Accessibility statement

UNIVERSITY of York

Lasers in Chemistry - CHE00036M

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- **Department**: Chemistry
- **Module co-ordinator**: Prof. Neil Hunt
- **Credit value**: 10 credits
- **Credit level**: M
- **Academic year of delivery**: 2020-21
  - See module specification for other years: 2019-20

Module will run

Occurrence	Teaching cycle
A	Spring Term 2020-21 to Summer Term 2020-21

Module aims

Lasers have become powerful tools in modern chemistry, where they find applications in fields as diverse as astrochemistry, atmospheric remote sensing and analytical research, while the arrival of ultrafast (femtosecond) pulsed lasers has enabled the observation of molecular reactions in real time. The course offers three perspectives on the applications of lasers in chemistry: The first presents an overview of modern lasers and their operation and will discuss how lasers have advanced our understanding in areas ranging from the chemistry of hostile environments to the biomedical arena. The second presents the field of modern laser spectroscopy as applied to the gas phase, focusing on optical spectroscopies of molecular clusters and the use of lasers to measure the fundamental intermolecular interactions that underpin chemistry and biology. The third introduces the field of femtochemistry, discussing how ultrafast lasers can be used to follow chemical processes in the gas and condensed phases in real time. This will include an introduction to advanced spectroscopic methods such as multidimensional spectroscopy and time-resolved electron diffraction.

Module learning outcomes

Students will gain an understanding of different laser types and understand how lasers are used to both generate and detect key intermediates that control chemistry in combustion processes, in the Earth's atmosphere, and beyond. Students should be able to apply their knowledge to predict the solution of unseen problems, as well as rationalise the application of different laser systems to these scenarios.

Students will learn about applications of modern optical spectroscopy to the study of molecular clusters – including using such techniques to gain detailed insight into intermolecular interactions.

Students will learn about ultrafast spectroscopy methods including experiments used to observe chemical process in the gas and solution phase in real time. Students will appreciate the applications of ultrafast lasers in molecular spectroscopy and the role of dynamics in chemical processes.

Module content

This module provides an introduction to the world of lasers and their application to a diverse range of problems in chemistry. The module will comprise three lecture courses, each comprising 6 lectures, covering the following content:

Part one: 6 lectures (AJK x 3 & TJD x 3): Laser fundamentals and applications. The course provides an introduction to the types of lasers used in modern chemistry. The course will then go on to discuss how lasers have contributed to a wide range of research fields within chemistry, from remote sensing applications in astrochemistry or environmental chemistry to biomedical uses of lasers. This course will be assessed by a **90 minute assessed workshop**.

Part two: 6 lectures (CED): Lasers for Intermolecular Interactions. The course covers applications of modern optical spectroscopy to the study of molecular clusters. The course will include discussions of intermolecular interactions, molecular beams, microwave and IR spectroscopy of neutral clusters and electronic, photoelectron and threshold photoelectron spectroscopy of neutral and charged clusters. The course will be supported by a **90 minute workshop (CED)** and will include the opportunity to observe some of the methods described in action in a research laboratory.

Part three: 6 lectures (NTH x 5 & DAW x 1): Lasers for making and directing molecular movies. This course introduces the concepts and methods of ultrafast spectroscopy that allow chemists to observe and influence reactions in real-time. The discipline of chemistry is based on changes in molecular structure, but observing the transition states that occur during reaction mechanisms requires a 'camera' capable of 'seeing' species that exist for just a few femtoseconds (10^{-15} s). Similarly, many important processes carried out by biological molecules are regulated by the fast dynamics of hydrogen bonds between water molecules, which exchange on picosecond (10^{-12} s) timescales. The course will describe the development of ultrafast spectroscopy applications in the gas and solution phases in detail before introducing state-of-the-art reaction-following experimental methods that have opened up new horizons for chemistry research. The course will be supported by a **90 minute workshop (NTH)** and will include the opportunity to observe some of the methods described in action in a research laboratory.

Assessment

Task	Length	% of module mark
24 hour open exam Lasers in Chemistry	N/A	70
Practical Assessed Workshop	N/A	30

Special assessment rules

None

Additional assessment information

The exam will feature two 20-mark compulsory questions.

Reassessment

Task	Length	% of module mark
24 hour open exam Lasers in Chemistry	N/A	70
Practical Assessed Workshop	N/A	30

Module feedback

Workshops: Written and/or oral feedback for workshops will be given either during the sessions or within a week.

Exams: Closed exam results with per-question breakdown are returned to the students via supervisors within 5 weeks (as per special approval by the University Teaching Committee). Outline answers are made available via the Chemistry web pages when the students

receive their marks, so that they can assess their own detailed progress/achievement. The examiners' reports for each question are made available to the students via the Chemistry web pages.

Indicative reading

Laser Chemistry: Spectroscopy, Dynamics and Applications by Telle, Gonzalez Urena and Donovan [Wiley]

Coronavirus (COVID-19): changes to courses

The 2020/21 academic year will start in September. We aim to deliver as much face-to-face teaching as we can, supported by high quality online alternatives where we must.

Find details of the measures we're planning to protect our community.

Course changes for new students