

# Multi-Color Laser Spectroscopy with a Dual-Color QCL

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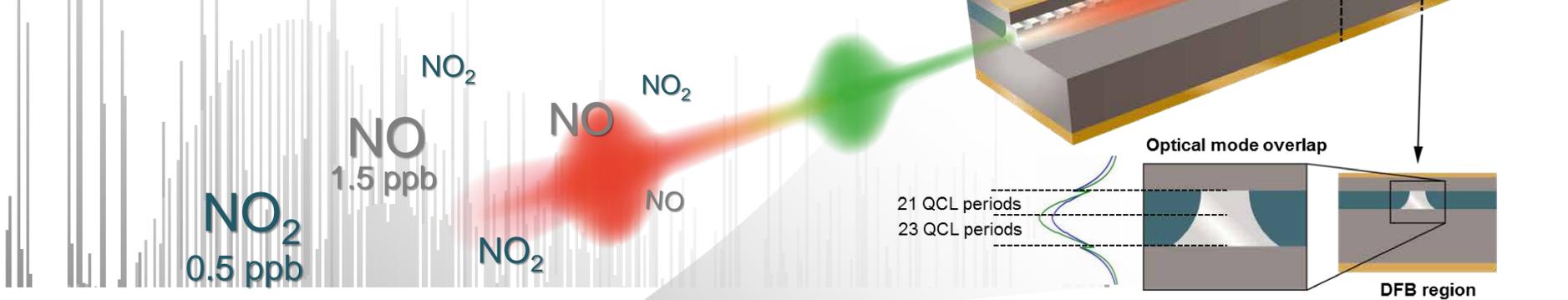
## Dual-Color Quantum cascade Laser

### Multi-component detection with a single laser source

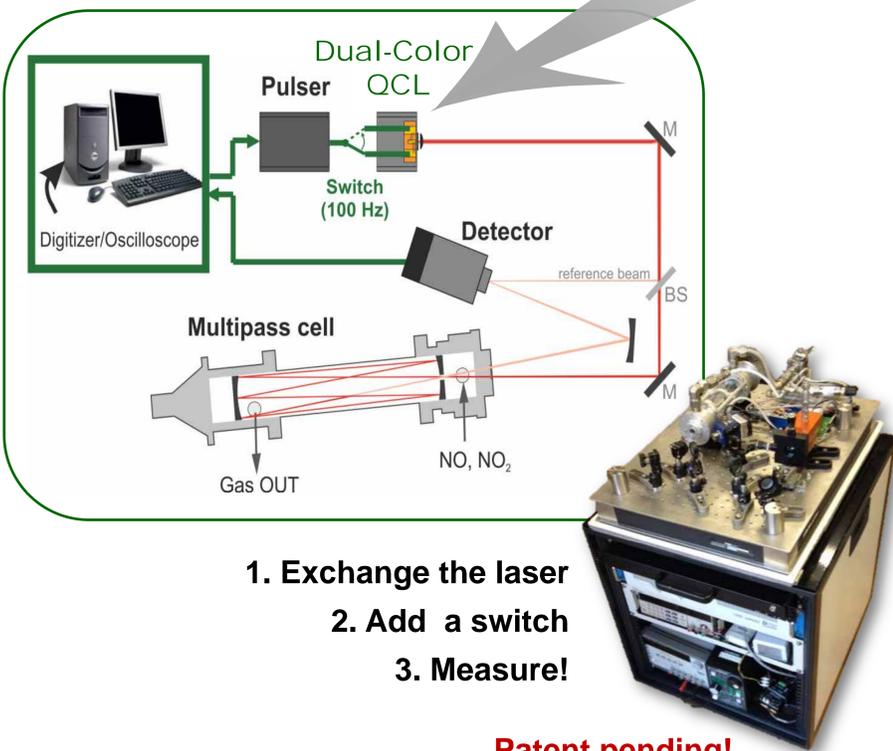
Dual-color Quantum Cascade Laser (QCL) can emit at two different, spectrally well-separated wavelength in one single output beam. Each of the wavelengths can be addressed independently, so that the laser can operate at 5.25  $\mu\text{m}$  or 6.25  $\mu\text{m}$  either simultaneously or sequentially.

Such a laser is an ideal light source for MIR laser spectroscopy as it allows for detection of multiple gas species in a compact, single-path setup and without any beam coupling optics.

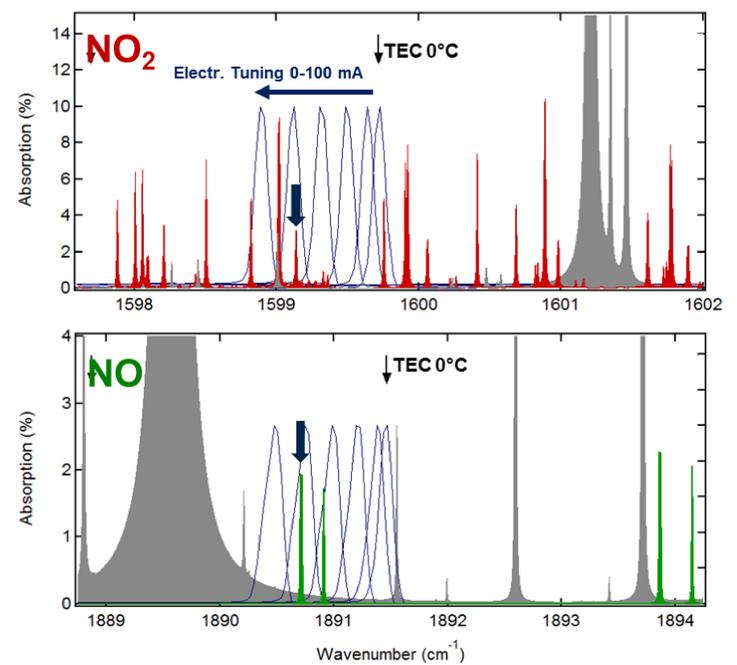
Here it is applied to measure trace-gas concentrations of NO and NO<sub>2</sub>, which are relevant pollutants produced e.g. in car combustion engines.



### Dual-color laser in a single-path spectroscopy setup



### NO / NO<sub>2</sub> spectroscopy



Strong absorption lines of NO<sub>2</sub> and NO around 1600  $\text{cm}^{-1}$  and 1890  $\text{cm}^{-1}$  exhibit a good spectral overlap with the Dual-color QCL emission. By setting the laser temperature to 0°C, spectral signatures of both gases are accessed simultaneously and their concentrations are measured with a sensitivity of 0.5 ppb for NO<sub>2</sub> and 1.5 ppb for NO after 100s of averaging.

## Heavy-duty diesel engine emissions

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NO and NO<sub>2</sub> emissions of a diesel engine operated in a WHTC dynamic test cycle were measured.

Comparison with a standardized automotive chemiluminescence NO<sub>x</sub> detector showed that our system is:

- excellent in terms of precision
- insensitive to water interference
- stable in harsh environment
- faster than CLD

