

Optogalvanic spectroscopy measurements of the electric field strength in a hydrogen glow discharge

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Among the different plasma diagnostics methods, laser spectroscopy techniques based on two-photon absorption provides a high spatial and temporal resolution. In the Plasma Laser Spectroscopy Laboratory (University of Valladolid), electric fields measurements in the cathode fall region of a hollow cathode discharge by Doppler free two-photon optogalvanic spectroscopy are performed, applied to the 15-25 atomic transition in hydrogen. The electric field in a hollow-cathode discharge causes the Stark splitting and shifting of the 25 level of hydrogen. The comparison of these measurements with the theoretical calculations allows determining the value of the electric field.

Experimental arrangement

Pulsed UV laser radiation centred in 243 nm is generated by a 10 Hz injection-seeded Q-switched Nd:YAG laser (Continuum, Powerlite) and a tuneable laser (Mirage 500, Continuum) that provides a single longitudinal mode radiation, with a temporal duration of 3 ns, and spectral quality of 300 MHz bandwidth. In the experimental arrangement, the UV radiation is divided in two beams with the same optical path, overlapping in the upper central part of the cathode fall region in a volume of 150 μm of diameter and 10 mm of length. The quality of the focus is controlled at real time by a spectral profile analyser (LaserCam-HR-UV) that gives size and energy distribution information in every measurement. The detection of the 15-25 Stark components is done by the absorption of two photons circularly polarized. While tuning the laser frequency, the change of the voltage drop between the cathode and one anode is measured, and recorded shot by shot for each scan.



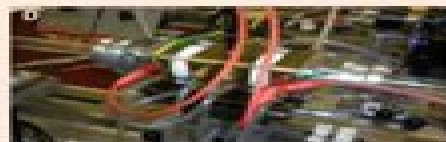
A: Tuneable laser Mirage 500, based on non-linear crystals

B: Optogalvanic spectroscopy experiment

C: Optogalvanic spectroscopy experiment scheme

Hollow cathode discharge

Low-pressure hydrogen plasma is generated by a hollow-cathode discharge in glow-discharge regime. The outer structure of the lamp is a vacuum seal chamber made of brass. The discharge is operated in a wide range of pressures, covering different currents. It is also possible to vary the cathode diameter and material. Previous to the optogalvanic measurements, a complete study of the stability and reproducibility of the discharge has been performed.



D: Discharge lamp

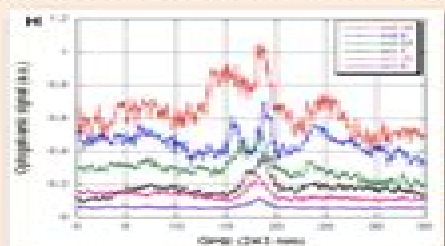
E: Scheme of the discharge lamp

F: Different aspects of the discharge

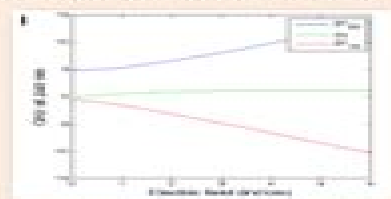
G: Study of the reproducibility of the discharge

Electric field measurements

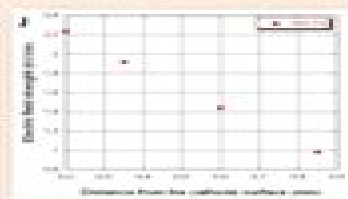
Linearity of frequency laser tuning is controlled by the transmission curve of a monitor etalon with a free spectral range of 7 GHz. Data acquisition has been updated and optimized, with a great improvement in temporal resolution and stability, by a new oscilloscope (model D505104A, Keysight Technologies Inc) and LabVIEW programming. Electric field strength is determined via the Stark splitting of the 25 level of atomic hydrogen, measuring the difference in GHz between the components $2p_{1/2}$ y $2p_{3/2}$ and comparing with the theoretical calculations (Figure I). Electric field strength depends mostly on the distance to the cathode surface, also on the pressure and current of the discharge, see figures H and J. Recently, an improvement in the measurements is achieved, reducing noise as can be seen in Figure K, where the experimental data are shown without any processing. Also the theoretical fits are included in the figure.



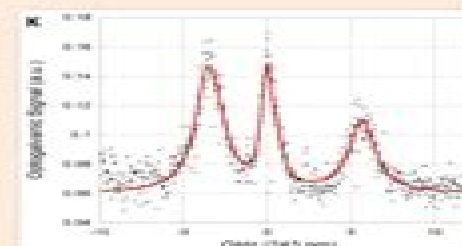
Optogalvanic spectra, with a pressure of 900 Pa and 100 mA of current in a 20 mm diameter stainless steel cathode.



Stark splitting calculation of the 25 level



Electric field strength vs distance from the cathode surface for a fixed current of 100 mA and 900 Pa



Optogalvanic spectrum with 500 Pa and 100 mA in a 10 mm diameter stainless steel cathode.

ACKNOWLEDGEMENTS

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Optogalvanic Spectroscopy 1990

Wolfgang Demtröder



Optogalvanic Spectroscopy 1990:

Optogalvanic Spectroscopy 1990, R. S. Stewart, J. E. Lawler, 1991-06 The proceedings comprise invited lectures and contributed and poster papers that consider recent developments in optogalvanic spectroscopy Among the topics are molecules plasma sheaths modelling resonance radiation trapping resonance ionization and high resolution spectroscopy plasma diagnostics penning and autoionization No subject index Annotation copyrighted by Book News Inc Portland OR

Ultraviolet Spectroscopy And Uv Lasers Prabhakar Misra, Mark A. Dubinskii, 2002-02-25 This volume presents a complete and thorough examination of advances in the instrumentation evaluation and implementation of UV technology for reliable and efficient data acquisition and analysis It provides real world applications in expanding fields such as chemical physics plasma science photolithography laser spectroscopy astronomy and atmospheric science **Molecular and Laser**

Spectroscopy V.P. Gupta, Yukihiro Ozaki, 2020-07-10 Molecular and Laser Spectroscopy Advances and Applications Volume 2 gives students and researchers an up to date understanding of the fast developing area of molecular and laser spectroscopy This book covers basic principles and advances in several conventional as well as new and upcoming areas of molecular and laser spectroscopy such as a wide range of applications in medical science material science standoff detection defence and security chemicals and pharmaceuticals and environmental science It covers the latest advancements both in terms of techniques and applications and highlights future projections Editors V P Gupta and Yukihiro Ozaki have brought together eminent scientists in different areas of spectroscopy to develop specialized topics in conventional molecular spectroscopy Cavity ringdown Matrix Isolation Intense THz Far and Deep UV Optogalvanic linear and nonlinear laser spectroscopy Rayleigh Raman Scattering Ultrafast Time resolved spectroscopy and medical applications of molecular spectroscopy and advanced material found in research articles This new volume expands upon the topics covered in the first volume for scientists to learn the latest techniques and put them to practical use in their work Covers several areas of spectroscopy research and expands upon topics covered in the first volume Includes exhaustive lists of research articles reviews and books at the end of each chapter to further learning objectives Uses illustrative examples of the varied applications to provide a practical guide to those interested in using molecular and laser spectroscopy tools in their research **Laser Spectroscopy** Wolfgang Demtröder, 2013-06-29 Keeping abreast of the latest techniques and applications this new edition of the standard reference and graduate text on laser spectroscopy has been completely revised and expanded While the general concept is unchanged the new edition features a broad array of new material e g frequency doubling in external cavities reliable cw parametric oscillators tunable narrow band UV sources more sensitive detection techniques tunable femtosecond and sub femtosecond lasers X ray region and the attosecond range control of atomic and molecular excitations frequency combs able to synchronize independent femtosecond lasers coherent matter waves and still more applications in chemical analysis medical diagnostics and engineering Encyclopedia of Plasma Technology - Two Volume Set J. Leon Shohet, 2016-12-12

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Atoms, Molecules and Photons Wolfgang Demtröder, 2010-11-10 This introduction to Atomic and Molecular Physics explains how our present model of atoms and molecules has been developed during the last two centuries by many experimental discoveries and from the theoretical side by the introduction of quantum physics to the adequate description of micro particles It illustrates the wave model of particles by many examples and shows the limits of classical description The interaction of electromagnetic radiation with atoms and molecules and its potential for spectroscopy is outlined in more detail and in particular lasers as modern spectroscopic tools are discussed more thoroughly Many examples and problems with solutions should induce the reader to an intense active cooperation

An Introduction to Laser Spectroscopy David L. Andrews, Andrey A. Demidov, 2012-12-06 Here is the first graduate level textbook to offer an introduction to the field of laser spectroscopy Chapters cover a broad range of topics in detail emphasizing the theoretical and experimental aspects of the field This much needed text will allow students to explore current research and gain an understanding of the analytical and industrial applications of laser spectroscopy

Proceedings of Optical Diagnostics of Living Cells and Biofluids, 1996

Springer Handbook of Lasers and Optics Frank Träger, 2012-05-05 This new edition features numerous updates and additions Especially 4 new chapters on Fiber Optics Integrated Optics Frequency Combs and Interferometry reflect the changes since the first edition In addition major complete updates for the chapters Optical Materials and Their Properties Optical Detectors Nanooptics and Optics far Beyond the Diffraction Limit Features Contains over 1000 two color illustrations Includes over 120 comprehensive tables with properties of optical materials and light sources Emphasizes physical concepts over extensive mathematical derivations Chapters with summaries detailed index Delivers a wealth of up to date references

Index of Conference Proceedings, 1991

Optics and Spectroscopy, 1994

Laser Experiments for Chemistry and Physics Robert N. Compton, Michael A. Duncan, 2016 This book provides a

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Laser-Based Measurements for Time and Frequency Domain Applications Pasquale Maddaloni, Marco Bellini, Paolo De Natale, 2016-04-19 Foreword by Nobel laureate Professor Theodor W Häch of Ludwig Maximilians Universität München Based on the authors experimental work over the last 25 years *Laser Based Measurements for Time and Frequency Domain Applications A Handbook* presents basic concepts state of the art applications and future trends in optical atomic and molecular physics

Optical Characterization of Epitaxial Semiconductor Layers Günther Bauer, Wolfgang Richter, 2012-12-06 The characterization of epitaxial layers and their surfaces has benefitted a lot from the enormous progress of optical analysis techniques during the last decade In particular the dramatic improvement of the structural quality of semiconductor epilayers and heterostructures results to a great deal from the level of sophistication achieved with such analysis techniques First of all optical techniques are nondestructive and their sensitivity has been improved to such an extent that nowadays the epilayer analysis can be performed on layers with thicknesses on the atomic scale Furthermore the spatial and temporal resolution have been pushed to such limits that real time observation of surface processes during epitaxial growth is possible with techniques like reflectance difference spectroscopy Of course optical spectroscopies complement techniques based on the interaction of electrons with matter but whereas the latter usually require high or ultrahigh vacuum conditions the former ones can be applied in different environments as well This advantage could turn out extremely important for a rather technological point of view i e for the surveillance of modern semiconductor processes Despite the large potential of techniques based on the interaction of electromagnetic waves with surfaces and epilayers optical techniques are apparently moving only slowly into this area of technology One reason for this might be that some prejudices still exist regarding their sensitivity

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