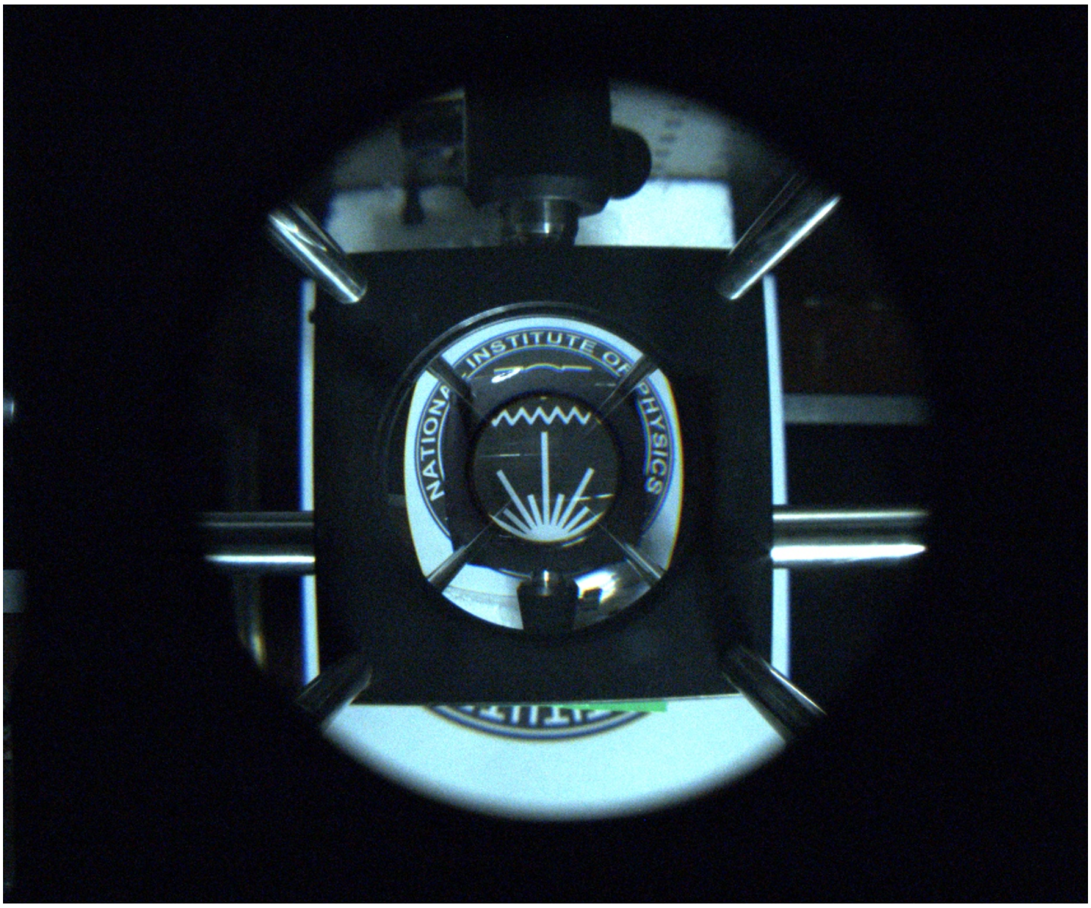

Annual Report 2018
Photonics Research Laboratory

Prepared by

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Program Coordinator
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Submitted: 17 January 2019

Contents

**The figure is a stylized photo of the cloaking setup with a four-lens system of arbitrary focal length.*

1. Executive Summary

1.1. Activities of the research group

1.1.1. Organization

Regular members		4
Student members		37
	PhD students	7
	MS students	5
	BS students	25
Apprentices		0
	Total	41

1.1.2. Mentoring

	Number of graduates
BS Physics	2
BS Applied Physics	2
MS Physics	1
MS MSE	0
PhD Physics	1
Total	6

1.2. Research highlights

International peer-reviewed journals	5 (2*)
Local peer-reviewed journals	1
International conference papers	3
International conference presentations	4
Local conference papers /presentations	29
Chapter in books	0
Patents	0
NIP funded projects	3
Non-NIP funded projects	6

* 2 are Proceedings from conferences but are SCOPUS-indexed

Major equipment acquired/ upgraded	
Research travels abroad	10
Visiting researchers	2
MOA's entered with local and foreign institutions	0

1.3. Extension work highlights

Extension work activities	10
Research interns/ OJT's for training held at NIP	9

1.4. Main challenges encountered and proposed solutions

1.5. Awards or accreditations received/ positions of responsibility held and other accomplishments

National awards or accreditation received, positions of responsibility held	0
International awards or accreditations received, positions of responsibility held	4
Other accomplishments	0

2. Technical Report

2.1. Activities of the research group

- The Photonics Research Laboratory has 41 research members. The group helped graduate 4 BS students, 1 MS student, and 1 PhD student. It also welcomed 3 new student members.

- The group had published 5 ISI/ Scopus-indexed papers. 2 of these publications are from proceedings that are indexed in Scopus and ISI Core Collection.

- Two of the ISI published by the group were highlighted as Editor's pick. These publications are "Position, orientation, and relative quantum yield ratio determination of fluorescent nanoemitter via combined laser scanning microscopy and polarization measurements", published in Optical Materials Express and "Diffraction of polygonal slits using catastrophe optics," published in Journal of Applied Physics.

- N. Hermosa is named one of the 100 Asian Scientist 2018 by Singapore-based science magazine, Asian Scientist.

- The group had 10 research-related travels abroad. Dr. Percival F. Almoro was invited as an OSA travelling fellow in the 3rd International Seminar on Photonics, Optics, and its Application in Surabaya, Indonesia and he was an invited speaker at the 3rd International Conference on Photonics and Optical Engineering in Xi'an, China. Jadze Priceton Narag attended the 2018 Siegman Summer School in H'ven, Sweden, Jenny Lou Sagisi attended the Summer School on Optics, Lasers and Laser Application in Gwangju, South Korea and Rommil Emparado attended the ICTP Asian Network School and Workshop on Complex Condensed Matter Systems in Nakhon Ratchasima, Thailand. Dr. Nathaniel Hermosa presented his work at the SPIE Photonics West in San Francisco, USA, Dina Grace Banguilan presented her work at the SPIE/COS Photoncis Asia 2018 in Beijing, China, Niña Angelica Zambale presented her work at the 79th JSAP Autumn Meeting, and Gilbert Oca presented his work at the 3rd International Conference on Photonics and Optical Engineering in Xi'an, China.

- The group continue to host students from different high schools and universities in the Philippines.

- Dr. Percival Almoro headed the celebration of the International Day of Light last May 16, 2018. The Photonics Research Laboratory joins the celebration also.

2.1.1. Organizations

2.1.1.1. Group members

Regular members (4)

1. Almoro, Percival
2. Dasallas, Lean
3. Garcia, Wilson
4. Hermosa, Nathaniel II

Student members (37)

PhD students (6)

1. Abregana, Timothy Joseph (P4)
2. De Mesa, Joseph (P3)
3. Emperado, Rommil (P2)
4. Miranda, Jessa Jayne (P1)
5. Olaya, Cherrie May (P2)
6. Onglao, Mario III (P2)

MS students (5)

1. Banguilan, Dina Grace (M3)
2. Cabanilla, Jayson (M5)
3. Narag, Jadze Princeton (M3)
4. Oca, Gilbert Moises (M4)
5. Zambale, Niña Angelica (M2)

MSE students (1)

1. Sagisi, Jenny Lou (P2)

BS Applied Physics students (13)

1. Abesa, Alvaro Jose (B5)
2. Alemania, Marielle Anne (B5)
3. Argonza, Maria Liana (B4)
4. De Mata, Joy Kristelle (B5)
5. Dela Cruz, Mary Nathalie (B4)
6. Estrada, Viron Gil (B5)
7. Gaffud, Ymmanuel (B4)
8. Gloria, Gelli Mae (B3)
9. Manzo, Agatha Jill (B4)
10. Ofina, Edrien Dominick (B4)
11. Pineda, Zeus (B5)
12. Remulla, Katherine Isabel (B5)
13. Tinte, Bienica Yzabelle (B3)

BS Physics students (12)

1. Binamira, Jonel (B5)
2. Buco, Christian Ray (B5)
3. Depasucat, Cyrill Hope (B4)
4. Jamilarin, Roger (B3)
5. Lorenzo, Joshua Cesar (B5)
6. Maestre, Loriza (B5)
7. Operaña, Jared Joshua (B5)

8. Revilla, Miguel (B5)
9. Tabuzo, Rigil (B5)
10. Tolentino, Meara Noelle (B4)
11. Valdeavilla, Charlyn (B4)
12. Villareal, Mark Roan Elrae (B4)

2.1.1.2. Summary

Regular members			4
Student members			37
	PhD students	7	
	MS students	5	
	BS students	25	
Apprentices			0
		Total	41

2.1.2.

2.1.3. Mentoring

2.1.3.1. List of graduates

1st semester 2017-2018 (1 MS)

1. Miranda, Jessa Jayne C.
   Femtosecond Pulsed Laser Deposition of ZnS on Silicon (100) and Glass Substrates (Adviser: W. O. Garcia)

2nd semester 2017-2018 (1 PhD, 4 BS)

2. Dasallas, Lean L.
   Surface Ablation and Thin Film Deposition Applications by Femtosecond Pulsed Laser (Adviser: W. O. Garcia)

3. Celebrado, Michelle B.
   Spectroscopic Studies of Hydrogen DC Glow Discharge (Adviser: W.O. Garcia)

4. Lofamia, Micherene Clauzette P.
   Enhanced Phase Reconstruction using Multiple Plane Phase Retrieval with Modulated Randomization (Adviser: P. F. Almoro)

5. Salcedo, Dylan Nicolas Emmanuel V.
   Enhanced Wavefront Reconstruction of Diffuser-Embedded Objects using Surface Smoothening Agents (Adviser: P. F. Almoro)

6. Wang, Maria Ysabel D.
   Highly Secure Optical Encryption using Multiple-diffuser Phase Retrieval and Chaos Phase Mask (Adviser: P. F. Almoro)

2.1.3.2. Summary

		Number of graduates
BS Physics		2
BS Applied Physics		2
MS Physics		1
MS MSE		0
PhD Physics		1
	Total	6

2.2. Research highlights

2.2.1. Publication in ISI/SCI and Scopus indexed journals (5)

1. Banguilan, D. G., Bareza, N., Escoto, E., and Hermosa, N., "Measuring the orbital angular momentum of light by dynamic polygon apertures", Proc. SPIE 10818, Holography, Diffractive Optics, Applications VIII, 108180U (8 November 2018). DOI:10.1117/12.2500986

2. Dasallas, L.L., Jaculbia, R.B., Balois, M.V., Garcia, W.O., Hayazawa, N., "Position, orientation, and relative quantum yield ratio determination of fluorescent nanoemitters via combined laser scanning microscopy and polarization measurements", *Optical Materials Express* 8(5), pp. 1290-1304. DOI: 10.1364/OME.8.001290

3. Dasallas, L.L., Garcia, W.O., "Numerical simulation of femtosecond pulsed laser ablation of copper for oblique angle of incidence through two-temperature model", *Materials Research Express* 5(1),016518. DOI: 10.1088/2053-1591/aaa4e8.

4. Olaya, C. M., Garcia, W. O., and Hermosa, N., "Goos-Hänchen effect on Si thin films with spherical and cylindrical pores", Proc. SPIE 10533, Oxide-based materials and Devices IX, 105332O (23 February 2018). DOI: 10.1117/12.2291484.

5. Narag, J., and Hermosa, N., "Diffraction of polygonal slits using catastrophe optics", *Journal of Applied Physics* 124(3), 034902. DOI: 10.1063/1.5029292.

2.2.2. Publication in local peer reviewed journals (1)

1. Revilla, M., Lorenzo, J.C., Narag, J.P. and Hermosa, N. "Paraxial optics cloak using four converging lenses with arbitrary focal lengths," PISIKA - Journal of the Physics Society of the Philippines 1(1) (2018).

2.2.3. International conference presentations with full papers (3)

1. Banguilan, D. G., Bareza, N., Escoto, E., and Hermosa, N., "Measuring the orbital angular momentum of light by dynamic polygon apertures", Proc. SPIE 10818, Holography, Diffractive Optics, Applications VIII, 108180U (8 November 2018). DOI:10.1117/12.2500986.

2. Oca, G and Almoro, P, "Enhanced schlieren imaging applied in heat and air jet visualizations: A wave propagation-based model" Proceedings of 3rd International Conference on Photonics and Optical Engineering, (Xi'an, China) Dec. 5-8, 2018.

3. Olaya, C. M., Garcia, W. O., and Hermosa, N., "Goos-Hänchen effect on Si thin films with spherical and cylindrical pores", Proc. SPIE 10533, Oxide-based materials and Devices IX, 105332O (23 February 2018). DOI: 10.1117/12.2291484.

2.2.4. International conference presentations without full papers (4)

1. Almoro, P., “Speckle Phase Retrieval: Techniques and Applications,” 3rd International Conference on Photonics and Optical Engineering, (Xi’an, China) Dec. 5-8, 2018.

2. N.A. Zambale, J.L. Sagisi, and N. Hermosa, “Goos-Hänchen shifts due to graphene when intraband conductivity dominates,” 79th JSAP Autumn Meeting (Nagoya, Japan) September 8-21, 2018.

3. R.C. Simon, C.J.D. Capuli, K.J. Fajardo,and N. Hermosa, “Low Reflectance and Polarization-Insensitive Surfaces by Graded Index Thin Film,” 79th JSAP Autumn Meeting (Nagoya, Japan) September 8-21, 2018.

4. Almoro, P., “Speckle Phase Retrieval: Principles, Applications and Recent Technological Advances”, 3rd International Seminar on Photonics, Optics, and its Applications, (Surabaya, Indonesia) August 1-2, 2018.

2.2.5. Local conference papers

2.2.5.1. With full paper (29)

1. Abregana, T. J., and Almoro, P. F. “Diffuser element binning in digital micromirror device-based phase retrieval,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

2. Almoro, P. F., “International Day of Light Workshop: Bahaghari Spectrometer,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

3. Argonza, M. L. O., Zambale, N. A. F., and Hermosa, N. P., “Multipoint interferometer diffraction patterns for laser interference lithography,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

4. Banguilan, D. G. C., and Hermosa, N. P., “Mapping optical vortices with a dynamic triangular aperture,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

5. Buco, C. R. L., and Almoro, P. F., “Enhanced wavefront reconstruction using multiple-plane phase retrieval of smooth objects with tilt illumination”, Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

6. Cabanilla, J., P., and Hermosa, N. P., “Reconstruction of 2D Gaussian phase from an incomplete fringe pattern using Fourier transform profilometry,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

7. Dasallas, Lean, and Garcia, L. L., “Angle of incidence dependence of copper reflectivity and absorption coefficient under femtosecond pulsed laser irradiation,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

8. De Mata, J. K. C., Alemania, M. A. P., and Garcia, W. O., “Conservation of momentum

in two-dimensional elastic collision," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

9. De Mesa, J. A., Miranda, J. J. C., Rillera, A., Sarmago, R. V., and Garcia, W, O., "Femtosecond pulsed laser deposition of CeO_2 thin films on silicon (100) substrates," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

10. Dela Cruz, M. N., Banguilan, D. G. C., and Hermosa, N. P., "Dynamic double slits for topological charge determination," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

11. Emperado, R. B., Miranda, J. J. C., Fernandez, N., Garcia, W. O., & Sarmago, R. V., "Ultrafast pulsed laser deposition of BSCCO target on silicon substrate," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

12. Estrada, V. G. A., Banguilan, D. G. C., and Hermosa, N. P., "Topological charge of a vortex beam using Hadamard matrix pattern of circular apertures," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

13. Lofamia, M. C. P., and Almoro, P. F., "Enhanced reconstruction in single-beam multiple intensity reconstruction by modulated randomization," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

14. Lorenzo, J. C. M., Revilla, M. L., and Hermosa, N. P., "Formation of hypocycloid-shaped beams from dynamic hypocycloid slits," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

15. Miranda, J. J. C., De Mesa, J. A., and Garcia, W. O., "In-situ and post-deposition heat treatment of femtosecond pulsed laser deposited ZnS on silicon (100) substrates," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

16. Narag, J. P. N., and Hermosa, N. P., "Orbital angular momentum beam diffraction through a dynamic single slit," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

17. Oca, G. M., and Almoro, P. F., "Optimum contrast in single mirror off-axis Schlieren system," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.*

18. Olaya, C. M. M., and Hermosa, N. P., "Angular Goos-Hänchen shift due to an epsilon-near-zero slab," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

19. Olaya, C. M. M., Sagisi, J. L. B., and Hermosa, N. P., "Comparison of sensitivity between reflectivity and angular Goos-Hänchen shift measurements in determining the thickness of CuO film on Cu substrate," Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines)

June 2018.

20. Onglao, M. J. S., and Almoro, P. F., “Evaluation of stress coverage for varying object loading using Statistical Fringe Processing,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

21. Operaña, J. J. C., Cabanilla, J. P. and Hermosa, N., “Suppressing inherent noise by combining different frequency peaks in Fourier transform profilometry,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

22. Remulla, K. I. T., and Hermosa, N. P., “Rotational orientation sensing via spatial mode projection of a Hermite-Gauss mode,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

23. Revilla, M. L., Lorenzo, J. C. M., and Hermosa, N. P., “Cloaking regions of a general four-lens paraxial cloak,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

24. Sagisi, J. L. B., Zambale, N. A. F., and Hermosa, N. P., “Measuring the principal axis angle and phase retardance of an adhesive tape via Mueller-Stokes formulation,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

25. Salcedo, D. N. E. V., and Almoro, P. F., “Wave reconstruction of objects behind a scattering surface using surface smoothening agents,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

26. Tabuzo, R. G., and Almoro, P. F., “Effects of object spatial frequencies on the convergence of multiple plan phase retrieval,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

27. Tolentino, M. N. A., Olaya, C. M. M., and Hermosa, N. P., “Ray trajectory in a graded refractive index material with a Gaussian and Lorentzian profile,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

28. Wang, M. Y. D., and Almoro, P. F., “Highly secure optical encryption using multiple-diffuser phase retrieval and chaos phase masks,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

29. Zambale, N. A. F., and Hermosa, N. P., “Detecting lateral misalignment of Laguerre Gaussian beams via spatial mode projection,” Proceedings of the 36th Physics Congress of the Samahang Pisika ng Pilipinas, (Puerto Princesa City, Philippines) June 2018.

* submitted but not presented in the conference

2.2.5.2. Without full paper (0)

2.2.6. Chapters in books (0)

2.2.7. Patents (0)

2.2.8. NIP funded projects (3)

Almoro, Percival	Efficient algorithm for multiple-plane phase retrieval (PhP 105,600)	01 Jan – 31 Dec 2018
Garcia, Wilson	Theoretical and Experimental Investigation of High Energy Laser-Matter Interaction: Laser Ablation and Pulsed Laser Deposition (PhP 105,600)	01 Jan – 31 Dec 2018
Hermosa, Nathaniel	Generation of optical beams with programmable slits (PhP 92,400.00)	01 Jan – 31 Dec 2018

2.2.9. Non-NIP funded projects (6)

Project proponent	Project title	Period	Amount	Project grantor
Dasallas, Lean	Surface ablation and deposition applications of femtosecond laser	1 September 2017 – 31 August 2018	Php 60,000.00	OVCRD thesis and dissertation grant
Hermosa, Nathaniel	Angular Goos-Hänchen Shift: An optical phenomena for ultra thin film thickness measurement	31 January 2017 - 30 January 2020	PhP 13,724,158.10[1]	DOST - PCIEERD
Hermosa, Nathaniel	Can the angular Goos-Hänchen shift be used for ultra thin film thickness determination?	13 February 2017 - 12 August 2018	PhP 550,000.00	UP OVPAA
Hermosa, Nathaniel	Resolution Limit of Fourier Transform Profilometry for Various Applications	01 January - 31 December 2018	PhP 510,800.00	DOST-NAST
Hermosa, Nathaniel	A Generalized Multidirectional Paraxial Optical Cloak in the Visible Range	15 July 2018- 14 July 2019	PhP 529,600.00	DOST-NAST
Hermosa, Nathaniel	Structured beam generation via polygonal and curve slits and their self-healing properties	01 May 2018 – 31 May 2019	PhP 300,000.00	OVCRD, UP Diliman

[1] Budget has changed due to the increase in salary of the project staffs.

2.2.10. Major equipment acquired (9)

Equipment	Cost	Source of fund	Project proponent
3D Printer (XYZ Printing Nobel 1.0A)	PhP 218,000.00	DOST-NAST	Hermosa, Nathaniel
Data Acquisition Modules and Accessories	PhP 350,000.00	DOST-PCIEERD	Hermosa, Nathaniel
Desiccator Cabinet	PhP 37,000.00	DOST-PCIEERD	Hermosa, Nathaniel
Digital Camera	PhP 62,388.00	DOST-NAST	Hermosa, Nathaniel
Optical Table	PhP 1,297,385.00	DOST-PCIEERD	Hermosa, Nathaniel
CCD Camera	PhP 279,000	DOST-PCIEERD	Hermosa, Nathaniel
XYZ Translator	PhP 220,000.00	DOST-PCIEERD	Hermosa, Nathaniel
DC Motor controller	PhP 220,000.00	DOST-PCIEERD	Hermosa, Nathaniel
UHD Smart TV	PhP 32,000.00	DOST-NAST	Hermosa, Nathaniel

2.2.11. Research travels abroad (10)

NIP Personnel	Purpose	Place	Dates	Mode of exchange
Hermosa, Nathaniel II	SPIE Photonics West 2018	San Francisco, California, United States	January 27 – February 01	Presenter
Sagisi, Jenny Lou	Summer School on Optics, Lasers, and Laser Applications	Gwangju, South Korea	July 9-13	Presenter
Narag, Jadze Princeton	Siegman Summer School	Hven, Sweden	July 28 - August 6	Presenter
Almoro, Percival	3rd International Seminar on Photonics, Optics, and its Applications (ISPhOA)	Surabaya, Indonesia	July 31 - August 2	OSA Travelling Lecturer
Zambale, Niña Angelica	Japan Society of Applied Physics (JSAP) - Optical Society of America (OSA) Joint Symposia 2018	Nagoya, Japan	September 19-21	Presenter
Dasallas, Lean	Quantum Materials Science Laboratory	Okinawa, Japan	Oct. 2 - 5	Presenter
Banguilan, Dina Grace	SPIE/COS Photonics Asia 2018	Beijing, China	Oct. 10-15	Presenter
Emperado, Rommil	ICTP Asian Network School and Workshop on Complex Condensed Matter Systems	Nakhon Ratchasima, Thailand	Nov. 5-9	Presenter
Oca, Gilbert Moises,	3rd International Conference on Photonics and Optical Engineering (icPOE 2018)	Xi’an, China	Dec. 5-8	Presenter
Almoro, Percival	3rd International Conference on Photonics and Optical Engineering (icPOE 2018)	Xi’an, China	Dec. 5-8	Invited Speaker

2.2.12. Visiting researchers (2)

Dr. Vince Daria and Prof. Dr. Hans Bachor of the Australian National University. They visited with grant from the travelling fellow program of the OSA thru the UP Diliman OSA student chapter.

2.2.13. MOA’s entered with local or foreign institutions (0)

2.3. Extension work highlights

2.3.1. Extension work activities (13)

Abregana, Timothy Joseph	Referee, Applied Optics
Almoro, Percival	Chair of DOST Technical Panel, PCIEERD Optics and Photonics Technical Panel of Experts Referee, various optical journals Topical editor for optics and photonics, 36th SPP Physics Congress. Reviewer for optics. Resource speaker for mentoring during NAST-sponsored research upgrading workshops. Invited by NAST. National Node and Contact Person, International Day of Light 2018 Topical Editor. Applied Optics
Garcia, Wilson	Reviewer for optics, photonics and plasma physics, 36th SPP Physics Congress
Hermosa, Nathaniel	Reviewer for optics, photonics and plasma physics, 36th SPP Physics Congress Referee, various journals in optics and physics NAST-arranged interviews and press conferences
Narag, Jadze Princeton	Referee, Applied Optics
Onglao, Mario Juvenal	Referee, Applied Optics
Members, Photonics Research Laboratory	Celebration of the International Day of Light 2018*

2.3.2. Research interns/OJT's (9)

SSIP	Kyronn Beltran Philippine Science High School Lawrence Canillas Philippine Science High School Zechariah Talo Philippine Science High School
OJT	Ellen Faith Adlaon Central Mindanao University

* *Please see appendix for the full report.*

Robert D. Agustin
Mindanao State University

Christian M. De Guzman
Mindanao State University

Carine Joy D. Garcia
University of the Northern Philippines

Nikki Rojo Rabe
Mindanao State University

Mark Angelou M. Siega
Mindanao State University

2.4. Main challenges encountered and proposed solutions

Procurement and maintenance of equipment are the major challenges in the research laboratory. The solution is to set aside MOOE for maintenance alone.

2.5. Awards or accreditations received/ positions of responsibility held and other accomplishments (0)

1. Two of our papers are Editor's pick of their respective issues.
2. N. Hermosa is named one of the 100 Asian Scientist of 2018.
3. P. Almoro is OSA Travelling Lecturer in the 3rd International Seminar on Photonics, Optics, and its Applications (ISPhOA).
4. P. Almoro is an invited speaker in the 3rd International Conference on Photonics and Optical Engineering (icPOE 2018)

4. Photos, ISI/SCI Publications and other appendices

4.1. Photos

Figure 1. Photonics Research Laboratory in Samahang Pisika ng Pilipinas Physics Conference held last June 6-9, 2018 in Puerto Princesa, Palawan.

Figure 2. D. Banguilan attending and presenting at SPIE Photonics Asia 2018 held last October 11-13 in Beiijng, China.

Figure 3. Dr. Percival Almoro as OSA Travelling Lecturer in Surabaya, Indonesia last July 31 to August 2, 2018.

Figure 4. The interns/OJTs in the Photonics Research Laboratory from June to July 2018, together with Dr. Wilson Garcia and some student members.

Figure 5. Some Photonics Research Laboratory Members during the NIP Recognition Day 2018 held on June 23, together with Dr. Hermosa, Dr. Garcia, and the guest speaker, DOST Secretary Fortunato dela Peña.

Figure 6. The Photonics Research Laboratory during their Christmas Party last December 14, 2018 (Photo courtesy of M. Alemania)

Figure 7. Optics conference group photo in Xi'an, China, December 5-8, 2018 with P. Almoro (1st row, 8th from right) and G. Oca (2nd row, 4th from right)

Figure 8. L. Dasallas visits and presents his work at Okinawa Institute of Science and Technology last October 02 – 05, 2018.

Almoro, Percival
National Node and Contact Person, International Day of Light 2018
May 16, 2018, NIP UP Diliman

PRL Joins Light Festival 2018

The NIP Photonics Group led by Dr. Almoro in partnership with the Samahang Pisika ng Pilipinas facilitated the conduct of the first International Day of Light with an optics and photonics exhibit held last May 16, 2018 at NIP UP Diliman. Based on a UNESCO Resolution, IDL aims to promote science, education, art, and culture related to the broad themes of light and light-based technologies.

The objectives of the exhibit are to make optics education and light-based researches accessible to everyone and to serve as venue for networking across the different disciplines. With exhibitors coming from the academe and industry, there were more than 30 hands-on demonstration setups ranging from basic to applied optics, biomedicine, astronomy, environment, satellite technology and the arts.

The exhibit was open to the public and the general response from visitors was encouraging. Based on visitors' exit survey for future IDL events, suggestions include more interactive booths and real-life applications, emphasize local researches and innovations, bigger exhibition hall and brighter more colourful lights.

Figure 1.. State-of-the-art optical equipment.

Figure 2. Hands-on demonstrations of optical effects.

Figure 3. Exhibitors and participants of Light Festival 2018.

3.2. ISI/SCI Publications

Measuring the orbital angular momentum of light by dynamic polygon apertures

Dina Grace Banguilan[a], Nestor Bareza Jr.[a], Esmerando Escoto[b], and Nathaniel Hermosa[a]

[a]National Institute of Physics, University of the Philippines-Diliman, Quezon City, Philippines 1101

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ABSTRACT

We offer a convenient and dynamic method for the measurement of the orbital angular momentum of light using its distinct Fraunhofer diffraction patterns(FDPs) after passing through programmable apertures generated by a digital micromirror device (DMD). The DMD allows for a practical way of testing and centering several apertures, while minimizing movements in the setup in between measurements. We show how to extract the topological charge value, polarity, and parity from the resulting patterns, along with the limitations of each polygon shape, such as the symmetry and uniqueness issues. An experimental demonstration is also provided, confirming the expected patterns simulated using the far-field diffraction integral. This study establishes the potential speed and accuracy brought by the use of a DMD for the challenging task of characterizing the orbital angular momentum of light.

Keywords: Orbital angular momentum, Fraunhofer diffraction patterns, dynamic polygon apertures, digital micromirror device

1. INTRODUCTION

Light can carry an orbital angular momentum (OAM) which is associated with spatial distribution, as first shown by the Woerdmann group in Leiden in 1992.[1] These light beams having an azimuthal ϕ dependence of the form $e^{il\phi}$ can carry an OAM of $l\hbar$ per photon, where l is the topological charge (TC) of the beam. TC characterizes the wave front dislocation of lines called optical vortex (OV).[2] The dislocation corresponds to the change of optical phase by a multiple of 2π on a closed loop around it. These wave front dislocations have an indeterminate phase which implies a zero wave amplitude seen as the central null region in the intensity profile of an OV beam. Examples of OAM beams are Laguerre-Gauss (LG) and higher-order Bessel laser modes.

Creating OAM beams are straightforward but measuring its l is not. Several methods to measure OAM of light have been reported. These include the Mach-Zehnder interferometry[3] and the use of a multipoint interferometer.[4] Interfering such a beam with a helical structure (OAM beam) with a uniform plane wave reveals phase information about the input beam through analysis and investigation of the observed fringes. Counting the fringes suffices to obtain the magnitude of l. Other methods to measure the OAM of light include a two-SLM scheme,[5] a study of diffraction effects by slits[6,7] and apertures.[8] These techniques work well in determining both the sign and magnitude of l by studying the produced interference fringes or patterns. However, such methods either have low throughput which can determine one state at a time only or are composed of sophisticated components that are experimentally challenging and are very hard to implement especially in large optical setups.

The development of a simple and reliable method for the measurement of OAM of light, however, remains an important problem in the field of light manipulation. In this paper, we demonstrate a convenient and a dynamic system to measure the OAM of light. We investigate the diffraction properties of a Laguerre-Gauss beam due to a programmable aperture, and establish rules between the properties of the OAM beam and the diffraction properties of the beam. We show that the magnitude, sign (+ or −) and parity (even or odd) of the TC value can be determined instantly from the interference fringes produced behind the dynamic polygon apertures.

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Position, orientation, and relative quantum yield ratio determination of fluorescent nanoemitters via combined laser scanning microscopy and polarization measurements

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Abstract: We present a universal method of determining the position, 3D orientation, and relative quantum yield ratio (RQYR) of fluorescent nanoemitters (ZnS coated CdSe quantum dots) in a glass slide by combining laser scanning microscopy (LSM) and polarization measurements. The quantum dots were located through LSM intensity maps using azimuthal, radial, and linear incident polarizations. LSM imaging was not sufficient to determine the orientation of the quantum dots due to the isotropic absorption dipole moment. The 3D orientation was obtained through polarization measurement. By combining LSM and polarization measurements, the RQYR of a single molecule was evaluated, allowing us to compare the quantum yield of the nanoemitters.

OCIS codes: (180.2520) Fluorescence microscopy; (260.5430) Polarization; (160.2540) Fluorescent and luminescent materials.

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Numerical simulation of femtosecond pulsed laser ablation of copper for oblique angle of incidence through two-temperature model

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Keywords: femtosecond laser, pulsed laser ablation, two temperature model

Abstract

We propose a numerical model to describe laser ablation of a copper target by a femtosecond laser pulse at an oblique angle of incidence. The model is based on the two temperature model and improved to include laser fluence, laser spot size, and dynamic changes in reflectivity of the target. Numerical results show that the electron and lattice temperatures decrease with the angle of incidence. The dependency of the maximum temperature with angle of incidence follow a cosine power law. The threshold laser fluence, ablation depth and crater size depend on the polarization and angle of the incident laser beam. Our model is supported by the experimental results reported by other group working in femtosecond pulsed laser ablation.

Introduction

The experimental and numerical investigations of femtosecond pulsed laser ablation and deposition are motivated by its application in micromachining [1], thin film fabrication [2], surface modification [3], and spectroscopy [4]. Advancements were possible by the rapid development of femtosecond laser technology together with understanding femtosecond laser–matter interaction through theoretical and numerical modeling. Several models such as comprehensive hydrodynamics [5–8] and molecular dynamics [7–10] were developed. Comprehensive hydrodynamics uses set of hydrodynamic equations in Lagrangian form along with the multiphase equation of state [5–8], while molecular dynamics simulation uses set of kinematic equations for every atom in the ablation volume in consideration at every time-steps [7–10]. These models are complex and sophisticated because of the additional physical concepts and long computation time needed. A model easy to implement and provide fast and reasonably accurate results is needed for simple and straight forward applications such as determination of ablation depth and crater size.

The two temperature model (TTM) of femtosecond pulsed laser ablation is widely and successfully employed to predict and explain the properties of ablation crater on the target [11, 12]. The model is based on the thermal energy transport describing the ablation in terms of the electron and lattice temperatures [11–13]. Most of the TTM computational works were performed by assuming an incident laser beam normal to the surface of the target [12–16]. However, in almost all applications, the laser–matter interaction occurs at an oblique angle. As an example, in pulsed laser deposition, the target is placed directly opposite the substrate [17, 18].

Haq *et al* found that threshold laser fluence increases with the angle of incidence for a polyimide target [19]. The group of Miyasaka *et al* observed that the ablation rate depends on both polarization and the incident angle of the laser beam [20]. Recently, the ablation threshold fluence with incident angle for dielectric (soda-lime glass), semiconductor (Si) and metallic (Au) target were investigated by Liu *et al* [21]. An analytical and numerical model complementing these investigations is needed. In this paper, we developed a numerical model describing the femtosecond pulsed laser ablation with oblique angle of incidence. We choose copper as the target to demonstrate our model because of its extensive background literature.

Diffraction of polygonal slits using catastrophe optics

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Young's boundary wave theory provides an alternative view of diffraction being an interference of a geometric wave and a boundary wave. Here, we show theoretically and experimentally that the transverse structure of a plane wave diffracted through slits originates solely from the boundary waves. For polygonal slits, we demonstrate that the concept of the ordinary evolute is ill-defined, and we solve this problem by taking the limit of the evolute as the curvature goes to zero. We show that light focuses not on caustic as ordinarily described in catastrophe optics but on regions which we define as second order evolutes. Experimentally, we show that these second order evolutes still correspond to the brightest regions of the diffraction because of the boundary waves at the vertices of the polygon. This research is valuable in the study of diffraction of slits in general and in optical self-healing where the reconstruction of the transverse structure is investigated. *Published by AIP Publishing*. https://doi.org/10.1063/1.5029292

I. INTRODUCTION

The boundary wave diffraction (BWD) theory describes the diffraction of light by apertures as a superposition of a geometric wave and a boundary wave that scatters from the edge of the aperture. This theory, proposed by Thomas Young when he observed that bright light emanates from the boundary of the aperture, is an alternative to the theory of diffraction by apertures described by Fresnel.[1] Fresnel thought of diffraction as a superposition of imaginary point sources from the aperture. Both theories are formulated at almost the same time, but Fresnel's was favored because the mathematics supporting it was developed earlier. Later however, it was proven, mathematically by Maggi[2] and Rubinowicz,[3] that the Kirchhoff-Fresnel diffraction integral over the aperture can be reduced to a line integral over the boundary of the aperture. This establishes a sound mathematical basis for the boundary wave formulation of Young. Experimentally, the existence of the boundary waves was also observed in Refs. 4–8.

The method of boundary waves has been applied by Sommerfeld to solve the diffraction of a perfectly conducting semi-infinite plane.[9,10] Recently, the BWD formulation together with catastrophe optics was used to describe the diffraction of a parabolic[11] and a cardioid aperture.[12]

In this paper, we derive the diffraction for polygonal slits using catastrophe optics and BWD theory. We prove that for slits, the diffraction comes solely from the boundary waves and that from these waves, we can determine the brightest regions of the diffraction pattern given by another kind of evolute. We show that the usual definition of the evolute will not suffice for polygonal slits and that a slight modification is necessary.

II. YOUNG'S BOUNDARY WAVE THEORY FOR SLITS

Young's theory of diffraction of a plane wave through an aperture assumes a geometric wave and a boundary wave. The geometric wave ψ_g is unity in the projection of the aperture on the diffraction plane, called the bright region, and zero outside the projection, called the dark region

$$\psi_g = \begin{cases} 1 & \text{directly in the beam (bright region)} \\ 0 & \text{shadow of aperture (dark region).} \end{cases} \tag{1}$$

The boundary wave ψ_b comes from the edge of the aperture and is given by a line integral over the boundary of the aperture

$$\psi_b = -\frac{1}{2\pi}\oint_A d\phi \exp\left(\frac{iu}{2}R^2(\phi)\right), \tag{2}$$

where R is the distance from the observation point and the aperture edge, while $u = k\ell^2/z$ is the Fresnel number of the aperture with characteristic length ℓ located a distance z from the observation plane. This geometry is depicted in Fig. 1.

For polygonal slits, we can imagine the slits as a combination of an aperture A and a smaller complementary aperture A'. Thus, the field ψ_s for the slit is a superposition of the field ψ_A from the aperture A and the field $\psi_{A'}$ from the complementary aperture A'

$$\psi_s = \psi_A + \psi_{A'}. \tag{3}$$

The fields of both apertures come from their respective geometric and boundary waves, that is, $\psi_A = \psi_g + \psi_b$ and

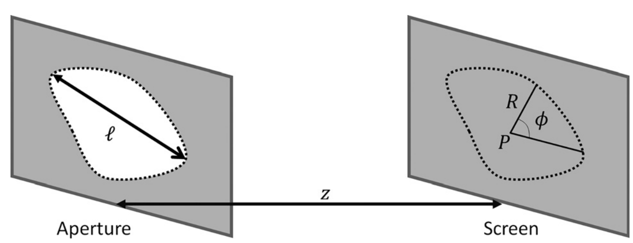

FIG. 1. Geometry for Young's Boundary Wave Diffraction. The field at point P is a contribution of the waves directly passing through the aperture and from those scattered off the boundary of the aperture.

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Enhanced schlieren imaging applied in heat and air jet visualizations: A wave propagation-based model

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ABSTRACT

Refractive index variations caused by temperature or pressure gradients in transparent fluids are invisible to the naked eye. Schlieren effect reveals this variation using refraction and the knife-edge method. High contrast schlieren images are important in the analyses of fluid flow, gas density, shockwaves, heat transfer, flames, ballistics, leak detection and other applications. The neglect of physical or wave theory in schlieren technique leads to erroneous results in some circumstance. Specifically, a study had mathematically shown that illumination is fairly uniform over large part of the field but suddenly increases at the edge and is fairly appreciable for some way outside the actual physical boundary of the aperture. This bright edge is noticeable in all schlieren systems whereas a geometrical optics would lead to a uniformly illuminated field. Geometric ray-tracing codes are useful for optical design, but they cannot describe the key role of diffraction in the formation of schlieren image. In this study, a wave propagation-based model of the schlieren technique is proposed. Compared to the ray optics approach, the proposed model provides valuable insights and visualization of fluid flow dynamics. Some predictions of the model will be confirmed through experimental demonstrations. Setup parameters are also optimized resulting in enhanced resolution of schlieren images.

Keywords: Schlieren devices, Reflection and refraction, Wave optics, Wave propagation, Fourier optics, Computational methods in fluid dynamics

1. INTRODUCTION

Schlieren technique is one of the oldest and least expensive methods to visualize non-uniformities in transparent media.[1] The applications are immense and it include quantitative measurement of gas density[2] and reflective surface shape[3], visualization of shockwaves[4], turbulence and transparent solids[2], air coming from hot object[5-7], and flames[8-11]. Some studies[12-13] have also shown that schlieren images can be recovered from holograms. Schlieren refers to the gradient disturbances of inhomogenous transparent media[14]. In this research, we apply schlieren imaging to heat convection and air jet formation.

Several studies[15-16] exploit geometric optics approach to discuss the schlieren phenomenon. However, it has been reported that geometrical optics description of a schlieren system with coherent illumination is inadequate[17]. The features of schlieren record extend beyond regions in which the phenomena themselves occur. In other words, the diffraction pattern extends well beyond the confining boundaries[17]. The specific study of Speak and Walters[18] had mathematically shown that illumination at the edge yields brighter intensity than the unblocked wave field and is fairly appreciable for some way outside the actual physical boundary. This bright edge is noticeable in all schlieren systems whereas geometrical optics would lead one to expect a uniformly illuminated field[18]. The limitations of ray optics-based model are attributed to individual rays that obey certain laws but assume not to interact with one another. Geometric ray-tracing codes are useful in optical design and can express the aberrations of some schlieren system, but they cannot describe the key role of diffraction in the formation of schlieren image[14]. To shed light on schlieren concepts that are untouched by geometric description, we propose a model that is based on wave propagation. Specifically, the Fresnel approximation of Rayleigh-Sommerfeld diffraction solution is adopted to model schlieren imaging. The choice of approximation is based on the resulting Fresnel number calculated from initial parameters. Fortunately, the advances in Fourier optics[19-20] and computer hardware[21] allow researchers to implement such numerical simulations.

Schlieren method consists of Fourier transforming an input image by a Fourier lens, cutting off half of the spatial frequencies by use of a knife edge at the Fourier plane and then reconstructing the image at the output plane[22]. The image carries the information regarding the refractive index variation due to the test object. In forming the schlieren images, the

Goos-Hänchen effect on Si thin films with spherical and cylindrical pores

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ABSTRACT

We examine the effects on the spatial and angular Goos-Hänchen (GH) beam shifts of spherical and cylindrical pores in a thin film. In our calculations, a p-polarized light is incident on a 1-μm thick porous silicon (Si) thin film on a Si substrate. The beams ahifts are within the measurement range of usual optical detectors. Our results show that a technique based on GH shift can be used to determine the porosity and pore structure of thin films at a given thickness.

Keywords: Goos-Hänchen shift, porous silicon, thin film

1. INTRODUCTION

Diffractive corrections to the law of reflection and refraction occur when bounded optical beams interact with a planar surface. With respect to the plane of incidence, the reflected beam shifts in-plane (Goos-Hänchen (GH) shift) and out-of-plane (Imbert-Fedorov (IF) shift). These shifts may undergo spatial (Δ_{GH} and Δ_{IF}) and angular (Θ_{GH} and Θ_{IF}) shifts that are dependent on the index of refraction of the material surface[1–4] and the properties of the beam such as its polarization,[1–3] divergence[5,6] and modal structure.[7,8]

Porous silicon (Si) films are an attractive material because of their wide ranging applications from solar cells,[9] biosensors,[10] Bragg reflectors,[11] and optical devices such as waveguides.[12] The presence of the pores greatly increases the interaction surface area. With the increased surface area, the sensitivity increases making it suitable for sensing applications.[13–15] Also, the pores decrease the dielectric constant of the material making the material desirable for electronic applications.[16] To maximize the applications of porous thin films, knowledge of its porosity, pore structure, pore size and optical properties is required.

In this paper, we calculate GH shift due to porous Si thin films with spherical and cylindrcal pores. Measurement of the beamshift provides a potential alternative technique in determining optical properties of materials that is a non-invasive, fast and relatively simple setup.[3]

2. THEORETICAL FRAMEWORK

We calculate the GH shift due to a 1-μm thick porous silicon (Si) thin film on a Si substrate with index of refraction $n = 3.8827$. We determine the GH shift of a p-polarized light beam from a helium-neon (HeNe) laser ($\lambda = 632.8$ nm) impinging the material at varying angles of inciedence, θ, from air. We assume that the extinction coefficient of Si is negligible at this wavelength. Figure 1 shows the schematic representation of the film-substrate structure with the incident beam.

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Paraxial Optics Cloak using Four Converging Lenses with Arbitrary Focal Lengths

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Abstract

In this paper, we achieved cloaking with four converging lenses of any focal length by solving the ray transfer matrix of a four lens optical system. It has been shown before that cloaking can be achieved using four converging lenses (so-called Rochester cloaks) but such cloaks required having 2 sets of 2 lenses with equal focal lengths, which we did not impose. We also discuss how the separation lengths between the lenses are affected by their focal lengths. In addition, we show how our formula holds under Rochester cloak condition.
Keywords: Geometrical optics, Lenses in Optical Systems

1 Introduction

The concept of making an invisibility cloak remains a popular subject in both science fiction and photonics research. The perfect optical cloak is characterized as omnidirectional, is invisible itself, and can hide the amplitude and phase distortion of the object to be cloaked. In essence, cloaking simply involves bending electromagnetic (EM) waves around a certain region referred to as the cloaking region. As the name implies, the cloaking region has no light passing through it; thus, objects placed in this region will not distort light from the background.

Even though it has been shown that omnidirectional invisible cloaks are impossible [1], different methods such as transformation optics, the use of dielectrics, and geometrical optics have been employed by researchers. Transformation optics, which makes use of coordinate transformations to direct EM waves, has been shown to produce cloaking effects for corners formed by two walls and hiding objects under a so-called "carpet" [2, 3]. Also, transformation optics and patterned dielectrics were involved in making hexagonal prism cloaks that were able to produce cloaking effects omnidirectional up to certain orientations with incoherent light [4, 5]. Similar to these hexagonal prism cloaks, cylindrical prism cloaks have been investigated and shown to have limited cloaking applications [6].

By far the simplest method for cloaking involves geometrical optics under paraxial approximation. This method has been explored using Fresnel lenses and diverging lenses [7] as well as with water in large glass containers making use of Snell's Law [8]. Geometrical optics that uses lenses and prisms has also been used in an attempt to preserve both the phase and amplitude of light while cloaking [9].

Another application of paraxial geometrical optics cloaking is using converging lenses. Converging lenses have also been used to cloak small regions, as noted in the well-documented Rochester cloak by Howell and Choi [10]. However, in the Rochester cloak, a four lens paraxial cloak is bound by the condition that the system must be symmetric (i.e., strictly using 2 sets of 2 lenses of focal lengths f_1 and f_2). Removing these conditions and generalizing cloaking for all converging lenses, this paper addresses the four lens paraxial cloak with lenses of arbitrary focal lengths.

2 Calculations

In making the Rochester cloak, Howell and Choi utilized the fact that any optical system can be described by a ray transfer matrix. Also, they were able to show that a four lens system can satisfy the necessary condition that the ray transfer matrix of the cloak $\mathbf{M_{eff}}$ "mimic" that of free space [11].

$$\mathbf{M_{eff}} = \begin{bmatrix} 1 & L_{\text{eff}} \\ 0 & 1 \end{bmatrix} \tag{1}$$

In characterizing an optical system, one simply multiplies the corresponding ABCD matrices of each optical element. The resulting matrix is the corresponding ABCD matrix of that system. Therefore, to describe a four lens system shown in Figure 1 using ray transfer matrices, one needs to multiply seven 2x2 matrices, each one corresponding to the medium the light passes through. Thus, the resulting $\mathbf{M_{eff}}$ for the system is the

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