

**UNIVERSIDAD DE GRANADA**  
FACULTAD DE CIENCIAS  
DEPARTAMENTO DE FÍSICA APLICADA  
GRUPO DE INVESTIGACIÓN DE FÍSICA DE LA ATMÓSFERA - IISTA

**Exploring aerosol-cloud interaction in the  
atmospheric column using improved remote  
sensing methods**

PhD. Dissertation

**María Soledad Fernández Carvelo**

PhD candidate

Universidad de Granada

Thesis director: Cat. Lucas Alados Arboledas

Catedrático de la Universidad de Granada

Thesis director: Dr. Juan Antonio Bravo Aranda

Profesor Titular de la Universidad de Granada

**2026**

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Tribunal nombrado por el Magfco. y Excmo. Sr. Rector de la Universidad Politécnica de Madrid, el día \_\_\_\_ de \_\_\_\_\_ de 202X.

Presidente: PhD jury committee 1.

Secretario: PhD jury committee 2.

Vocal: PhD jury committee 3.

Vocal: PhD jury committee 4.

Vocal: PhD jury committee 5.

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Opta a la mención de "Doctor Internacional"

Evaluadores de organizaciones internacionales:

Reviewer 1, Institution, Country.

Reviewer 2, Institution, Country.

Realizado el acto de defensa y lectura de la Tesis el día \_\_\_\_ de \_\_\_\_\_ de 202X en la E. T. S. Ingenieros Industriales.

CALIFICACIÓN:

EL PRESIDENTE

LOS VOCALES

EL SECRETARIO



The research leading to this doctoral dissertation has received funding from the following programs.





# Abstract

Abstract (English version).



# Resumen (Spanish)

Resumen (versión en español).



# Acknowledgements

Time to say thank you!



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# Abbreviations

**EOA**            Example of Abbreviation.



# Part I

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## INTRODUCTION





## State of the art

Background of your work.

This is an example of a reference (Croff 1983).



## Objectives of this Thesis

Main goals and contributions arising from this Thesis.



## Layout of this Thesis

This Thesis is divided into five Parts, with several related Chapters in each of them. Firstly, Part I establishes the framework and background of this Thesis and presents the original contributions and outcomes.

Part ?? corresponds to the description of the fundamentals that applies to this work...



# Part II

---

## FUNDAMENTALS









## Atmosphere structure and properties



## Radiation-atmosphere interaction

- 6.1 Elastic scattering
- 6.2 Extinction
- 6.3 Raman scattering
- 6.4 Absorption
- 6.5 Radiative transfer equation



## Atmospheric aerosol characterization





## Atmospheric aerosol properties

### 8.1 Optical properties

### 8.2 Microphysical properties



## Lidar technique

- 9.1 Principle and equation
- 9.2 Aerosol intensive properties
- 9.3 Depolarization lidar
- 9.4 Fluorescence lidar



# Part III

---

## INSTRUMENTATION



ALHAMBRA lidar system

10





## Setup of the ALHAMBRA lidar system

- 11.1 Overlap function retrieval
- 11.2 Depolarization calibration
- 11.3 Vibrational and rotational Raman channels characterization
- 11.4 Bandwidth filter fluorescence channel calibration
- 11.5 Spectrometer coupling fluorescence channel characterization



## Quality Assurance of the ALHAMBRA lidar system

12.1 Rayleigh-fit

12.2 Telecover test

12.3 Polarization calibration

12.4 Zero bin



# Part IV

---

METHODOLOGY



## 13.1 Introduction

Introduction to Chapter 1 of Part Developments and Applications II. Here we go!

Let's include Figure 13.1 as an example.

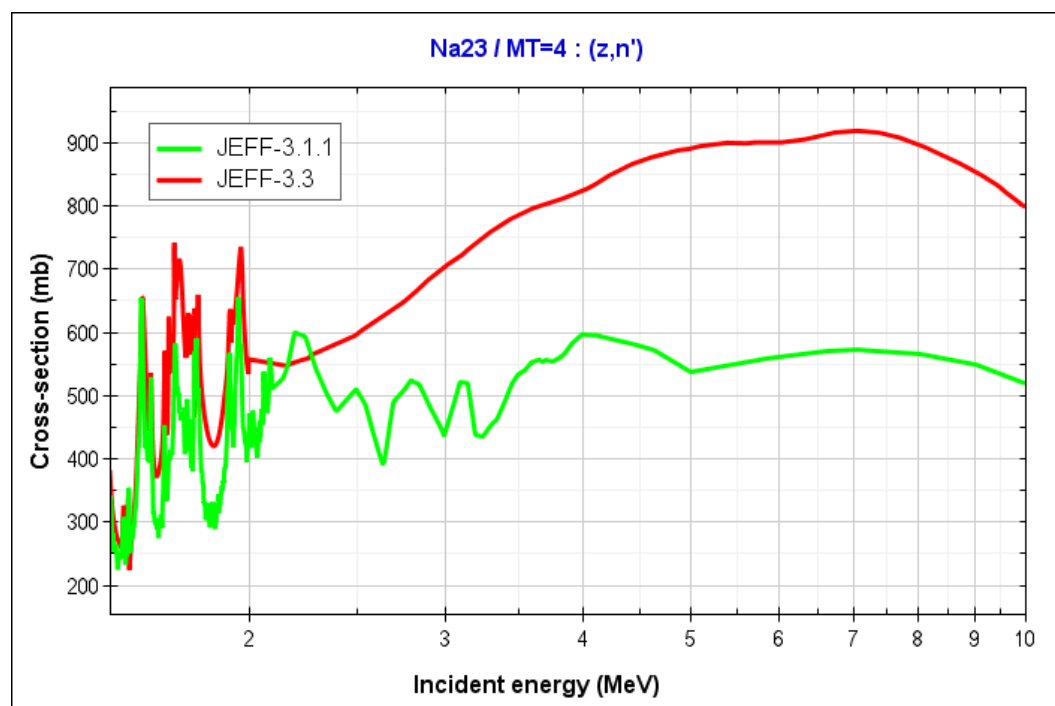


Fig. 13.1.: Figure caption.





14.1 Introduction

Introduction to Chapter 2 of Part Developments and Applications II. Here we go!

Let’s include Table 14.1 as an example.

**Tab. 14.1.:** Table caption.

X1	X2	X3	X4	X5
Y1	XY1	XY2	XY3	XY4



# Chapter

# 15

## 15.1 Introduction

Introduction to Chapter 3 of Part Developments and Applications II. Here we go!



# Part V

---

## CONCLUSIONS AND FUTURE WORK



# Conclusions

# 16

Conclusions and main outcomes of work carried out in this Thesis.





## Future work

As a continuation of the work carried out in this Thesis, the following lines are identified for further research.



# Bibliography

Croff, A. G. (1983). "ORIGEN2: A Versatile Computer Code for Calculating the Nuclide Compositions and Characteristics of Nuclear Materials". In: *Nuclear Technology* 62.3, pp. 335–352. DOI: 10.13182/NT83-1 (cit. on p. 3).



# APPENDIX

A

## A.1 APPENDIX I

