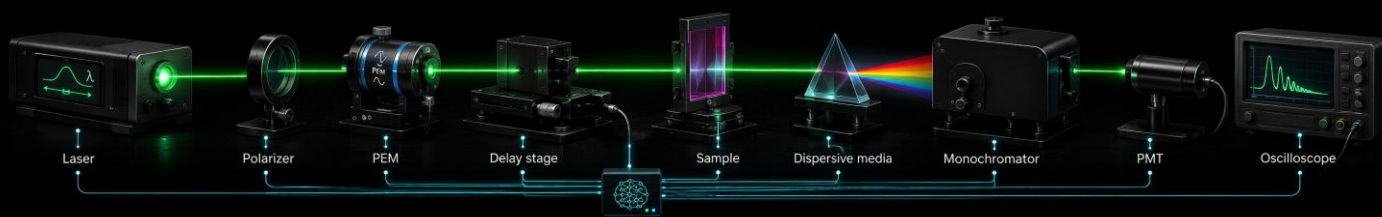


Master Thesis Project

From optics to autonomy: AI-assisted automation of laser spectroscopy

Can AI make laser spectroscopy autonomous and self-optimizing?



Research area: Laser Spectroscopy | Artificial Intelligence | Optical Instrumentation | Automation

Scientific motivation: Modern laser spectroscopy can generate large multidimensional datasets while requiring precise control of polarization, sample position, acquisition parameters, and optical components. Conventional automation can execute predefined measurement sequences, but it cannot readily decide which measurement should be performed next, recognize when an experiment is drifting, or adapt acquisition parameters in response to the data.

This project aims to go beyond conventional laboratory automation by integrating **AI-based decision making directly into an optical experiment**. An existing laser spectroscopy setup will be equipped with computer-controlled hardware and intelligent software that can monitor measurement quality, optimize experimental parameters, identify anomalous behaviour, and ultimately adapt the measurement strategy in real time. The long-term objective is an experimental platform capable of progressing from automated measurements toward **self-optimizing spectroscopy**.

Research question: Can AI be integrated into a laser spectroscopy experiment to autonomously optimize measurement conditions and improve the efficiency and reliability of data acquisition?

Your project and the skills you will develop: During this Master thesis, you will develop an AI-assisted control architecture for an existing laser-based optical spectroscopy setup. You will connect motorized optical components, sample positioning, detectors, and data acquisition into a coordinated software environment and implement algorithms that use the acquired data to influence subsequent experimental decisions. The project will progress from deterministic automation toward adaptive measurement strategies in which the experiment can recognize measurement quality, optimize selected parameters, and respond intelligently to changing experimental conditions.

You will gain hands-on experience with:

- Laser-based optical spectroscopy
- Motorized optics and sample positioning & Hardware–software interfacing
- Automated data acquisition
- AI and machine-learning methods for experimental data
- Real-time data processing and visualization
- Instrument synchronization and triggering
- Experimental calibration and reproducibility testing
- Development of autonomous measurement workflows

The project offers the opportunity to work with advanced experimental methods at the interface of physical chemistry, quantum sensing, magnetism, and materials science. It is suitable for students in **Chemistry | Physics | Mechatronics | Electrical Engineering**. Previous experience in spectroscopy, optics, or magnetic materials is helpful but not required. An interest in interdisciplinary experimental work, instrumentation, and careful quantitative measurements is particularly valuable.

Interested? For more information contact: PD. Dr. Aras Kartouzian | aras.kartouzian@tum.de