



Universiteit
Leiden
The Netherlands

Absorption, luminescence and scattering of single nano-objects

Yorulmaz, M.

Citation

Yorulmaz, M. (2013, June 26). *Absorption, luminescence and scattering of single nano-objects. Casimir PhD Series*. Retrieved from <https://hdl.handle.net/1887/21018>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/21018>

Note: To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/21018> holds various files of this Leiden University dissertation

Author: Yorulmaz, Mustafa

Title: Absorption, luminescence, and scattering of single nano-objects

Issue Date: 2013-06-26

Absorption, Luminescence, and Scattering of Single Nano-Objects

Mustafa Yorulmaz

Absorption, Luminescence, and Scattering of Single Nano-Objects

PROEFSCHRIFT

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van Rector Magnificus prof. mr. C. J. J. M. Stolker,
volgens besluit van het College voor Promoties
te verdedigen op woensdag 26 juni 2013
klokke 15:00 uur

door

Mustafa Yorulmaz
geboren te Nevsehir, Turkije
op 26 augustus 1984

Promotor:	Prof. dr. M. A. G. J. Orrit	Universiteit Leiden
Co-promotor:	Dr. A. Gaiduk	Carl Zeiss Microscopy GmbH, Jena
Overige Leden:	Prof. dr. F. Cichos	Universität Leipzig
	Prof. dr. A. F. Koenderink	Universiteit van Amsterdam
	Prof. dr. E. R. Eliel	Universiteit Leiden
	Dr. M. P. van Exter	Universiteit Leiden
	Prof. dr. E. J. J. Groenen	Universiteit Leiden
	Dr. ir. S. J. T. van Noort	Universiteit Leiden

The work reported in this thesis was carried out at the ‘Leids Instituut voor Onderzoek in de Natuurkunde’ (LION). This work is a part of the research programme of the ‘Stichting voor Fundamenteel Onderzoek der Materie’ (FOM), which is financially supported by the Netherlands Organization for Scientific Research (NWO). We acknowledge financial support by the European Research Council (Advanced Grant SiMoSoMa).

An electronic version of this dissertation is available at the Leiden University Repository (<https://openaccess.leidenuniv.nl>).

Printed by: Proefschriftmaken.nl || Uitgeverij BOXPress

Casimir PhD series, Delft-Leiden 2013-17

ISBN: 978-90-8593-157-7

to Elif Sena, Çiğdem, and my parents

Contents

1	Introduction	1
1.1	Single nano-objects	1
1.2	Advantages of single nano-object studies	2
1.3	Optical properties of single nano-objects	4
1.4	Optical detection of single nano-objects	7
1.4.1	Correlation of absorption, luminescence and scattering	12
1.5	Plasmon resonance of a single gold nanorod near a dielectric interface	12
1.6	Outline of this thesis	14
2	Room-temperature detection of a single molecule's absorption by photothermal contrast	17
2.1	Introduction	18
2.2	Photothermal detection	20
2.3	Optimizing the SNR in photothermal detection	22
2.4	Experiment	23
2.4.1	Samples	23
2.4.2	Photothermal microscopy setup	25
2.5	Characterization of photothermal detection sensitivity on gold nanoparticles	27
2.5.1	Minimum detectable dissipated power	29
2.6	Detecting a single molecule by its absorption	30
2.6.1	Single BHQ1-10T-BHQ1 constructs	30
2.6.2	Single BHQ1-Amine molecules	33
2.7	Conclusions	33
3	Absorption, luminescence and sizing of organic dye nanoparticles	35

Contents

3.1	Introduction	36
3.2	Experimental section	37
3.2.1	Combined photothermal and fluorescence microscopy	37
3.2.2	Atomic force microscopy	39
3.2.3	Organic nanoparticles preparation	40
3.2.4	Sample preparation for optical microscopy	40
3.3	Result and discussion	41
3.3.1	Optical microscopy of organic nanoparticles	41
3.3.2	Submonolayers and labyrinth structures formed by organic molecules	45
3.4	Conclusions	47
4	Correlated absorption and photoluminescence of single gold nanospheres	49
4.1	Introduction	50
4.2	Experimental section	51
4.2.1	Absorption (photothermal) and fluorescence microscopy	51
4.2.2	Atomic force microscopy (AFM)	52
4.2.3	Sample preparation	52
4.3	Results and discussion	53
4.3.1	AFM characterization of gold NPs	53
4.3.2	Correlation of AFM and optical microscopy results on gold NPs	54
4.3.3	Correlation of absorption and luminescence of individual gold NPs	55
4.3.4	Laser-induced enhancement of luminescence from gold nanospheres	60
4.4	Conclusions	65
5	Luminescence quantum yield of single gold nanorods	67
5.1	Introduction	68
5.2	Experimental	70
5.2.1	Sample preparation	70
5.2.2	Optical microscopy	71
5.3	Results and discussion	72
5.4	Conclusions	81

Contents

6 Influence of an approaching dielectric interface on the plasmon resonance of a gold nanorod	83
6.1 Introduction	84
6.2 Methods and materials	87
6.2.1 Fluorescence spectroscopy and white-light interferences	87
6.2.2 Variable-distance cell	89
6.2.3 Samples	91
6.3 Results and discussions	92
6.3.1 Newton's rings and distance measurement	92
6.3.2 Plasmon resonance as a distance ruler	95
6.4 Conclusions	100
A The dissipated power for some common chromophores	103
B Organic dye nanoparticles	107
C Single gold nanospheres	115
D Single gold nanorods	117
Bibliography	129
Summary	149
Samenvatting	153
Curriculum vitae	157
List of publications	159
Acknowledgements	161

