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From Laser Spectroscopy Research to Nonlinear Optics Instruction

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Abstracts

In this paper we describe how to join the two fundamental activities of a university professor: research and teaching. The work of our research team is devoted to the applications of two photon polarization spectroscopy to plasmas and combustion processes diagnostics. As a result of this work now we have powerful equipment and experience on nonlinear processes. Therefore, we decided to offer Nonlinear Optics as an elective subject, to the students in the last year of the Physics Degree at Valladolid University. We conclude that research at the University acquires its total significance when it is applied to the student's instruction.

Summary

In this paper we describe how to join the two fundamental activities of a university professor: research and teaching. The work of our research team in the last years has been devoted to the principle, development and applications of a new laser spectroscopic technique: two photon polarization spectroscopy. This method is suitable for the diagnostic of plasmas and combustion processes, even in far off thermodynamic equilibrium conditions. The full potential of this technique requires tunable pulsed high power UV laser radiation of single longitudinal mode. To achieve this we modified a commercial laser system. From the academic point of view, the whole experimental setup or some parts of it, especially the laser spectrometer, can be very useful at different academic levels as Ph.D. or even with undergraduate students.

The laser spectrometer consists of a 10 Hz injection-seeded Q-switched Nd:YAG laser (Continuum, Powerlite 8000) and an OPO-OPA system (Continuum, Mirage 500). This laser offers tunable radiation in the visible and near-IR range (426 nm to 2.12 m). Then by sum frequency generation (SFG) in a BBO crystal UV radiation can be obtained. As an example of this conversion process, we are working now in the application of two-photon polarization spectroscopy to the study of the 1S-2S transition in hydrogen, i.e. 243 nm radiation. To get this wavelength, the second harmonic of the Nd:YAG laser (532 nm) is converted into tunable SLM near-infrared radiation at 722 nm by frequency splitting in the optical parametric oscillator (OPO) based on a Type II KTP crystal. The Mirage OPO uses a patented grazing incidence grating oscillator, which generates SLM radiation close to the Fourier transform limit. The OPO output is subsequently amplified in the optical parametric amplifier (OPA)

based on two Type I BBO crystals pumped by the third harmonic of the Nd:YAG (355 nm). Finally, 243 nm radiation is obtained by sum-frequency generation (SFG) of the 772 nm and the third harmonic in a BBO crystal. This system provides up to 10 mJ in 2.5 ns and 300 MHz bandwidth.

Evidently, nonlinear effects in Optics offer the possibility of generating or manipulating light in almost any way. The laser itself, producing light not available in nature, is the most obvious example. Therefore, with our powerful equipment and experience, we have decided two years ago to offer Nonlinear Optics as an elective subject, to the students in the last year of the Physics Degree at Valladolid University. The main goal of this new subject is the study of some fundamental topics of Nonlinear Optics. Besides, the field of nonlinear interaction of light and matter is progressing quickly and new applications with strong economic and social implications can be expected. This fact adds a great excitement to the student's instruction.

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A brief description of the main topics of the Nonlinear Optics course appears below:

1. General remarks
2. Nonlinear Susceptibility Tensor
3. Second order effects
   a Generation of the second harmonic
   b Frequency mixing
   c Parametric amplifiers and oscillators
   d Pockels' effect
4. Third order effects
   a Generation of the third harmonic
   b Raman techniques
5. Introduction to tunable pulsed lasers

The practical aspects are organized as follows:

1. Harmonic frequency generation from Nd:YAG laser in a nonlinear crystal
   a Second harmonic: type I and II
   b Third harmonic: type I
   c Fourth harmonic: type I
2. Opto-parametric processes in nonlinear crystals
3. Laser spectroscopy: some examples

As a final conclusion we would like to remark that research at the University acquires its total significance when it is applied to the student's instruction. At the same time this kind of experiences contributes to improve our own research, as we realize in everyday educational tasks.