Photoluminescence Studies

from ps to ms with high-power fast-gate cw pulse patterns by a RGB laser excitation source: Characterization and Applications

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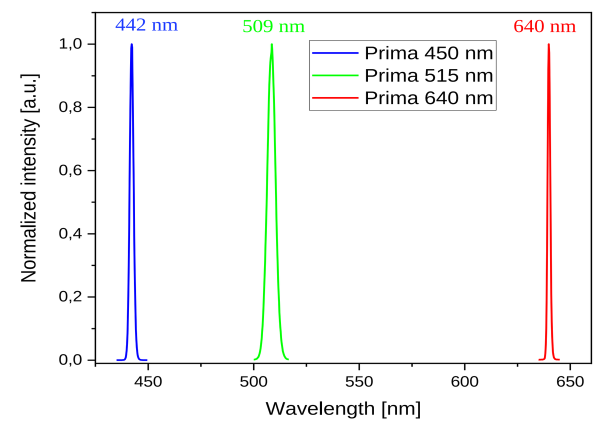
Introduction

Pulsed diode lasers have found widespread applications in many fields of time-resolved fluorescence spectroscopy and microscopy. Often, use of different excitation wavelengths in the same system requires the use of different diode heads, whose beam paths need to be combined for measurements. Here we present a new stand-alone picosecond laser (Prima) with three integrated colors, which can easily be switched in software. We integrate the laser into a time-resolved fluorescence spectrometer (FluoTime 300) and a confocal microscope (MicroTime 100). There, its performance is compared to that of a standard laser diode, especially for the measurements of long luminescence lifetimes in the μs range.

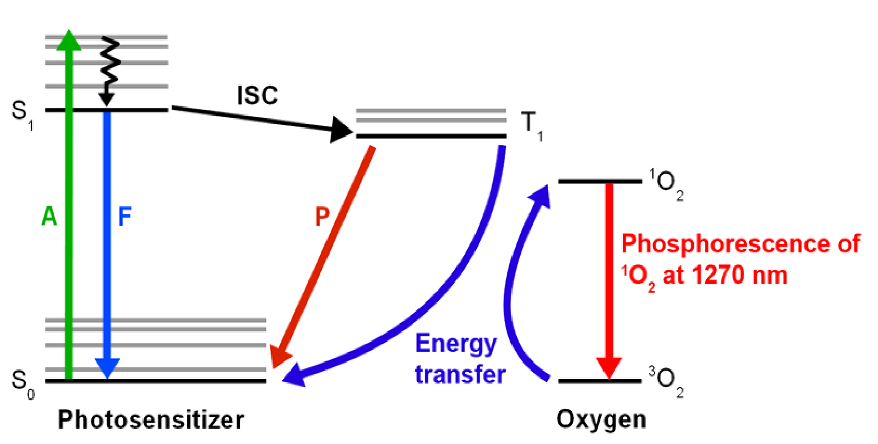
3-Color Picosecond Laser

Pulse duration:
- 120 ps @ 450 nm
- 200 ps @ 515 nm
- 150 ps @ 640 nm

Power:
- Max pulsed: 10 mW
- Max cw : 50 mW

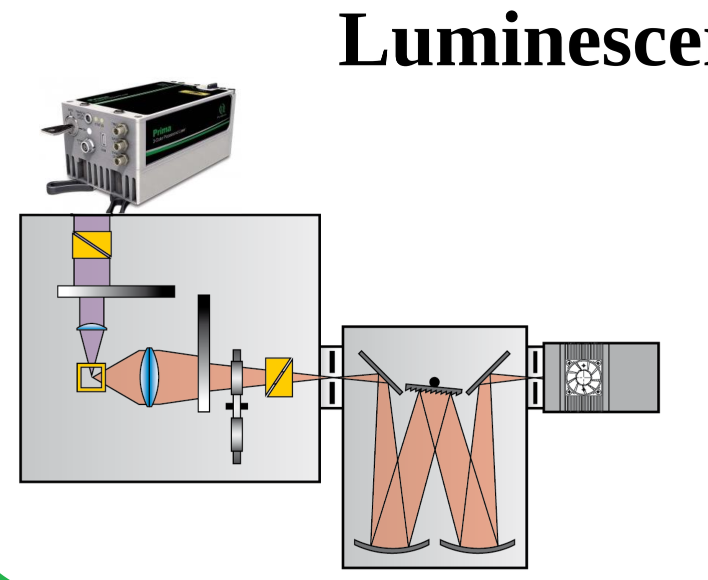


Singlet Oxygen Luminescence



- Singlet oxygen typically is generated via energy transfer from excited state of a photosensitizer to oxygen molecule
- singlet oxygen emission lifetime is solvent dependent → gain information about environment of emitting oxygen molecules
- studies are usually performed with emission detection around 1270 nm
- singlet oxygen emission is very weak → measurements challenging

Luminescence spectroscopy

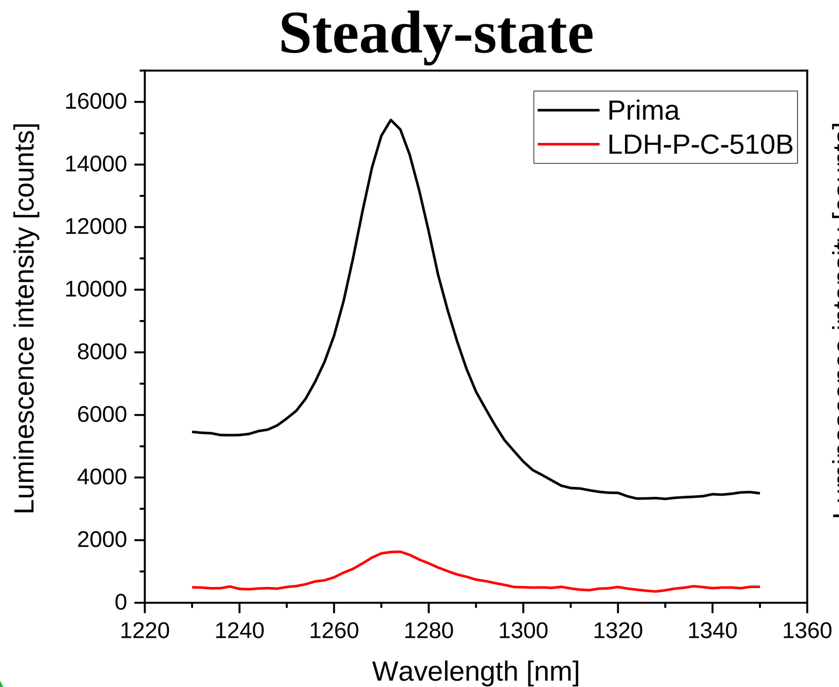


FluoTime 300 spectrometer equipped with

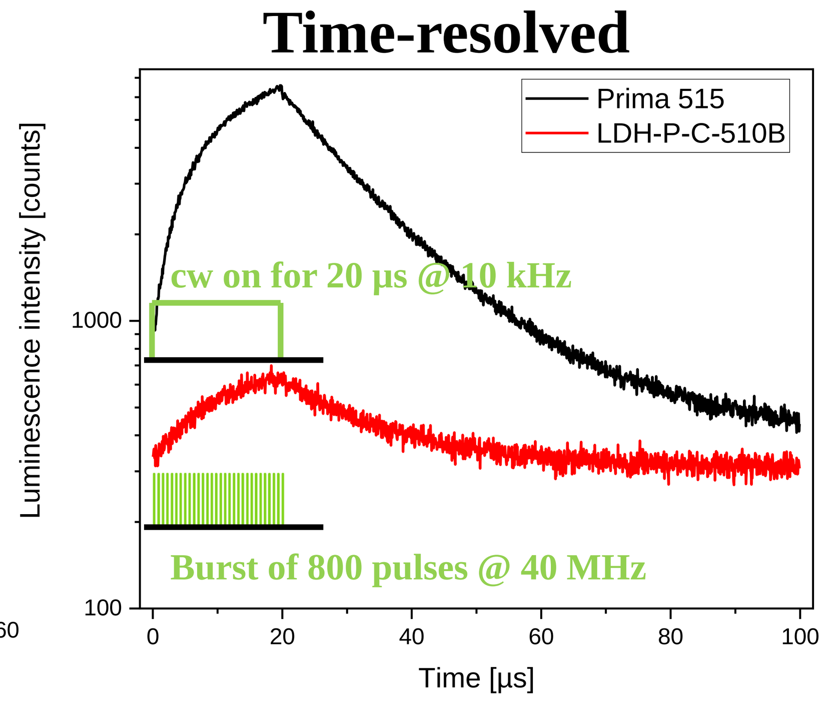
- excitation either with Prima @ 515 nm or LDH-P-C-510B laser head
- an NIR-PMT (H10330-45, Hamamatsu) detector
- detection wavelength: 1270 nm
- detection bandwidth: 30 nm
- a TimeHarp260 Nano TCSPC module
- acquisition time: 150 s

Results: Detecting singlet oxygen luminescence

Steady-state



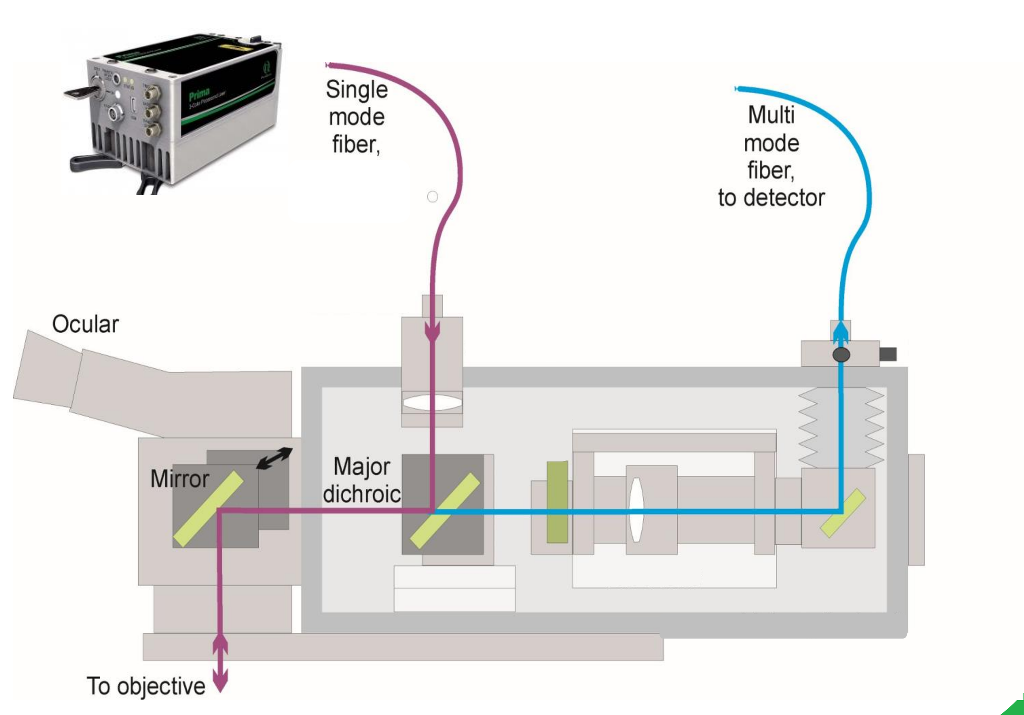
Time-resolved



Time-resolved photoluminescence (TRPL) imaging microscopy

MicroTime 100 microscope equipped with

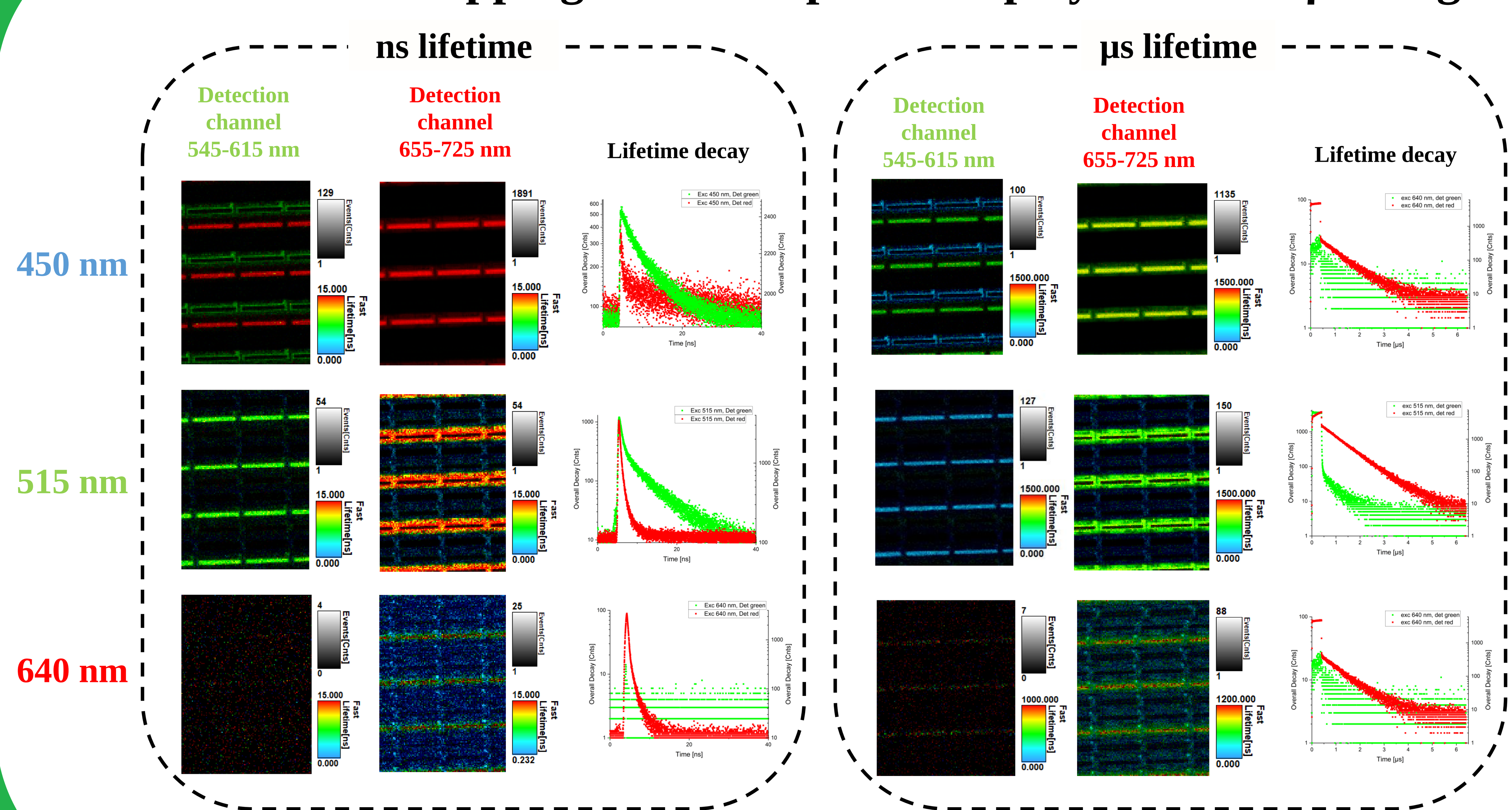
- excitation with Prima @ 450, 515 or 640 nm gated cw, cycle freq. 0.4 MHz
- 2 SPAD detectors: detection wavelengths: @ 545-615 nm and 655-725 nm
- a MultiHarp 150 TCSPC module
- acquisition time: 250 x 150 px, 1 ms/px



Conclusion

- Gated cw mode efficiently excites luminescence, compared to single pulse or burst of pulses
- Low cycle frequency enables measurement of long lifetimes in μs range
- Higher signals from weakly phosphorescent samples, such as singlet oxygen, than previously possible
- Improved efficiency: single laser source to study multicolor samples such as RGB smartphone displays

Results: TRPL mapping of a smartphone display in ns and μs range



Display pixels: