2020 Annual Report
Instrumentation Physics Laboratory
National Institute of Physics
www.nip.upd.edu.ph/ipl
01 January - 31 December 2020

Submitted by:
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Coordinator, Instrumentation Physics Program
Date: 18 January 2021

with assistance from:
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University Research Associate I
Instrumentation Physics Laboratory (IPL)

I. Executive Summary

A. Research Group Activities (AY 2019-2020)

1. Affiliated Personnel as of December 2020
   PhD Faculty: 6
   Student Members: 53
      PhD Physics (7)
      MS Physics (15)
      BS Applied Physics/Physics (31)

2. Graduates with Dissertation or Thesis Research Conducted in IPL
   PhD Physics: 3
   MS Physics: 1
   BS Applied Physics/Physics: 21

B. Research Highlights: Peer-Reviewed Technical Publications

1. SCI and SCOPUS Indexed Journals: 4
2. Philippine-based Journals (Indexed in SCI and/or SCOPUS): 5
3. International conference presentations (with full paper in conference proceedings): 0
4. International conference presentations (without full paper): 0
5. Local conference presentations: with full paper): 30
6. Chapters in books: 0
7. Patents: 0
8. NIP funded projects: 6
9. Non-NIP funded projects: 6
10. Major equipment acquired/upgraded: 0
11. Research travels abroad (Outbound): 0
12. Visiting researchers: 0
13. MoAs entered with local or foreign institutions and other external collaborators: 0

C. Extension Work Highlights
1. Extension Work Activities: 1
2. Research Interns/OJT's (Non-NIP), for trainings held at NIP: 0

D. Main Challenges Encountered and Proposed Solutions

E. Awards or Accreditations Received/Positions of Responsibility Held and Other Accomplishments
1. National awards or accreditations received, positions of responsibility held: 5
2. International awards or accreditations received, positions of responsibility held: 0
3. Other accomplishments: 0

II. Technical Report

A. Research Group Activities

The Instrumentation Physics Laboratory (IPL) aims to provide all qualified PhD, MS and BS students of the National Institute of Physics (NIP) with an enabling and nurturing environment that allows them to pursue their research projects successfully in fulfillment of their dissertation/thesis degree requirement.

Each IPL student-member is assigned an IPL PhD thesis supervisor who will direct his or her thesis research and guide his/her steady development as a young scientist. To become a student-member of IPL an applicant must be a *bonafide* NIP student during the time of application and he or she must successfully complete an in-house application process.

The IPL has consistently presented and published the research results of its faculty and students in technical conferences and peer-reviewed scientific journals over the years since the late 1980's. Its student-alumni are now occupying critical research and managerial positions in the academic and research institutions in the public and private sector all over the world.

B. Organization - Members as of December 2020

B.1. PhD Faculty (6)

Professors: Caesar Saloma, Maricor Soriano, Giovanni Tapang, May Lim
Associate Professor: Johnrob Bantang
Assistant Professor: Ritz Ann Aguilar

B.2. Students

- **PhD Physics (7)**

Jamika Ann Roque, Louie Rubio, Christian Valgomera, Chester Balingit, Damian Dailisan, Wynn Improso, Gerold Pedelmonte

- **MS Physics (15)**

MS2 (7)
Wilbur Galarion, Anthony Paul Fox, Jan Parvin Zoluaga, Ivan Fenis, Joshua Abuel, Kristen Joyce Cervantes, Mark Jeremy Narag

MS1 (8)
Reinier Xander Ramos, Rian Fritz Jalandoni, Matthew Joseph Banaag, Kenneth Leo, Rene Principe Jr., Adrielle Cusi, Jobeth Martecio, Patricia Pangilinan

- **BS Applied Physics/Physics Students (31)**

BS5 (11)
Kit Guial, Jona Vistal, Raymond Luke Rebong, Stephanie Anne Vergara, Kelvin Bartilad, Rafael Bagood, Charles Louie Fernan, Maria Tisha Bagasala,d Sarakiel Rayco, Jemima Bian Anila, Jireh Vera Cruz

BS4 (2)
Beatriz Movido, Karl Aleta

BS3 (18)
Jocam Camara, Christian Magsigay, Martin Recentes, Chae Malipol, Julia Esteibar, Bret Ordono, Andrea Castro, Carl Valdellon, Mariau Beltran, Olyn Desabelle, Elmo Jose, Mark Badua, Sean Roxas, Earl Crusina, Jano Peria, Reignel Pangilinan, Julliana Ching, John Urbi

- **Research Collaborators (6)**

Dr. Atchong Hilario (DOST Project Researcher with Dr Soriano)
Dr Andrew Banas (DOST Project Researcher with Dr Soriano)
Dr Cynthia Palmes-Saloma (PGC and NIMBB)
Dr. Ranzivelle Marianne Roxas-Villanueva (UPLB)
Dr. Marissa G. Pastor (USC)
Dr. Rene C. Batac (DLSU)

Table 1. IPL Membership as of December 2020:

Membership Type	Category	Number
PhD Faculty		6
Students	BS3	18
	BS4	2
	BS5	11
	MS1	8
	MS2	7
	PhD1	2
	PhD2	2
	PhD3	0
	PhD+	1
	PhD++	2
	Total	**59**

C. Successful Mentoring

Table 2. PhD, MS and BS Graduates

Program	Name	Thesis Title	Adviser(s)
PhD Physics	Ritz Ann Aguilar	Adaptive Methods for Fourier Ghost Imaging Development and Applications	Dr Soriano (MS)
PhD Physics	Alfred Abella	Eulerian Vorticity On and Beneath Surface Waves Generated at the Liquid-Gas Interface	MS
PhD Physics	Maria Teresa Pulido	The Local Acceptance Model : A Comprehensive Tool to Study Collective Decision-Making in Complex Networks	Dr Saloma (CS)
MS Physics	Jesli Joshua Santiago	Self-Organized Criticality in an Hourglass	CS
BS Applied Physics	Adrielle Theresa Cusi	Brownian motion diffusion coefficient measurement accuracy and precision via single particle tracking method	CS, Dr Tapang (GT)
	Alec Kevin Rigonan	Effect of reallocated levies on the wealth inequality through time of an agent-based population in a small-world network system	CS
	Matthew Joseph Banaag	Statistical dynamics of a thin-layer granular system confined in a horizontally vibrated box	Dr Bantang (JB)
	Rian Fritz Jalandoni	Mechanical model of cancer cells in 2D confined continuous space	JB
	Samantha Ruth Lahoz	Spiking dynamics in a Wilson-Cowan model of neuronal populations	JB
	Jose Nazareno Gabriel Macalintal	Interacting extended Bak-Sneppen evolutionary model for RNA virus epidemics	JB
	Chris Dion Bautista	Reversible photowriting using polyanthracene in visible light	GT

	Daniella Hernandez	Underwater acoustic characterization of electret hydrophone with speaker as sound source	GT
	Emil Joseph Mateo	Performance of multi-radio wireless sensor network on distributed environmental sensing	GT
	Paolo Rafael Mawis	Overcoming limited phase range by successive modulation with two transmissive SLMs	GT
	Eric Joshua Vincent Reyes	Performance comparison of galvanometer scanners and spatial light modulators in photolithography	GT
	Patricia Pangilinan	A modified Gerchberg-Saxton algorithm for phase retrieval in lensless optical systems	GT
	Creo Baylon	Pitch control for a towed underwater pipe platform with rise and dive functions	MS
	Kenneth Domingo	Compressive sensing: Applications from 1-D to N-D	MS
	Kyngzer-Rem Vargas	Fourier transform profilometry of travelling surface waves	MS
	Lou Josef Tan	Pose estimation and action recognition of basketball players using machine learning techniques	MS
	Rene L. Principe	Color error tendencies in spectral super-resolution	MS
	Andrea Rica Advincula	Fluid mechanics experiments using commercial off-the-shelf components	MS
	Crizzia Mielle De Castro	Extracting Philippine voting patterns through hyperspectral unmixing	Dr. Lim (ML)
	Charles Jason Diaz	Relating urbanization to convexity and transport channels using remote sensing data	ML
	Kenneth Leo	Designing a resilient autonomous convection-driven Brownian bug network	ML

Table 3. Summary of Graduates in 2020

Degree Program	2nd Sem AY 2019-2020	Midyear AY 2019-2020	Total
PhD Physics	1	2	3
MS Physics	1	0	1
BS Applied Physics	21	0	21
BS Physics	0	0	0
Total	**23**	**2**	**25**

D. Research Highlights (publications/patents/research travels)

D.1. Publications in SCI-Indexed Journals (4)

1. Abella, A.P., Soriano, M.N. (2020). Measurement of Eulerian vorticity beneath rotating surface waves. Physica Scripta, 95(8). https://doi.org/10.1088/1402-4896/aba056.
2. Abella, A.P., Soriano, M.N. (2020). Spatio-Temporal Analysis of Surface Waves Generating Octupole Vortices in a Square Domain. J. Exp. Theor. Phys. 130 (3), Pages 452–462. https://doi.org/10.1134/S1063776120030085
3. Dailisan, D.N., Lim, M.T. (2020). Crossover transitions in a bus-car mixed-traffic cellular automata model. Physica A: Statistical Mechanics and its Applications, 557. https://doi.org/10.1016/j.physa.2020.124861
4. Pulido, M.T., Saloma, C.A. (2020). Local acceptance and emergence of consensus in a heterogeneous small-world network of agents with and without memory. https://doi.org/10.1016/j.physa.2019.123851

D.2. Other publications in SCOPUS-Indexed journals (5)

5. Saloma C.A. (2020). Positional Fitness. Philipp. J. Sci 149-1
6. Saloma C.A. (2020). The COVID-19 Pandemic and the Readiness of Nations. Philipp. J. Sci 149-2
7. Saloma C.A. (2020). Journal Status Report 2020, Philipp. J. Sci 149-3
8. Saloma C.A. (2020). Expanding the Pool of STEM PhD Supervisors, Philipp. J. Sci 149-4
9. Tiongson, J.A., Aganda, K.C., Bruzon, D.V., Guevara, A.P., Basilia, B.A., Tapang, G.A., Martinez, I.S. (2020) Exploring the corrosion inhibition capability of FAP-based ionic liquids on stainless steel. https://doi.org/10.1098/rsos.200580

D.3. International conference presentations (with full paper in print proceedings): 0
D.4. International conference presentations (without full paper): 0
D.5. Conference presentations with full paper in conference proceedings: 30

1. Dailisan, D. and Lim M.T. Simultaneous identification of transportation-deficient zones and transit hubs through Origin-Destination and Boarding-Alighting surveys. Proc 38th Samahang Pisika ng Pilipinas Physics Conference (online), 19-23 October 2020.
2. Rubio, L.J, Perez, R., and Lim M.T. Intracity bus trip dynamics using GPS data. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
3. Fenis, I.M., Dailisan, D., and Lim, M.T. Traffic dynamics of multiple paired U-turn slots. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
4. Fox, A.N. and Saloma, C.A. Axial response in semiconductor laser confocal interferometric microscope under full optical feedback. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
5. Pedemonte, G. and Lim M.T. Analysis of social network formation of students in a classroom. Proc 38th SPP Physics Conference, 19-23 Oct 2020.

6. De Castro, C. and Lim M.T. Extracting voting patterns across three Philippine senate elections using hyperspectral unmixing. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
7. Diaz, C. and Lim M.T. Co-occurrence analysis of waterway access, transport proximity, and urbanization. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
8. Fernan, C. and Bantang J.Y. Kinematics of a developing internet subscription service. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
9. Pulido, M. and Saloma C.A. Emergence of multi-scale consensus in Watts-Strogatz networks using the local acceptance model. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
10. Ramos, R. and Bantang J.Y. Verhulst and bifurcation analyses of a neuronal network on an outer-totalistic toroidal cellular automata. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
11. Tan, L. and Soriano M.N. A pose-based action recognition machine learning framework for basketball analytics. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
12. Mateo, J. and Tapang G.A. Acquisition of temperature and humidity using multi-radio wireless sensor network. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
13. Cusi, A., Improso, W., Tapang, G.A., Saloma, C.A. Measurement of the Brownian motion diffusion coefficient: Displacement-distribution versus mean-squared-displacement trajectory technique. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
14. Hernandez, D. and Tapang, G.A. Underwater acoustic characterization of electret hydrophone with speaker as sound source. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
15. Pangilinan, P., Improso, W., and Tapang, G.A. Using the angular spectrum method and Fresnel transform as kernels in a modified Gerchberg-Saxton algorithm. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
16. Advincula, A., Abella, A., Soriano, M.N. Fluid mechanics experiments using commercial off-the-shelf components. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
17. Baylon, C. and Soriano, M.N. Pitch control simulation for underwater pipe platform with rise and dive functions. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
18. Jalandoni, R. and Bantang J.Y. In silico study of stress distribution in a tissue surrounding a cancer growth using Centroidal Voronoi Tessellations. Proc of the 38th SPP Physics Conference, 19-23 Oct 2020.
19. Lahoz, S. and Bantang J.Y. Critical exponents of neuronal avalanches in a stochastic model of Wilson-Cowan neuronal populations. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
20. Leo, K. and Lim, M.T. Designing a self-sustaining Brownian bug network Proc 38th SPP Physics Conference, 19-23 Oct 2020.
21. Martecio, J. and Bantang J.Y. Effect of noise and particle density in the dynamic network formed by Vicsek model of swarming mobile agents. Proc 38th SPP Physics Conference, 19-23 Oct 2020.

22. Reyes, E., Improso, W., and Tapang G.A. Comparison of single focus and dual foci scanning in single-photon photopolymerization. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
23. Domingo, K. and Soriano, M.N. Compressively sampled speech: How good is the recovery. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
24. Principe, R. and Soriano M.N. Color error tendencies in spectral super-resolution. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
25. Banaag, M. and Bantang J.Y. Excitation of a conserved lattice gas model as a possible toy model for granular systems. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
26. Macalintal, J. and Bantang J.Y. Dynamics of an interacting Bak-Sneppen model system. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
27. Balingit, A. and Lim, M.T. Trade-offs in local traffic signal control algorithms on a grid network. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
28. Novabos, N., Madalipay, J., Hilario, P., and Soriano, M. A motion-free pushbroom scanner testing platform. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
29. Aguinaldo, R.A.S., Lofamia, M.C.P., Maestro, M.A.M., Ba√±as, A.R.M. and Soriano, M.N. 2020. Modulation transfer function of a scanning hyperspectral imager. Proc 38th SPP Physics Conference, 19-23 Oct 2020.
30. Alampay, M.J.P., Chua, J.E., Aguinaldo, R.A.S., Ba√±as, A.R.M. and Soriano, M. 2020. A portable image scanning platform based on a rotating mirror mechanism. Proc 38th SPP Physics Conference, 19-23 Oct 2020.

D.5. Book Chapter (0)
D.6. Patents (0)
D.7. NIP Funded Projects (6)

Each IPL PhD faculty was awarded a one-year research project by the NIP in 2020.

D.8. Non-NIP Funded Projects (6)

1. Optical Payload Technology In-depth Knowledge Acquisition and Localization (OPTIKAL). Project under the STAMINA4SPACE Program DOST-GIA 2018-2021 (Project Leader: Dr Soriano).
2. Data Analytics for Research and Education (DARE) Project 2: Design and analysis of algorithms CHED PCARI IIID-2016-006 (Project Leader: Dr Lim).
3. Generalized Automated Microfluidics and Micro-actuator Assembly (GAMMA) PCIEERD 2018-2020 (Project Leader: Dr Tapang).
4. CATFish: A Modular, Mini-Autonomous Underwater Vehicle System (CATFISH) PCIEERD 2018-2020 (Project Leader: Dr Tapang).
5. Microfluidic Diagnostic Assay (MiDAs) under the Field Integrated Novel Diagnostics for Flaviviruses (FIND-Flaviviruses) Program of PCHRD 2019-2021 (Project Leader: Dr Tapang).
6. Standards and Testing Automated Modular Platform (STAMP) PCIEERD 2016-2020 (Project Leader: Dr Tapang).

D.9. Major Equipment Acquired/Upgraded (0)
D.10. Research Travels Abroad (Outbound) (0)
D.11. Visiting Researchers (0)
D.12. MoAs entered into with local or foreign institutions and other external collaborators (0)

E. Extension Work Highlights

Caesar Saloma (2011 – present)
Editor-in-Chief
Philippine Journal of Science
Publisher: Department of Science and Technology
www.philjournalsci.gov.ph

Maricor Soriano (2016 - present)
Technical Panel in Photonics
DOST-PCIEERD

May Lim
Academic Editor
Complexity
www.hindawi.com/journals/complexity/editors

F. Main Challenges Encountered and Proposed Solutions

The primary challenge of IPL in 2021 will be the successful design, formulation and approval of a PhD Applied Physics program in the National Institute of Physics that is suitable and appropriate for the outlook, mindset and technical training that has been developed and acquired by a BS graduate of IPL.

Such a PhD program is urgent long overdue. The BS Applied Physics program produced its first batch of graduates in AY 1985-1986 and the program has been its the main producer of BS graduates in NIP since AY 2005-2006 (see Figure 1).

The offering of a PhD Applied Physics Program is key to accomplishing the strategic goal of producing more PhD graduates from NIP. Since AY 2005-2006, the NIP has produced only one (1) PhD Physics graduate for every 8.6 BS and 4.03 MS graduates, respectively.

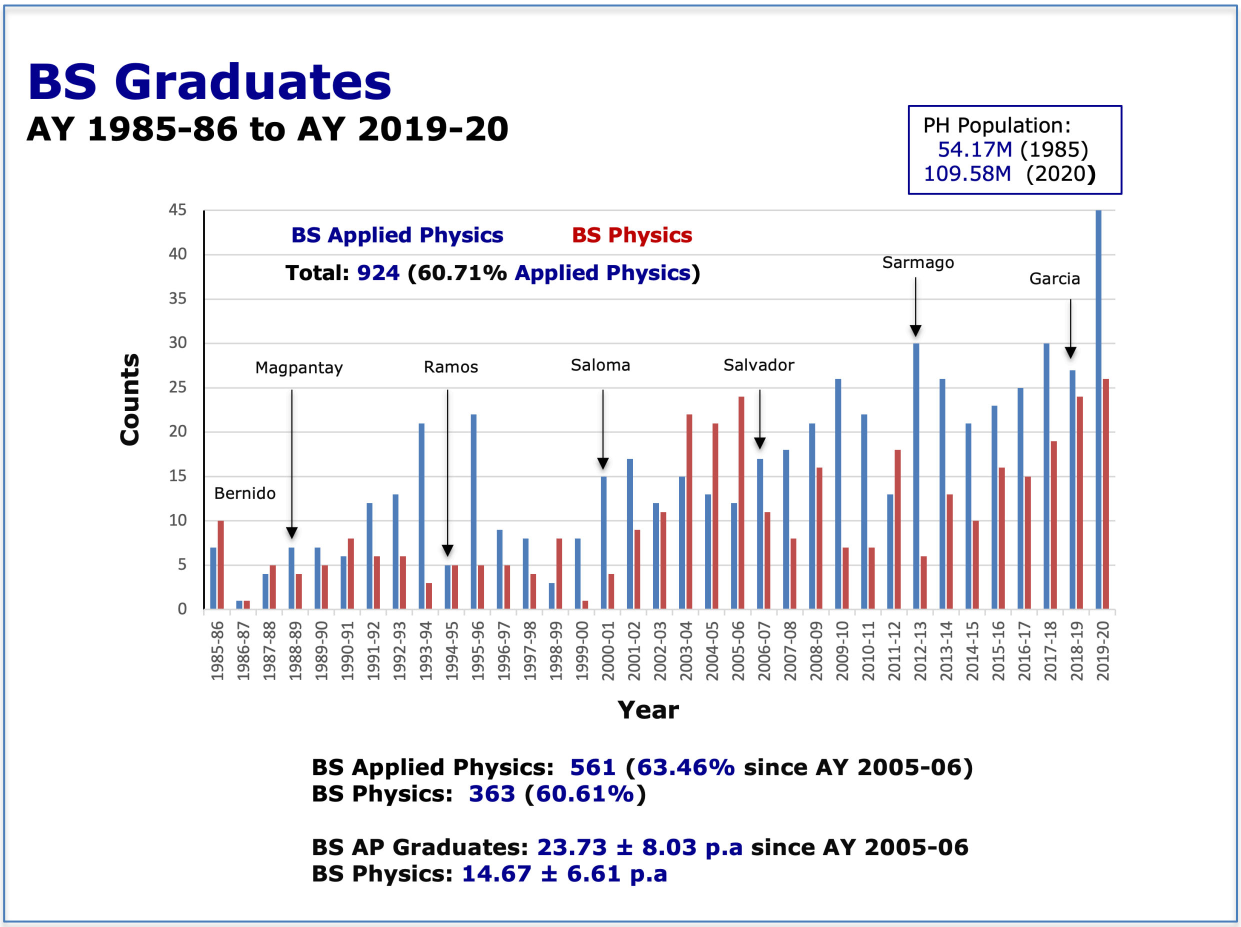

Figure 1. BS Applied Physics and BS Physics graduates produced by NIP per year since AY 1985-1986. Also indicated are the names of the corresponding NIP Directors during the periods of reckoning. The NIP was established in 1983 as an institutional evolution of the Department of Physics of UP Diliman.

F. Awards or Accreditations Received / Positions of Responsibility Held

1. Dr. Tapang, Dean, College of Science, UP Diliman
2. Dr. Bantang, Director, Computational Science Research Center, College of Science
3. Dr. Lim, Deputy Director for Research and Extension, NIP
4. Dr. Saloma, Editor-in-Chief, Philippine Journal of Science
5. Dr Aguilar, Chair, General Physics Committee, National Institute of Physics

III. Photos, ISI/SCI Publications and Other Appendices

Figure 2. IPL PhD Faculty (left to right): C. Saloma, M. Soriano, M. Lim, G. Tapang, J. Bantang and RA Aguilar

Figure 3. New BS Student Members of IPL who joined in August 2020.

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Measurement of Eulerian vorticity beneath rotating surface waves

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Abstract

In this study, we report experimental verification of the existence of an Eulerian contribution to vortices beneath rotating gravity surface waves. We are motivated by recent theoretical predictions regarding the generation of vortices by surface waves. The first prediction indicates that surface waves which produce vortex lattices at the liquid-gas interface can also produce vorticity beneath them and in the liquid bulk. The second prediction is the existence of an Eulerian contribution to the vorticity, owing to the liquid viscosity. First, we establish that we can generate a vortex lattice at the liquid-air interface using rotating waves, resulting from the superposition of two orthogonal phase-shifted standing waves. Using glycerol-water solution as the liquid, we then conduct Particle Image Velocimetry of tracer particles to measure the velocity and vorticity profiles of the flow beneath the interface. We found that vortices are indeed generated beneath these rotating surface waves. To verify the existence of the Eulerian vorticity, we first measure the vorticity at different values of the liquid layer $z < 0$. After this, we set a reference vorticity value at a specific z closest to the interface that does not intersect with the waves, and get its ratio with respect to the vorticities at other z. We introduce the computation of the normalized density curves of the vorticity ratios, and compare the peak values to the vorticity prefactor ratios obtained using the theoretical predictions. Our results are in close agreement with the theoretical analysis which accounts for this additional contribution. Our experiments shed light on the mechanism of vorticity generation beneath rotating surface waves.

Keywords: Hydrodynamic waves, Flow visualization and imaging, Vortex dynamics

(Some figures may appear in colour only in the online journal)

1. Introduction

The manipulation of floaters on liquid surfaces has found its applications in biofabrication and tissue engineering, and enhancement of surface properties [1–3]. In a previous work of Lukaschuk, Denissenko and Falkovich [4], the clustering of particles in standing wave nodes and antinodes based on their wettability was studied. In their experiments, the particles are initially scattered on the air-water interface. The standing waves force the particles to cluster and are produced on the water surface inside a vertically-vibrated rectangular container. Hydrophilic particles were found to cluster into the wave nodes, while hydrophobic particles settled on the wave antinodes [4]. In another study by the group of Chen [1], they studied liquid-based templated assembly for tissue engineering purposes. They were able to generate different patterns of particle clusters on the liquid-gas interface after vertically shaking small polygonal containers. Recently an experimental set-up has been presented by Francois and company to restrict the motion of floater particles along vortex lattices at the liquid-gas interface [5]. To generate the vortex lattice, they used rotating waves, which is a result of the superposition of two orthogonal standing waves with a phase delay between them of $\pi/2$. These rotating waves provided the necessary local angular momentum to generate the vortices. Here in our study, we ask the questions of whether and how these rotating waves can also generate vorticity beneath the liquid-gas interface. The motivation arises from the theoretical prediction regarding the generation of vorticity by surface waves presented by Filatov and company [6], and later improved by Parfenyev and Vergeles [7]. For the specific case of two orthogonal monochromatic standing waves producing

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STATISTICAL, NONLINEAR, AND SOFT MATTER PHYSICS

Spatio-Temporal Analysis of Surface Waves Generating Octupole Vortices in a Square Domain

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Abstract—In this study, we examine the underlying surface wave dynamics forming an octupole structure of vortices on the air–water interface. The surface waves are generated by a square wavemaker made of four cylindrical edges half-submerged on the interface. These waves direct the motion of floaters into gyrating trajectories, forming two counter-rotating vortices along each edge of the wavemaker and generating the overall octupole pattern. We 3D reconstruct the wave heights and describe the underlying flow through spatio-temporal analysis. Specifically, we decompose the overall wave field into components coming from the edges and corners of the wavemaker. To our knowledge, we are first to obtain a closed-form solution for a velocity potential, via a superposition of edge and phase-shifted oblique progressive waves produced by the wavemaker, to qualitatively model these octupole vortices. The methodology outlined provides a phenomenological approach to characterize the flow that may be useful for characterizing waves inside arbitrary finite-sized domains.

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1. INTRODUCTION

Several forcing techniques have been presented in the past to elicit floater control. Such are the use of Faraday waves inside a vertically-shaken container [1], or through oscillons formed by strongly nonlinear surface waves [2]. In relation, the collective motion of particles arising from intrinsic properties such as wettability and density have been studied through various forcing techniques [3–5]. Vorticity generation and wave focusing have also been possible due to wall meniscus and depth specifications that prescribed the surface wave motion [6–8]. In [9], they restrict the motion of floaters via standing waves generated through vertically forcing small-scale basins, primarily for tissue engineering applications. On the other hand, a set-up has been presented in [10] to control the movement of floater particles along multiple cell-like trajectories involving two rectangular paddles which oscillated with a phase delay between them of $\pi/2$. A separate group of authors in [11] have also done this previously using two cylindrical half-submerged plungers instead of rectangular fully-submerged paddles. Together with the container or wave tank walls, these wavemakers enclosed a square domain for the particles. They were able to generate rotating waves, as a result of the superposition of orthogonal standing waves formed by the wavemakers and walls, which provided the necessary local angular momentum to form nested gyrating particle trajectories [10]. Rotating waves are different from standing waves in that for rotating waves, the crests and troughs rotate and switch positions to enclose nodal points, whereas standing wave crests and troughs only oscillate vertically, with fixed locations for every period of wave oscillation.

In this study, we contruct a square wavemaker using four cylindrical rods as its edges. It is suspended on the air-water interface and oscillates as a single structure. Using this set-up, we generate an octupole structure of vortices on the surface. The octupole structure is characterized by pairs of counter-rotating vortices of nested gyrating particles across each edge of the wavemaker. It turns out that rotating waves are the ones responsible for the advection of floaters inside the square wavemaker that we use here. In [10], they were able to express the rotating waves and reproduce their cell-like vortices via superimposing orthogonal and phase-shifted standing wave velocity potentials. The goals here then are to also study and reproduce to some extent the generation of these waves and our generated octupole vortices, by first analyzing the component waves which generate these structures, and then modeling them analytically through a straightforward superposition of progressive waves. Through our spatio-temporal analysis of the flow, we find that these rotating waves are composed of edge and phase-shifted oblique waves, coming from the corners of the wavemaker. We outline a methodology of decomposing the incident and reflected waves into oblique waves, to a case when all four edges oscillate,

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Crossover transitions in a bus–car mixed-traffic cellular automata model

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ABSTRACT

We modify the Nagel–Schreckenberg (NaSch) cellular automata model to study mixed-traffic dynamics. We focus on the interplay between passenger availability and bus-stopping constraints. Buses stop next to occupied cells of a discretized sidewalk model. By parametrizing the spacing distance between designated stops, our simulation covers the range of load-anywhere behavior to that of well-spaced stops. The interplay of passenger arrival rates and bus densities drives crossover transitions from platooning to non-platooned (free-flow and congested) states. We show that platoons can be dissolved by either decreasing the passenger arrival rate or increasing the bus density. The critical passenger arrival rate at which platoons are dissolved is an exponential function of vehicle density. We also find that at low densities, spacing stops close together induces platooned states, which reduces system speeds and increases waiting times of passengers.

1. Introduction

Public transportation is universally acknowledged as a fundamental component in solving traffic congestion. Together with rail systems, buses form the backbone of medium- to long-haul modes of people transport. Since the interaction of buses and passengers introduces complex behavior in transportation systems, more so in cities that do not have designated stops, several models have been proposed to study bus traffic [1–5]. In these models, a delay in the arrival time of a bus leads to more passengers waiting for the bus, which then leads to further delays. Succeeding buses find fewer waiting passengers leading them to catch up to the delayed bus. Thus, buses form platoons (or bunches). These models also show a transition from the platooning state to a non-platooned state with increasing bus density.

The tendency of buses to form platoons is problematic for public transport. In an ideal scenario, an efficient transport system would try to maintain equal time intervals between vehicle arrivals. However, an equal headway configuration of vehicles is unstable [6], more so with buses [1]. Since the instability is inherent to the interaction between public transport vehicles and passengers, approaches to maintain equal headways should consider both traffic and passenger behavior [7].

Bus route models [1–3] omit interactions between buses and other vehicle types. Yet we expect that these vehicular interactions play a key role in the dynamics of traffic flow — buses making curbside stops impede traffic flow outright [8], while small perturbations in vehicle speeds can induce congestion [9,10]. Even a single bus in two-lane mixed traffic alters traffic states and jam transition densities [11]. As such, it is also critical to decision makers when curbside stops have to be replaced by bus bays to alleviate congestion [12]. Using a modified comfortable driving model, Yuan et al. [13] focused on system performance to show a dependence of the system capacity on the number of bus stops. They also found a gradual

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Local acceptance and emergence of consensus in a heterogeneous small-world network of agents with and without memory

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A B S T R A C T

We formulate a spatiotemporal model of social interaction that explores the role of local acceptance or influence in consensus-building. It is applied to a population of interacting agents that forms a small-world Watts–Strogatz network to determine the level of consensus that emerges as a function of the local acceptance parameter α ($0 \leq \alpha \leq 1$), agent memory capacity, and interaction scale. Parameter α sets the probability that an agent copies the majority state of its neighbors while $(1-\alpha)$ is the corresponding likelihood that it conforms with the minority state. An agent with memory may retain its present state regardless of the local state of its neighborhood. We track the emergence of global agreement in a heterogeneous population of agents with and without memory, using density metrics that correspond to three different interaction scales — entire population, neighborhoods, and pairs of agents. We have found that for a given α and population heterogeneity, the degree of agreement would depend strongly on the chosen interaction scale and network connectivity. Unlike its disordered counterpart, a homogeneous small-world network with memory, is unable to reach a simple majority of 51% over a wide range of $\alpha < 0.83$. The degree of agreement then peaks towards 80% at $\alpha = 0.95$ before decreasing rapidly back to 50% as $\alpha \to 1.0$. Memory prevents a heterogeneous small-world network from achieving full agreement at $\alpha = 1.0$, even when the agents with memory is a weak minority. All density profiles are asymmetric about $\alpha = 0.5$, indicating the uneven impact of copying the majority or minority state in consensus building. They are also distinct and difficult to extrapolate from each other. The model provides an adaptive platform for exploring the spatiotemporal performance of existing collective decision-making strategies either separately or in multiple combination of each other. It can be deployed to probe the possible triggers of strategy modification in adaptive social networks. We have identified its presence in animal groups that were observed while in pursuit of predefined tasks such as group emergency evacuation.

1. Introduction

There are a number of ways in which a population of interacting individuals is able to reach a consensus on an issue that affects the common good, or to agree on a common plan of action towards a shared objective. The series of actions that is

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Exploring the corrosion inhibition capability of FAP-based ionic liquids on stainless steel

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Corrosion is clearly one of the more common causes of materials failure in stainless steel. To manage corrosion, chemical inhibitors are often used for prevention and control. Ionic liquids due to their hydrophobic and corrosion-resistant property are being explored as alternative protective coatings and anti-corrosion materials. In this particular study, ionic liquids containing functionalized imidazolium cations and tris(pentafluoroethyl)trifluorophosphate (FAP) anions were investigated for their ability to inhibit corrosion on stainless steel surfaces in acidic environment. Using surface characterization techniques, specifically scanning electron microscopy and energy-dispersive X-ray (EDX), the morphology and the elemental composition of the steel surfaces before and after corrosion were determined. Contact angle measurements were also performed to determine how these ionic liquids were able to wet the stainless steel surface. In addition, potentiodynamic studies were carried out to ensure that corrosion inhibition has occurred. Results show that these ionic liquids were able to inhibit corrosion on the stainless steel surfaces. This indicates promise in the use of these FAP-based ionic liquids for corrosion management in stainless steel.

1. Introduction

Stainless steel is widely used in various applications such as in construction, maritime transport and aerospace engineering [1,2].