TEACHING GUIDE ON

LASER PHYSICS AND APPLICATIONS

<table>
<tr><th>MASTER MODULE</th><th>SEMESTER</th><th>CREDITS</th><th>COURSE TYPE</th></tr>
<tr><td>Physics and Radiation Technology</td><td>1</td><td>6</td><td>Optative</td></tr>
<tr><th colspan="2">PROFESSOR(S)</th><th colspan="2">CONTACT DETAILS</th></tr>
<tr><td colspan="2" rowspan="2">Theory:
• Enrique Buendía Ávila
• Daniel Rodríguez Rubiales

Laboratory:
• Daniel Rodríguez Rubiales</td><td colspan="2">• Enrique Buendía Ávila
Atomic, Molecular and Nuclear Physics Department
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• Daniel Rodríguez Rubiales
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Room 136.
E-mail: danielrodriguez@ugr.es</td></tr>
<tr><td colspan="2">TUTORIALS TIMETABLE</td></tr>
<tr><td colspan="2"></td><td colspan="2">• Enrique Buendía Ávila
Atomic, Molecular and Nuclear Physics Department
Monday and Friday: 11:00-13:00

• Daniel Rodríguez Rubiales:
Atomic, Molecular and Nuclear Physics Department
Monday: 11:30-13:30
Tuesday: 16:00-18:00
Thursday: 17:00-19:00</td></tr>
<tr><th colspan="4">MASTER DEGREE</th></tr>
<tr><td colspan="4">University Master in Physics: Radiations, Nanotechnology, Particles and Astrophysics, University of Granada</td></tr>
<tr><th colspan="4">TEACHING DATES AND TIMES</th></tr>
<tr><td colspan="4">Monday: 17:00-18:00</td></tr>
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Wednesday: 17:00-18:00
Thursday: 16:00-17:00

PRE-REQUISITES FOR REGISTRATION

Bachelor in Physics, Electronic or Telecommunication Engineering

BRIEF CONTENTS DESCRIPTION

Fundamentals of lasers. Production of laser light. Interaction of laser beams with atoms and molecules. Applications in fundamental physics and technology. Other applications.

PROGRAM

Theory:

1. Fundamentals of the laser: Coherence light sources. Principle of operation of a laser system. Description of laser radiation. External elements associated with the measurement of laser light, its transport and manipulation: polarizers, transmission modes of light and optical fibers, modulators. Interferometers. Lights sensors and detectors.
2. Production of laser light: Laser systems: He-Ne laser, semiconductor lasers, solid state lasers and fiber lasers. Cw lasers and frequency stability. Optical cavities. Finesse. Pulsed lasers, short and ultra-short. Photonics. The frequency comb.
3. Interaction of lasers with atomic systems: Ion traps. Coupling between atoms and electromagnetic fields: 2-level system. Laser cooling of ions. Laser cooling of neutral atoms.
4. Precision experiments with ion traps and lasers: Optical spectroscopy techniques. Frequency standard. Quantum computing. Nuclear physics and fundamental interactions.
5. Other scientific and technological applications of the laser: LIDAR. Ions acceleration. The laser in medicine, micro-fabrication, micro-lithography, monitoring, communication, data storage.

Laboratory:

1. Ti:Sa laser hands-on training, frequency stabilization, and control of the laser linewidth.
2. Diode laser hands-on training including frequency stabilization.
3. Frequency comb hands-on training.
4. Laser diode locking to a high-finesse cavity.

1. Determination of the laser linewidth using a Fabry-Perot interferometer.
2. Precise frequency measurement of the light emitted by the Ti:Sa laser using the frequency comb.

BIBLIOGRAPHY

- ***Springer Handbook of Lasers and Optics***, 2nd edition, F. Träger Editor, Springer-Verlag Berlin Heidelberg 2012
- ***Basic of Laser Physics***, K.F. Renk, Springer-Verlag Berlin Heidelberg 2012
- ***Optics, Light and Lasers***, 2nd edition, revised, D. Meschede, Wiley-VCH Verlag GmbH & Co. KGaA 2007
- ***Ion Traps***, P.K. Ghosh, Oxford University Press, Oxford, United Kingdom 1995

- ***Charged Particle Traps***, F.G. Major, V.N. Gheorghe, G. Werth, Springer-Verlag Berlin Heidelberg 2005
- ***Charged Particle Traps II***, F.G. Major, V.N. Gheorghe, G. Werth, Springer-Verlag Berlin Heidelberg, 2009
- ***Building Electro-Optical Systems***, P.C.D. Hobbs, John Wiley & Sons, 2009
  Introduction to Quantum Optics, G. Grynberg, A. Aspect, C. Fabre, Cambridge University Press, United Kingdom 2010