Abstract

Author:	Michal Ďurian
Title:	Development of a Fourier Transform Spectrometer for Electron Induced Fluorescence Experiment and its Application
University:	Comenius University in Bratislava
Faculty:	Faculty of mathematics physics and informatics
Department:	Department of experimental physics
Supervisor:	prof. Dr. Štefan Matejčík DrSc.
Place:	Bratislava
Date:	8.5.2022
Pages:	196
Degree of qualification:	Doctoral thesis

Abstract: In this thesis we present the results of our work at the electron induced fluorescence (EIF) experiment and at construction of a Fourier transform spectrometer for optical emission spectroscopy in UV/VIS spectral range based on Michelson interferometer, with the perspective of using it at the EIF experiment. The EIF experiment focuses on studying electron collisions with atoms and molecules and can obtain fluorescence spectra and electron excitation-emission cross-sections. We have expanded the technical capabilities of the EIF experiment by solving issues of a new Jobin Yvon THR 1500 optical monochromator and its integration into the apparatus. We developed a software for controlling all elements of the EIF apparatus and for automation of measurements and data acquisition. We explored ways of obtaining absolute cross-sections using the relative-flow technique, which we used to obtain absolute electron excitation-emission cross-sections of argon transition $4P^2[½] \rightarrow 4S^2[½]°$ in range of electron energies from excitation threshold to 95 eV, with difference from literature being less than 20%. During the study of electron induced fluorescence of hydrogen and deuterium molecules we obtained fluorescence spectra at electron energies close to the excitation threshold of the hydrogen continuum emission ($a^3\Sigma_g^+ \rightarrow b^3\Sigma_u^+$). Based od obtained excitation curves we proved, that we have detected

the fluorescence radiation of the hydrogen continuum and 670 nm, which is significantly higher than commonly reported values in literature. In the second part of our work we present details about the construction of two Fourier transform spectrometer models capable of stepped mirror motion due to the use of high-precision linear translation stages. The first model operates in the spectral range 320 – 1100 nm and experimental spectral resolution ~4000. The setup consists of two optically coupled Michelson interferometers. Laser diode radiation in the reference interferometer is used as position reference for the mirror motion. We have implemented in the control software a mirror stepping scheme and continuous error correction mechanism that are designed to minimize mechanical errors produced by the translation stage. The properties of model 1 interferometer are demonstrated on measurements of emission spectra of a HgAr CCFL lamp and electron induced fluorescence of ambient air. The newer model 2 interferometer uses a linear translation stage of higher quality and precision, due to which it does not require external position reference. Its spectral range is 200 – 1100 nm, experimental spectral resolution ~3300 and 4-times higher detection dynamic range compared to model 1. Spectral artifacts are at a level of max. 1% of the actual signal value and their removal during data-processing does not pose a problem due to their systematic character. The properties of model 2 interferometer are demonstrated on measurements of a white LED and the same HgAr CCFL lamp as with model 1 interferometer.

Keywords: electron induced fluorescence, electron collisions, Fourier transform spectroscopy, Michelson interferometer