PhD Open Days

Ultrashort optical parametric oscillator up to the mid-IR

APPLAuSE PhD PROGRAM

Mario Galletti (mario.galletti@tecnico.ulisboa.pt)

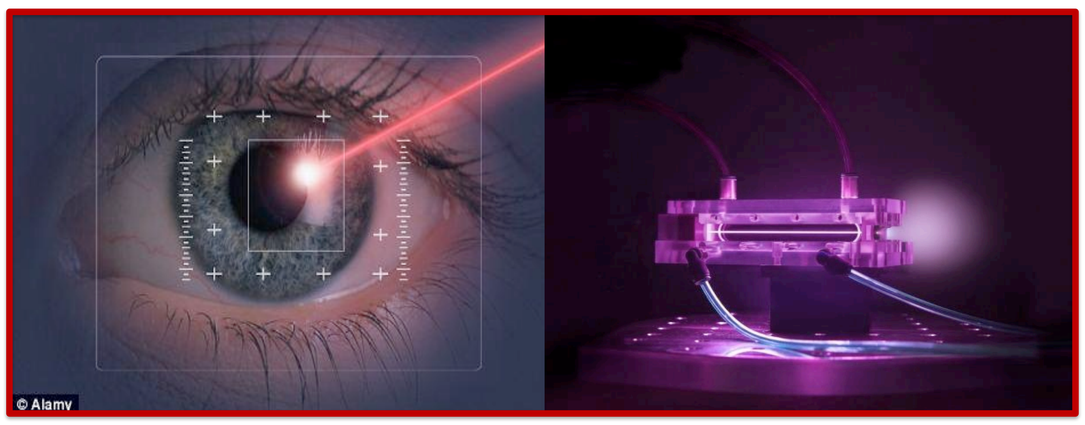
Scientific Motivation

Coherent light sources in spectral regions that are inaccessible to lasers have been an important issue for more than five decades. This limitation arises from the **limited gain bandwidth of the active medium**, which defines the operating laser spectral region (e.g. limitation for spectroscopy purposes [1]).

Coherent optical sources based on nonlinear conversion, with

- **femtosecond pulse** duration and
- **wide tunability**

are rapidly emerging. They are **extremely versatile** and of considerable interest for a wide range of scientific and technological applications in different areas [2].



Laser application in human surgery (left) and in plasma based accelerator (right): Figure 1

Ultrashort lasers: from ultrafast phenomena to particle acceleration

The great variety of ultrashort laser [3] systems available nowadays is capable of generating pulses

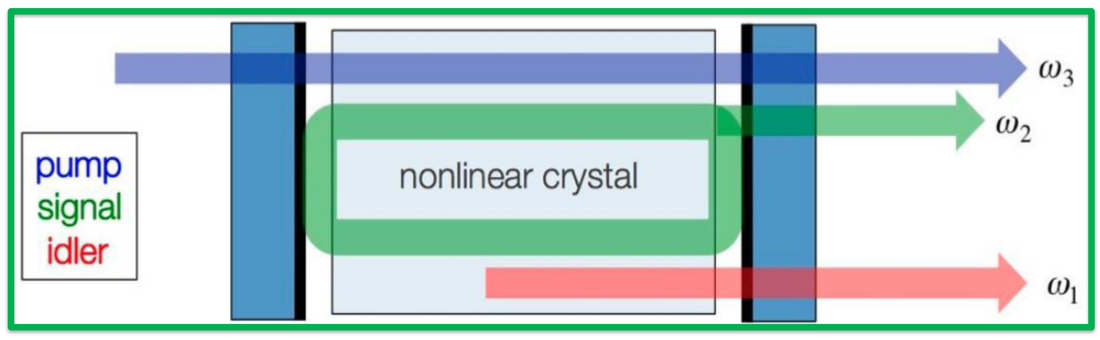
- from **CW to fs** temporal range;
- from **UV to IR** in the spectral domain;
- energies from **nJ to thousands of J**;
- **TW peak powers** in few kHz repetition rate and reaching tens of MHz at lower powers.

The applications of ultrashort laser pulses derive mainly from two characteristics:

- **the duration** ⟹ induce and measure ultrafast phenomena
- **the ultra-intense fields associated to them** ⟹ ionization processes and particle acceleration by e.m. field to high energies [4].

Shaping the next generation of ultrafast, widely tunable laser sources with OPOs

The Optical Parametric Oscillator (OPO) is an optical tool that converts an input laser wave with frequency ω_p into two output waves of lower frequency ω_s, ω_i ($\boldsymbol{\omega_s + \omega_i = \omega_p}$) by means of **a 2nd order nonlinear optical interaction** mediated by a nonlinear, birefringent crystal.



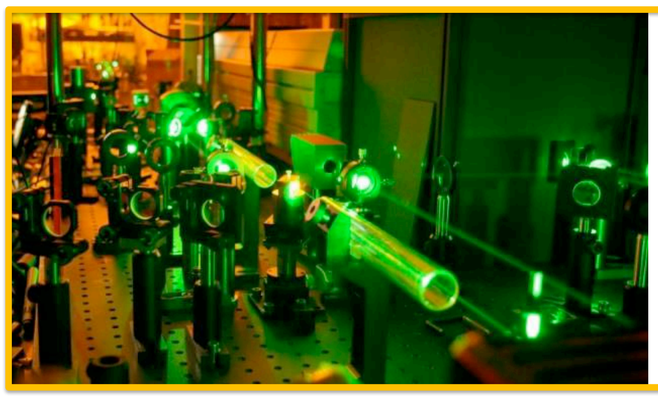
The OPO main attraction is to generate **widely tunable coherent radiation** (mid-IR [5], deep-IR, far-IR, or tera-Hz spectral region)

- **all time-scales** from the CW to the ultrafast ps and fs [6] regime
- **versatile tunable** sources thanks to **innovative architectures**
- **high power levels** [6] thanks to the availability of high-power pump lasers.

Research activities goal

This project consists in performing studies, designing and assembling two OPOs and completely characterization of their output.
The two operational OPOs will be adapted and optimized to:

- **Upgrade of the L2I system @IST**: the OPO is able to generate high quality, reproducible, spectrally tunable, broadband ultrashort pulses.



L2I laser system @IST: Figure2

- **Upgrade of the Vulcan system @RAL**: Off-harmonics **femtosecond probe** generation and realization of an **oscillator** for the 20PW project.

Vulcan laser system @RAL: Figure3

References & Acknowledgements

[1] A. Schliesser et al, Nature Photonics 6, 2012.
[2] G. Edwards et al, Nature 371, 416 -9, 1994.
[3] P. French, Rep. Prog. Phys. 58, 169-267,1995.
[4] W. Leemans et al, Nature Physics 418: 2006.
[5] V.R. Badarla et al, Optics Letters, (3), 2015.
[6] S.C. Kumar et al, Optics Letters, (7), 2015.

Work supported by FCT, grant PD/BD/114327/2016