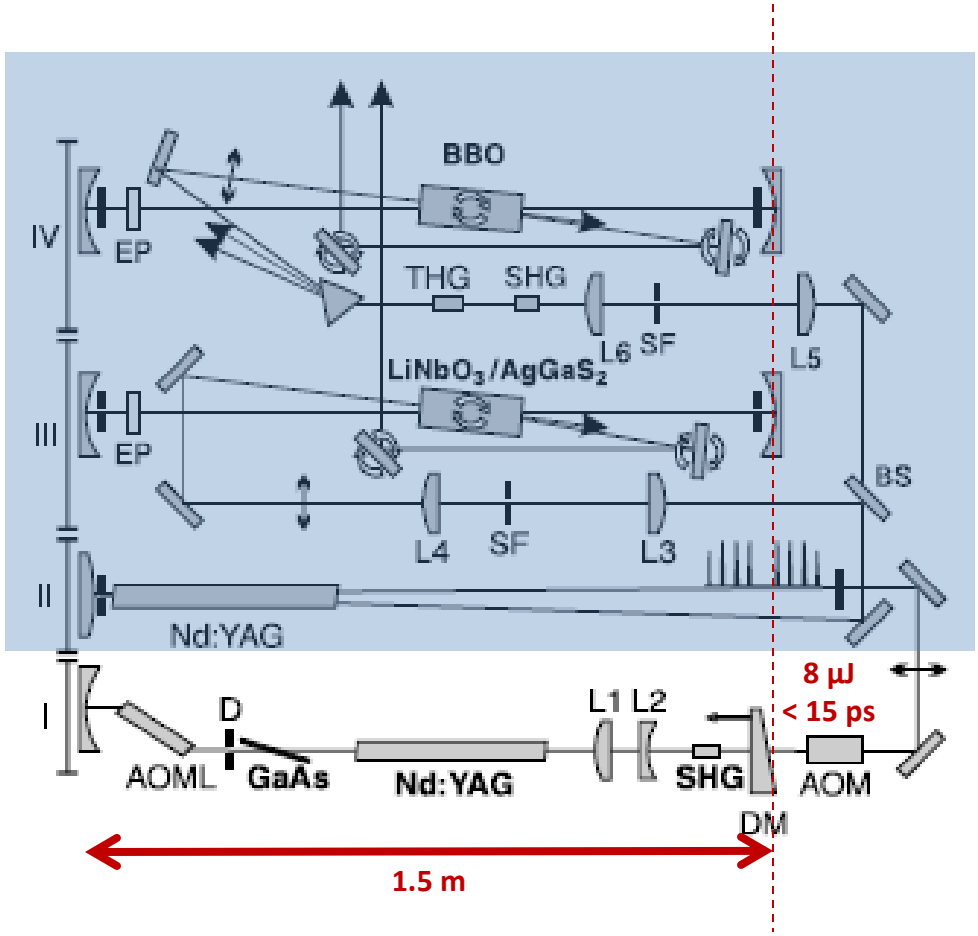
Frequency doubling nonlinear mirror



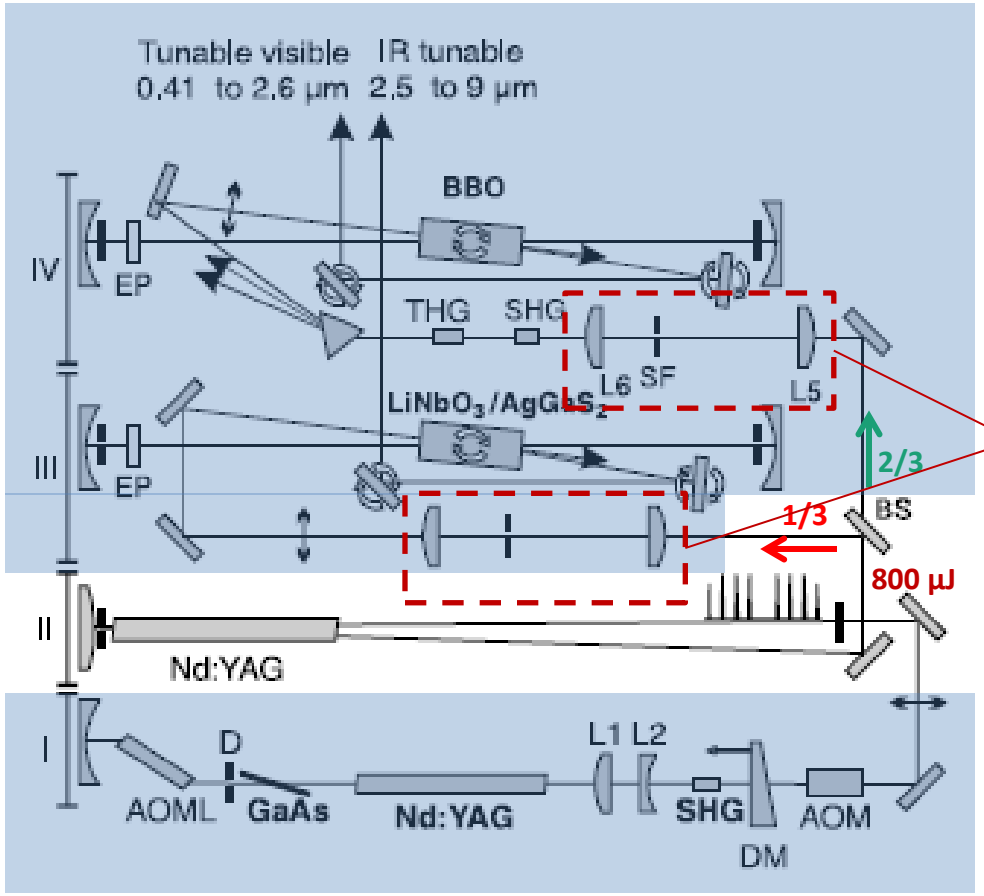


The Fourier-transform limited pulse duration: the balance between the pulse shortening mechanism by the FDNLM and the stretching mechanism introduced by the saturated semiconductor.

Picosecond laser optical oscillator stage

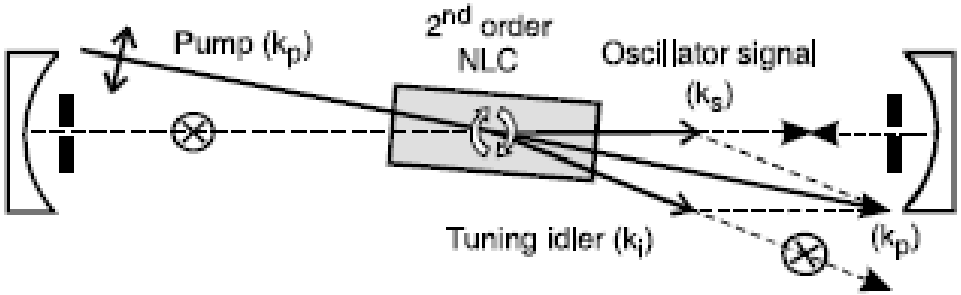


Double-pass optical amplifier stage

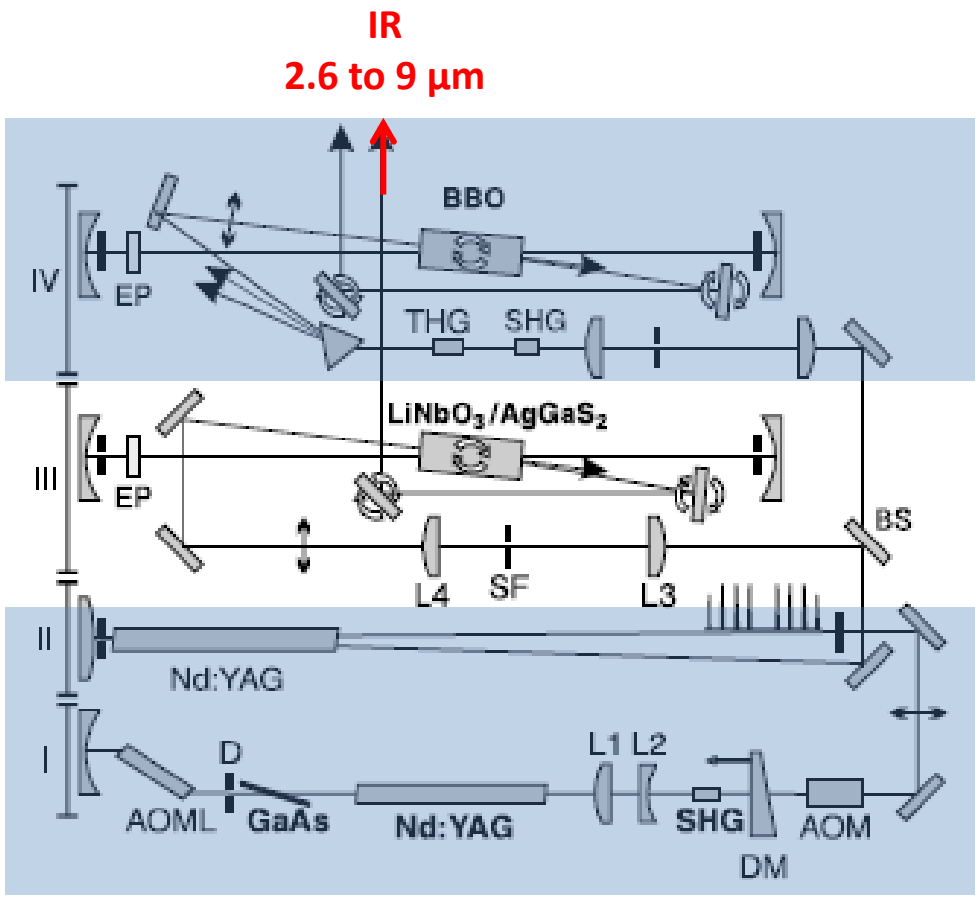


1/3-magnification telescopes reduce the beam

Optical parametric oscillator



$LiNbO_3/AgGaS_2$ OPO in the IR range

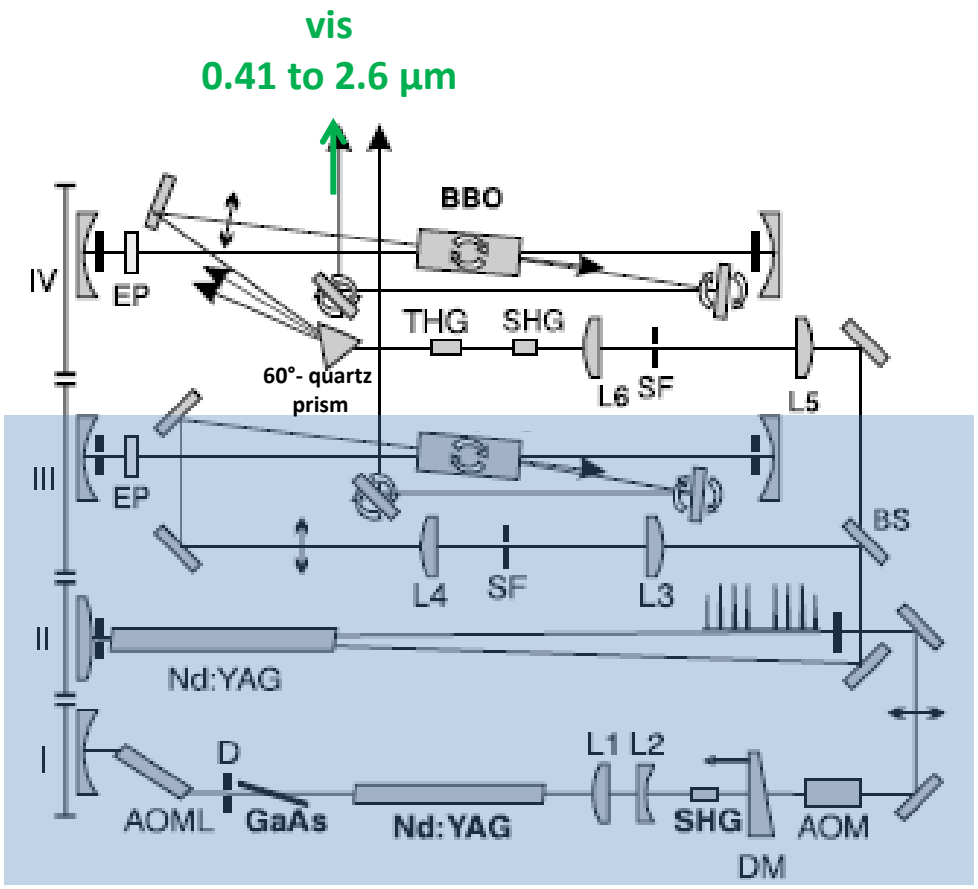


Tunability

$LiNbO_3$ permits wavelength tuning in 2.5 - 3.6 µm

$AgGaS_2$ permits wavelength tuning in 4 to 9 µm

OPO in the visible spectral range



Conclusion

1. Two-color laser system based on an all-solid state pulsed Nd:YAG laser pumping picosecond OPOs.

2. The system is integrated in a DR-SFG spectrometer dedicated to the infrared-visible range.

3. The presented set-up offers the advantages of high sensitivity, high resolution, and maintenance free operation due to the use of an all-solid-state technique.