

UNIVERSITY OF IBADAN, IBADAN, NIGERIA

DEPARTMENT OF MATHEMATICS

Ezekiel O. Ayoola
BSc. M.Sc, Ph.D. (Ibadan)
Professor of Mathematics



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PROFESSOR E. O. AYOOLA

CURRICULUM VITAE

- Full Name:** AYOOLA, Ezekiel Olusola
- Marital Status:** Married with children
- Nationality:** Nigerian
- Current Address/Contact Details:** Department of Mathematics,
University of Ibadan, Nigeria
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- and
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+234 80 6360 1588 (Personal Contact)
- Home Address:** : Plot 122, Ajibode Settlement Area, Behind University of Ibadan

6. EDUCATIONAL INSTITUTIONS ATTENDED WITH DATES

S/No	Institution	Date
1	University of Ibadan (Undergraduate)	Oct 1980-July 1984
2	University of Ibadan (M.Sc. Program)	Oct 1986- April 1988
3	University of Ibadan (Part time Ph.D. Program)	Oct 1991- Jan 1999

(a) ACADEMIC AND PROFESSIONAL QUALIFICATIONS AND DISTINCTIONS

S/No	Certificate/Degree	Awarding Institution and Year
1	B.Sc. Mathematics, Second Class Honours Upper Division	University of Ibadan, July, 1984
2	M.Sc. Applied Mathematics	University of Ibadan, April, 1988
3	Ph.D (Mathematics)	University of Ibadan, January, 1999

7. PRESENT AND RECENT POSITIONS- STATUS AND SALARY

- Professor of Mathematics, since October 1, 2008, SALARY: CONNUASS 07/10
- Pastor Enoch Adeboye Chair in Mathematics (February 2021 -Jan 2022)
- Deputy Vice Chancellor (Administration) University of Ibadan, November 9, 2021 -Nov 8, 2023.

MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS/BODIES

1. Member, Nigerian Mathematical Society
2. Member, Nigerian Association of Mathematical Physics.
3. Member, New York Academy of Sciences
4. Affiliate Member, American Mathematical Society.
5. Member, Society for Industrial and Applied Mathematics (SIAM).
6. Fellow of the Nigerian Mathematical Society (FNMS) Elected June 2023.

• **RESEARCH INTEREST**

- Stochastic Analysis and Applications,
- Financial Mathematics,
- Stochastic Numerical Analysis,
- Quantum Stochastic Calculus, Quantum Finance,
- Quantum Information Science and Quantum Computing.

8. SOME SIGNIFICANT ADMINISTRATIVE EXPERIENCE

I have taken part in the following:

- the successful appointment of two UI Registrars in 2012 and 2018, respectively;
- the successful appointment of the immediate past UI Bursar in 2015;
- the successful appointment of the current University Librarian in 2017;
- the successful appointment of the 12th Vice Chancellor in 2015; and
- the appointment of many professors, Deputy Registrars and Directors.

9. WORK EXPERIENCE (IN CHRONOLOGICAL SEQUENCE)

1. NYSC Lecturer in Mathematics, former Gongola State College of Education, Jalingo, August 1984-July 1985.
2. Assistant Lecturer in Mathematics, St Andrew's College of Education, Oyo, January 2 1986- Jan 31, 1989.
3. Assistant Lecturer, Mathematics Department, University of Ibadan, February 2, 1989 - September 30, 1992.
4. Lecturer Grade II, Mathematics Department, October 1, 1992 - September 30, 1999
5. Lecturer Grade I, Mathematics Department, October 1, 1999 - September 30, 2002.
6. Senior Lecturer, Mathematics Department, October 1, 2002 to September 30, 2005.
7. Reader in Mathematics, October 1, 2005 to September 30, 2008.
8. Professor of Mathematics, October 1, 2008 to date.

- **MATHEMATICS COURSES REGULARLY TAUGHT**

Undergraduate:

1. Ordinary and partial Differential Equations
2. Real and Functional Analysis
3. Numerical Analysis and Scientific Computations
4. Stochastic Numerical Analysis.
5. Financial Mathematics
6. Mathematical modelling
7. Measure theory and Integration
8. Point Set Topology
9. Elementary Abstract and Linear Algebra
10. Metric Spaces and Applications

Postgraduate

1. Numerical Analysis of Ordinary Differential Equations,
2. Numerical Analysis of Stochastic Differential Equations.
3. Stochastic Analysis and computations
4. Stochastic Finance
5. Option Theory in Financial Markets (Complete and Incomplete Markets)
6. Mathematical and Statistical Modelling (With Applications to Real Life Problems)

- **COMPLETED SUPERVISION OF MASTERS, MPHIL, AND PHD RESEARCH STUDENTS**

The Following PhD Research Have Been Successfully Completed So Far.

1. A. O. Atonuje, PhD Thesis: Oscillatory Properties of Solutions of Stochastic Delay Differential Equation. Date of Examination: January 14, 2010.
2. Ignatius Njoseh, PhD Thesis: Numerical Solutions of Stochastic Cahn-Hilliard and Wave Equations. Date of Examination: January 14, 2010.

3. Michael Ogundiran: PhD Thesis: On the existence of solutions of discontinuous quantum stochastic differential inclusions. Date of Examination: May 7, 2010.
4. Joel Ukaegbu, PhD Thesis: Modelling and Approximation of American Option Pricing in Weighted Sobolev Spaces. Date of Examination: June 13, 2013.
5. S. A. Bishop, PhD Thesis: Existence and Stability of Solutions of Kurzweil Equations associated with Quantum Stochastic Differential Equations. May 12, 2012. Awarded by Covenant University, Ota, Ogun State, Nigeria
6. Kehinde Adelegan, PhD Thesis: Measurement of Value-at-Risk through Modified Stochastic Volatility Model of Financial Returns in Nigerian Stocks. Date of Examination: January 12, 2016.
7. Latifat Adebisi Abimbola, M.Phil Dissertation: Existence of Solutions of Impulsive Quantum Stochastic Differential Inclusions. Date of Examination. June 7, 2017.
8. Sikiru Adetona Ajibola, PhD Thesis: Qualitative properties of solutions of a class of quantum stochastic partial differential equations. Date of Examination: March 20, 2018.
9. Titilayo Akinwumi, PhD Thesis: Existence of Viable Solutions of Quantum Stochastic Differential Inclusions. Date of Examination: March 20, 2018.
10. Taiwo Faniran: PhD Thesis: Mathematical Modeling of the Effects of Non-Drug Compliance on Transmission Dynamics of Malaria-Typhoid Co-Infection. Date of Examination: March 21, 2018.
11. Adeyemi Akeju: PhD Thesis: Malliavin Calculus Approach to Pricing and Hedging of Options with More than One Assets. Date of Examination: March 29, 2021.
12. Michael Adeyemo: PhD Thesis: Brinkman-Forchheimer Equations in Homogenous Sobolev Spaces. Date of Examination: March 29, 2021.
13. Latifat Adebisi Abimbola, PhD thesis: Mild Solutions of Evolution Quantum Stochastic Differential Inclusions. Date of Examination. December 30, 2021.
14. Dauda Alani Dikko, PhD Thesis: Topological Solutions of Quantum Stochastic Differential Inclusions. Date of Examination December 30, 2021.
15. Hellen Oluyemisi Emeka, PhD Thesis: Systemic Risk in Financial Networks in the Banking System in Nigeria. Date of Examination: July 16, 2024. Lecturer at Afe Babalola University, Ado Ekiti.

All of these former M. Phil and PhD students have excelled themselves in their professional career, three of them have been elevated to position of Professor (Numbers 1, 2 and 3).

ON GOING SUPERVISION AT PHD LEVEL:

I am currently serving as supervisor of the following five doctoral students. Three of them have reached advance stages.

1. Mr Kolawole T.Ijaduola,- Aproximations of solutions of quantum stochastic differential equations and inclusions driven by basic operators in quantum field theory.
2. Mr Adams Salawu- Quantum Computing Applied to Quantum Stochastic Differential Equations.

I have served as internal-external examiner for many conversion examinations of MPhil/PhD to PhD registration in Physics and Statistics Departments.

I have served as internal-external examiner for many successful PhD examinations in Statistics Department, Physics, Mechanical Engineering, Petroleum Engineering and Computer Science Departments, University of Ibadan.

I have served as publication assessors for many professorial candidates in Nigeria and Ghana.

Research Grants/Supports Attracted for Research

1. University of Ibadan Advancement Board Multidisciplinary Research Grant of ₦1,500,000.00 for Production of Algal Oil –based Biodiesel using a Micro-reactor, granted on July 9, 2009.
2. 2010 Senate Research Grant No. SRG/FS/2010/4c of N 1,000,000.00 of July 25, 2012.
3. Many other small Senate Research grants awarded between 1999 and the year 2010.
4. Sponsorship of the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy for diverse conferences and research at the Centre.
5. Sponsorship of the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy for Postdoctoral Studies, 2000/2001.
6. Sponsorship of the Abdus Salam International Centre for Theoretical Physics as Junior and Regular Associate of the Centre.
7. Sponsorship of the Swedish Institute for Guest Scholarship, 2004/2005, at Chalmers University of Technology, Goteborg and Conference sponsorship at University of Alabama, Birmingham, USA.
8. Sponsorship of the Department of Pure Mathematics and Applied Mathematics, University of Pretoria, South Africa, for research visit to the University, Nov/Dec 2006.
9. Sponsorship of the Winston Salem State University, Winston Salem, NC, USA for research visit to the University, April, 2005.
10. Simulation on Quantum Computers and Approximation of Solutions of Quantum Stochastic Differential Equations, Quantum Flows and Application. Research Grant of N2million made by the Nigerian Tertiary Education Trust Fund (TETFUND IBR 2018)
11. Pastor E.A. Adeboye Chair sponsored research in Mathematics, Feb 2021 to Jan 31, 2022.

• PROFESSIONAL ACCOMPLISHMENTS

1. Junior Associate, The Abdus Salam International Centre for Theoretical Physics (ICTP) Trieste, Italy, January 1991 - December 1994 (in Support of Postgraduate Research).
2. The Abdus Salam ICTP Postdoctoral Research Fellowship in Mathematics - October 2000 - September 2001.

3. Regular Research Associate, The Abdus Salam ICTP, Trieste, Italy, January 1, 2003 – December 31, 2010.
4. Swedish Institute Guest Scholarship for Research, School of Mathematical Sciences, Chalmers University of Technology, Goteborg, Sweden, November 1, 2004 - July 31, 2005.
5. Visiting Professor, Department of Mathematics and Applied Mathematics, University of Pretoria, Pretoria, South Africa, November 27, 2006 - December 11, 2006.
6. Visiting Scientist, Mathematics Department, Olabisi Onabanjo University, Ago Iwoye, Oct 2001 - August 30, 2002.
7. Visiting Professor, Department of Mathematics, Federal University of Agriculture, Abeokuta, December 1, 2014-November 30, 2016.
8. Reviewer, Journal of Mathematical Analysis and Applications.
9. Reviewer, Nigerian Journal of Science.
10. Reviewer, Journal of the Nigerian Association of Mathematical Physics.
11. Reviewer, Mathematical Reviews (MR) published by the American Mathematical Society, Print and Digital Versions (MATHSCINET).
12. Member, and on many occasions, Chairman, National Universities Commission (NUC) Science and Mathematics Program Accreditation team to the following universities:
 - Federal University of Technology, Effurun, Warri, Delta State,
 - Federal University of Technology, Minna, Niger State,
 - Ibrahim Badamosi University, Lapai, Niger State,
 - National Open University, Lagos
 - Ondo State University of Technology, Okitipupa, Ondo State,
 - Godfrey Okoye University all during the period 2011-2013.
 - Chairman, NUC Science Accreditation team to Federal University of Technology, Effurun, Delta State, December 8-12, 2014.
 - Chairman, NUC Science Accreditation team to National Open University of Nigeria, Lagos, March 16-March 20, 2015.
 - Chairman, NUC Mathematics Accreditation team to University of Nigeria, Nsukka, Nnamdi Azikiwe University, and Chukwuemeka Odimegu Ojukwu University, Uli, Anambra State, Nigeria, December 7- 15, 2016.
 - Chairman, NUC Mathematics Accreditation team to Benue State University, Makurdi, March 4-8, 2017.
 - Member, NUC Statistics Accreditation team to University of Agriculture, Makurdi, Benue State, June 6-8, 2018.
 - Chairman, NUC Mathematics Accreditation team to Adamawa State University, Mubi, October 28-30, 2018.
13. Visiting Professor, Mathematics Department, Federal University of Agriculture, Abeokuta, December 1, 2014 – November 30, 2016.

14. Associate Lecturer (Professor Status), Mathematics Department, Federal University of Agriculture, Abeokuta, 2016- 2017.
15. Pastor E. A. Adeboye Professor of Mathematics, University of Ibadan, Feb 1, 2021
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▪ **CONFERENCES, SEMINARS AND WORKSHOP ATTENDED WITH DATES**

- Annual Conference of Nigerian Mathematical Society, 1997 - to date.
- Conference on Ordinary Differential Equations, National Mathematical Centre, Abuja, 28-30 July, 2000.
- The Abdus Salam International Centre for Theoretical Physics, Italy, Mathematics Seminar, June 18, 2001.
- School and Workshop on Dynamical Systems, The Abdus Salam ICTP, Italy, 30 July - 17 August 2001.
- Summer School on Mathematical Control Theory, The Abdus Salam ICTP, Italy, 3 - 28 September, 2001.
- International Workshop on Modeling Bio-Medical Signals, Physics Department, University of Bari, Italy, 20 - 22 September, 2001.
- School and Conference on Probability Theory, The Abdus Salam ICTP, Italy, 13-31 May, 2002.
- RAMAD International Conference on Bio-Mathematics, Bamako, Mali, 01 - 13 July, 2002.
- Workshop on Modeling in Life and Material Sciences and in Technology, The Abdus Salam ICTP, Trieste, Italy, 8 March - 2 April, 2004.
- Web Enabling Technologies and Strategies for Scientific e - Learning, The Abdus Salam ICTP, Trieste, Italy, 14 - 23 April, 2004.
- First Research Visit to the Abdus Salam ICTP, Trieste, Italy as ICTP Regular Associate, March 8 - June 12, 2004.
- International Conference on Differential Equations and Mathematical Physics, Department of Mathematics, University of Alabama at Birmingham, USA, March 29 - April 2, 2005.
- Second Research Visit to the Abdus Salam ICTP, Trieste, Italy, as ICTP Regular Associate, August 20 - November 17, 2006.
- Visiting Professor, Department of Mathematics and Applied Mathematics, University of Pretoria, Pretoria, South Africa, November 27, 2006 - December 11, 2006.
- Annual Meeting, Nigerian Mathematical Society, Department of Mathematics, University of Ado Ekiti, Nigeria, July 10-12, 2011.
- Joint Annual Meeting, American Mathematical Society, Hyne Convention Center, Boston, January 4 - 11, 2012. Workshop in Stochastic Analysis and Applications.
- Annual Meeting, Nigerian Mathematical Society, Ahmadu Bello University, Zaria, Nigeria, October 2-5, 2012.
- Nigerian Association of Mathematical Physics, Redeemer University, Mowe, November 6-9, 2012.

- Annual Meeting, Nigerian Mathematical Society, Department of Mathematics, Obafemi Awolowo University, Ile-Ife, 26-28 June, 2013.
- Workshop for Improving Mathematics Teaching and Learning in Secondary Schools, organized under the auspices of Pastor E.A. Adeboye Professorial Chair in Mathematics, University of Ibadan, Tuesday March 25, 2014.
- Nigerian Association of Mathematical Physics, Olabisi Onabanjo University, Ago Iwoye, November 5-7, 2014.
- The Seventh International Conference on Dynamic Systems and Applications & The Fifth International Conference on Neural, Parallel, and Scientific Computations, Department of Mathematics, Morehouse College, Atlanta, Georgia, USA, May 27-30, 2015.
- International Conference in Honour of GOS Ekhaguere at 70, May 22-25, 2017, University of Ibadan Conference Center, Ibadan, Nigeria.
- CIMPA Research School on Combinatorial and Computational Algebraic Geometry, University of Ibadan, June 11-24, 2017.
- The Second Conference, West African Women in Mathematics, Department of Mathematics, University of Ibadan, June 25-27, 2018
- **ADMINISTRATIVE EXPERIENCE:**
 1. Member Representing Senate, University of Ibadan Governing Council: Jan 2, 2011 – July 31, 2011
 2. Member Representing Senate, University of Ibadan Governing Council: August 1, 2011 – July 31, 2015.
 3. Member, Representing Senate, University of Ibadan Governing Council: August 1, 2015 – July 31, 2019 (2nd and Final Term).
 4. Head, Department of Mathematics, University of Ibadan October 2, 2009 to July 31, 2014.
 5. Council Representative on University of Ibadan Senior Staff Disciplinary Committee, August 1, 2011 to date.
 6. Member, University of Ibadan Project and Procurement Committee of Council, January 2, 2011 to date.
 7. Member, University of Ibadan Appeal and Petition Committee of Council, January 2, 2011 to July 31, 2019.
 8. Member, University of Ibadan Project Monitoring Committee of Council, January 2, 2011 to July 31, 2019.
 9. Council Representative, Board of the Institute of Education, University of Ibadan, Jan 2011- July 31, 2015.
 10. Chairman, University of Ibadan Budget Implementation and Monitoring Committee (BIC) of Governing Council, January 2, 2012 to November, 2017.
 11. Member, The NEEDS Assessment/Revitalization Committee, University of Ibadan, June 2, 2014 to July 31, 2019.
 12. Chairman, University of Ibadan Administrative Investigation Committee on Ad Hoc Staff, April 12, 2011 – December 31, 2011.

13. Convener/Chairman Panel O of the Senior Staff Disciplinary Committee, University of Ibadan, May 17, 2012 to date.
14. Hall Master, Nnamdi Azikiwe Hall, University of Ibadan, January 1, 2013 to Dec 31, 2019.
15. Member, Joint Senate/Council Development Committee, August 2015 to July 31, 2019.
16. Member, Council Committee on Internally Generated Revenue, August 2015 to July 31, 2019.
17. Chairman, Council Committee on Computerization of the Bursary, Audit units, August 2015 to July 31, 2019.
18. Member, Council Project Committee, Jan 2011 to July 31, 2019.
19. Member, Finance and General Purpose Committee of Council, August 2015 to July 31, 2019.
20. Member, Council Committee on Honorary Degrees, Jan 2011 to July 31, 2019.
21. Assistant Hall Warden, Tedder Hall, University of Ibadan, June 1, 1999 to September 30, 2001.
22. Hall Warden, Tedder Hall, University of Ibadan, October 1, 2005 to November 30, 2009.
23. Departmental Representative, Faculty Admission Committee, 1989-90.
24. Departmental Representative, LTTS Committee, 1990-92.
25. Faculty Send-Off Committee, 1992-93.
26. Member, Faculty Security Committee, 1992-93.
27. Departmental Representative at the Faculty Board of Arts, 1993-1996.
28. Chairman, Departmental ICT Committee, 1999 to 2002.
29. Member, Committee of Hall Wardens, University of Ibadan, October 1, 2005 to Nov.30, 2009.
30. Congregation Representative in Senate, University of Ibadan, August 2000 - July 2002, August 2005 to November 30, 2009.
31. Statutory Member of UI Senate, December 2010 till date.
32. Departmental Postgraduate Coordinator, October 2002 - October 2004.
33. Faculty Representative on Faculty of Science Appointment and Promotion Committees, 2003/2004, 2007/2008 and 2008/2009 Sessions.
34. Senate Representative, Board of Distance Learning, 2007/2008 Session.
35. Senate Representative, Board of the Institute of Education, 2007/2008 Session.
36. Member, Finance Committee, Distance Learning Centre, 2007/2008.
37. Member, Finance Committee, Faculty of Science, 2008/2009 Session.

1. SOME RELEVANT INFORMATION

- Most of my academic publications have been reviewed and indexed in popular research data bases such Scopus as the well - known Mathematical Reviews published by the American Mathematical Society (AMS) (see for example: <https://mathscinet.ams.org/mrlookup>), and the Thomson ISI web of Science.
- The web presence of my research is also significant as indicated in the Google Scholar website. https://scholar.google.com/citations?view_op=search_authors&mauthors=E.O.+Ayoola&hl=en&oi=ao.

- **MATHEMATICIAN OF THE AFRICAN DIASPORA:**

I am mentioned in Professor Scott Williams' web pages on Mathematicians of the African Diaspora, (http://www.math.buffalo.edu/mad/PEEPS/ayoola_ezekielo.html) created to exhibit the accomplishments of the people of Africa and the African Diaspora within the Mathematical Sciences. My articles have attracted a significant citations on the Google scholar.

16. EXTRA CURRICULAR ACTIVITIES

1. Patron, MFM Campus Fellowship, University of Ibadan, 2002 to date.
2. Zonal Pastor, Mountain of Fire and Miracles Ministry, 32 Salami Estate, Bodija, Ibadan, Nigeria, March 1, 2013 to July 31, 2017.
3. Regional Overseer, Mountain of Fire and Miracles Ministries, Region 32, Tent Makers Pastoral Ministry, Mount Zion Region, Ibadan. August 1, 2017 – March 24, 2020.
4. Regional Overseer, Mountain of Fire and Miracles Ministries, SW Region 5, Tent Makers Pastoral Ministry, City of Mercy, Ibadan. March 25, 2020 till date.
5. Reading, Jogging, Christian Music, Prayers and Ministration

17. PUBLICATIONS

Dissertations and Thesis:

- (a) AYoola, E.O. (1988). Solution of an Elliptic Boundary Value Problem on Polygonal Domain by Fredholm Theory. **M.Sc. Dissertation, Department of Mathematics, University of Ibadan.**
- (b) AYoola, E.O. (1999). On Numerical Procedures for Solving Lipschitzian Quantum Stochastic Differential Equations. **Ph.D. Thesis, Department of Mathematics, University of Ibadan.**

BOOK PUBLICATIONS

- [1] AYoola, E. O. (2008): MAT 351: Numerical Analysis, Theory and Computations, **Ibadan Distance Learning Centre Series in Mathematics**, Publisher: **Distance Learning Centre, University of Ibadan**, 140 pages. ISBN 928-021-355-4.
- [2] AYoola, E. O. (2014): MAT 241: Ordinary Differential Equations and Applications (2nd Edition) **Ibadan Distance Learning Centre Series in Mathematics**, Publisher: **Distance Learning Centre, University of Ibadan**, 155 pages.
- [3] AYoola, E. O. (2014): MAT 405: Advanced Analysis I: Measure Theory and Integration, **Ibadan Distance Learning Centre Series in Mathematics**, Publisher: **Distance Learning Centre, University of Ibadan**, 106 pages.
- [4] AYoola, E. O. (2014): MAT 406: Advanced Analysis II: Functional Analysis, **Ibadan Distance Learning Centre Series in Mathematics**, Publisher: **Distance Learning Centre, University of Ibadan**, 114 pages.

CONFERENCES

[1] Existence and uniqueness of solutions of a class of quantum stochastic partial differential equations. Workshop on Stochastic Analysis and Applications, **Seventh International Conference on Dynamic Systems and Applications, Morehouse College, Atlanta, Georgia, May 27-30, 2015.**

[2] **Computation of approximate solutions of a class of quantum stochastic differential inclusions. 2023 Quantum Conference on Computing, Baba Farid College, Bathinda, India, Feb 8-11, 2023.**

ARTICLES IN LEARNED JOURNALS:

- [1] AYoola, E.O. (1998). Solutions of Lipschitzian quantum stochastic differential equations in a locally convex space. **Journal of Science Research, Faculty of Science, University of Ibadan, Vol. 4, No. 1, 15 - 23.**
- [2] AYoola, E.O. (1999). Discrete approximations of weak solutions of a class of quantum stochastic evolution equations. **Journal of Science Research, Faculty of Science, University of Ibadan, Vol. 5, No.1, 17 - 24.**
- [3] AYoola, E.O. (1999). Error estimations in the Gauss and Newton Cotes quadrature schemes for weak solutions of quantum stochastic differential equations. **Journal of the Nigerian Association of Mathematical Physics, Vol. 3 No. 1, 12-35.** Publisher: NAMP, Benin City, Nigeria.
- [4] AYoola, E.O. (2000). Converging multistep schemes for weak solutions of quantum stochastic differential equations. **Stochastic Analysis and Applications, Vol. 18, No. 4, 525 - 554.** Publishers: Taylor & Francis Group. Mathematical Review: MR 2001e:81065,
- [5] AYoola, E.O. (2000). Convergence of general multistep schemes for weak solutions of quantum stochastic differential equations. **Proceedings of the National Mathematical Centre - Ordinary Differential Equations - Vol. 1, No.1, 43 - 55.** Publishers: NMC, Abuja, Nigeria. MR: 2004e:81072.
- [6] AYoola, E.O. (2001). On Convergence of one-step schemes for weak solutions of quantum stochastic differential equations. **Acta Applicandae Mathematicae, Vol. 67, No. 1, 19 - 58.** Publishers: Springer Science. Mathematical Review: MR 2002f: 65017,
- [7] AYoola, E.O. (2001). Lipschitzian quantum stochastic differential equations and the associated Kurzweil equations. **Stochastic Analysis and Applications, Vol. 19, No. 4, 581-603.** Publishers: Taylor & Francis Group Mathematical Review: MR: 2002g: 81078
- [8] AYoola, E.O. (2001). Construction of approximate attainability sets for Lipschitzian quantum stochastic differential inclusions. **Stochastic Analysis and Applications, Vol. 19, No. 3, 461 - 471.** Publishers: Taylor & Francis Group. Mathematical Reviews: MR 2002f:65018.
- [9] AYoola, E.O. (2002). Lagrangian quadrature schemes for computing weak solutions of quantum stochastic differential equations. **SIAM Journal on Numerical Analysis, Vol. 39, No. 6, 1835 - 1864.** Publishers: SIAM Publications, Philadelphia, USA. Mathematical Review: MR: 2003e: 60121.

- [10] AYoola, E. O. (2002). On Computational procedures for weak solutions of quantum stochastic differential equations. **Stochastic Analysis and Applications, Vol. 20, No. 1, 1 - 20.** Publishers: **Taylor & Francis Group**. Mathematical Review: **MR: 2002m: 81124.**
- [11] AYoola, E. O. (2002). Existence and stability results for strong solutions of quantum stochastic differential equations. **Stochastic Analysis and Applications, Vol. 20, No. 2, 263 - 281.** Publishers: **Taylor & Francis Group** Mathematical Review: **MR: 2003b: 6008.**
- [12] AYoola, E. O. (2003). Exponential formula for the reachable sets of quantum stochastic differential inclusions. **Stochastic Analysis and Applications, Vol. 21, No. 3, 515 - 543.** Publishers: **Taylor & Francis Group** Mathematical Review: **MR 2004e: 81073.**
- [13] AYoola, E.O. (2003). Error Estimates for discretized quantum stochastic differential inclusions. **Stochastic Analysis and Applications, Vol. 21, No. 6, 1215 - 1230.** Publishers: **Taylor & Francis Group** Mathematical Review: **MR: 2005a: 60109,**
- [14] AYoola, E. O. (2004). On the properties of weak solutions of Lipschitzian quantum stochastic differential equations. **Journal of the International Centre for Mathematical and Computer Sciences, (ICMCS, Lagos, Nigeria.), Vol. 1. 361-369.** Publishers: **ICMCS Publications, Lagos, Nigeria.** Mathematical Review: **MR: 2005j:00013.**
- [15] AYoola, E. O., GBOLAGADE, A.W. (2004). On the existence of Weak Solutions of Quantum Stochastic Differential Equations. **Journal of the Nigerian Association of Mathematical Physics, Vol. 8 (2004), 5-8. MR: 2007i: 81131.**
- [16] AYoola, E. O. (2004). Continuous selections of solution sets of Lipschitzian quantum stochastic differential inclusions. **International Journal of Theoretical Physics Vol. 43, No. 10 , 2041 – 2059.** Publishers: **Springer Science, The Netherlands.** Mathematical Review: **MR: 2005i: 81076..**
- [17] AYoola, E. O. and GBOLAGADE, A. W (2005) Further results on the existence, uniqueness and stability of strong solutions of quantum stochastic differential equations. **Applied Mathematics Letters. Volume 18, 219 - 227.** Publishers: **Elseviers Science, USA.** Mathematical Review: **MR: 2005m:81179.**
- [18] AYoola, E. O; ADEYEYE, JOHN: (2007) Continuous interpolation of solution sets of Lipschitzian quantum stochastic differential inclusions. **Journal of Applied Mathematics and Stochastic Analysis, Volume 2007 (2007), Article ID 80750, 12 pages, doi: 10.1155/2007/80750.** Publishers: **Hindawi Publishers, New York, USA. AMS Mathematical Review: 2008m: 65012.**
- [19] ATONUJE, A. O; AYoola, E. O. (2007): On noise contribution to the oscillatory behavior of solutions of stochastic delay differential equations. **Journal of the Institute of Mathematics and Computer Sciences (Computer Science Series), Volume 18, No.2, 51 – 59.** Publishers: **Indian Mathematics Institute, India. AMS Mathematical Review Number: MR 2387478.**
- [20] AYoola, E. O: (2007): On the properties of Continuous selections of solution and reachable sets of quantum stochastic differential inclusions. **Journal of the Nigerian**

Association of Mathematical Physics, Vol. 11, 71 - 82. Publishers: **Nigerian Association of Mathematical Physics.**

- [21] AYoola, E. O (2008): Further results on the existence of continuous selections of solution sets of quantum stochastic differential inclusions. **Dynamic Systems and Applications, Volume 17, 609 - 624.** Publishers: **Dynamic Publishers, Atlanta, Georgia, USA.** AMS Mathematical Review: MR 2011d:81177.
- [22] AYoola, E. O. (2008): Quantum stochastic differential inclusions satisfying a general Lipschitz condition. **Dynamic Systems and Applications, volume 17, 487-502.** Publishers: **Dynamic Publishers, Atlanta, Georgia, USA).** AMS Mathematical Review: MR: 2011d: 81176.
- [23] AYoola, E. O. (2008): Topological properties of solution sets of Lipschitzian quantum stochastic differential inclusions. **Acta Applicandae Mathematicae, Volume 100, Number 1, 15 - 37.** Publishers: **Springer Science + Business Media.** AMS Mathematical Review: 2008k: 81174.
- [24] NJOSEH, IGNATIUS N.; AYoola, EZEKIEL O. (2008): Finite element method for a strongly damped stochastic wave equation driven by space - time noise. **Journal of Mathematical Sciences, Volume 19, Number 1, 61 - 72.** Publishers: **International Center for Advance Studies, Dattapukur, India.** AMS Mathematical Review: MR 2009e: 65016.
- [25] ATONUJE, A.O.; AYoola, E. O. (2008): On the complementary roles of noise and delay in the oscillatory behavior of stochastic delay differential equations. **Journal of Mathematical Sciences, Volume 19, Number 1, 11-20.** Publishers: **International Center for Advance Studies, Dattapukur, India.** AMS Mathematical Review: MR 2009h: 60103.
- [26] ATONUJE, A.O.; AYoola, E. O. (2008): Oscillation in solutions of stochastic delay differential equations with real coefficients and several constant time lags. **Journal of the Nigerian Association of Mathematical Physics, Volume 13, November 2008, 87 -94.** Publisher: **Nigerian Association of Mathematical Physics, Nigeria.**
- [27] NJOSEH, IGNATIUS N., AYoola, EZEKIEL O. (2008): On the Finite Element Analysis of the Stochastic Cahn-Hilliard Equation. **Journal of Institute of Maths & Comp. Sci (Maths Series) Vol.21 No. 1, 2008) 47-53.** AMS Mathematical Review: MR 2009h: 60114.
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SOME SIGNIFICANT INVITED TALKS

- [1] AYoola, E.O: (2006): Noncommutative quantum formulation of classical stochastic differential equations, quadrature solutions and applications to financial mathematics. An invited seminar paper presented as a Visiting Professor at the **Department of Mathematics and Applied Mathematics, University of Pretoria, South Africa, Monday, December 4, 2006, 18 pages.**
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18. MAJOR TECHNOLOGICAL INNOVATION/INVENTION/PROJECTS COMPLETED

Research Projects Completed: I have completed the following projects:

- ✓ Establishment of solutions of a class of elliptic boundary value problems on polygonal domains by Fredholm theory.
- ✓ Existence results for various classes of quantum stochastic differential equations having solutions in a locally convex space endowed with a weak topology generated by a family of seminorms defined on the space of quantum stochastic processes. These are accomplished

within the framework of Hudson-Parthasarathy formulations of quantum stochastic calculus.

- ✓ Introduction and study of a number of numerical schemes for approximating weak solutions of a class of quantum stochastic differential equations.
- ✓ Establishment of the existence and stability of strong solutions of Lipschitzian quantum stochastic differential equations.
- ✓ Applications of stochastic analysis for solving portfolio problems, calculation of derivative pricing and finding values at risks in mathematical finance.
- ✓ Introduction and study of Kurzweil equations associated with a class of quantum stochastic differential equations in the framework of the Hudson-Parthasarathy formulation of quantum stochastic calculus.
- ✓ Construction of approximate attainability sets for Lipschitzian quantum differential inclusions (LQDI).
- ✓ Establishment of an exponential formula for the reachable sets of quantum stochastic differential inclusions.
- ✓ Development and analysis of approximate solutions for LQDI and their error estimates.
- ✓ Establishment and applications of the existence of continuous selections of solution sets of Lipschitzian quantum stochastic differential inclusions.
- ✓ Existence of solutions of impulsive Quantum Stochastic Differential Inclusions,
- ✓ Value at Risks in Financial Returns
- ✓ Financial Options via the Malliavian calculus.

Accordingly, the following specific and major breakthroughs have been achieved:

DEVELOPMENT OF NUMERICAL SCHEMES FOR QSDE/QSDI

On numerical procedures for solving QSDE, I have developed for the first time and published a number of new results concerning operator discrete schemes such as multistep schemes, one step schemes, Runge - Kutta and one step integral schemes when the coefficients are smooth enough and for the case when the coefficients satisfy general Caratheodory conditions. These schemes are extensions of the analogous schemes in the classical context to the present noncommutative case involving QSDE defined in infinite dimensional locally convex spaces. Results have appeared in the prestigious journal: **Acta Applicandae Mathematicae, 2001** see [11].

Several benefits are associated with these schemes. An important benefit is the complete elimination of the need for additional burden of simulation of random increments of the driving process as obtained in the implementation of stochastic Taylor schemes for classical Ito SDE. There are no correction terms in the limit as in the case of Wong - Zakai approximation of classical SDE. As demonstrated in my publication [11], computation of the discrete solutions are done in the same way as for classical initial value problems.

My further contribution is the establishment of the Lagrangian quadrature schemes for computing weak solutions of QSDE. The theory of Chebyshev minimax best approximation was employed to establish the quadrature algorithm. Precise error estimate was given in the case when the zeroes of

Chebyshev polynomials are chosen as discretization nodes. The result of this work appeared in the prestigious **SIAM Journal on Numerical Analysis**, 2002, publication [14] above.

Further contributions involved the establishment of numerical procedure for QSDI. Since our discrete schemes for QSDE require continuity of the coefficients at least in the state variables, numerical approximations for discontinuous QSDE are established via the QSDI since discontinuous QSDE can be reformulated in some sense as QSDI with regular coefficients. To this end, I have established some error estimates by employing the averaged modulus of continuity associated with the coefficients of the QSDI. I have also established an exponential formula for the reachable sets. The formula has been found useful for approximation of the reachable sets. These contributions appeared in the well - known **Stochastic Analysis and Applications** published by Taylor and Francis. See publications [13, 15, 17, 18].

- **EXTENSION OF KURZWEIL–HENSTOCK INTEGRATION TO QUANTUM STOCHASTIC CALCULUS**

I have also made a major contribution to scholarship by extending the classical theory of Kurzweil-Henstock integral calculus to quantum stochastic analysis. I have extended the well-known equivalence relationship between Kurzweil - Henstock integrals and the Lebesgue integrals to quantum stochastic integrals under some suitable conditions in the framework of Hudson – Parthasarathy quantum stochastic calculus. The extension facilitates the proof of the equivalence of Lipschitzian QSDE and its associated Kurzweil equation. By using the associated Kurzweil equation, I established the numerical approximation of QSDE whose coefficients satisfy pure Caratheodory conditions. This is the first time such extension will be done in the literature. Jointly with my former PhD student, Bishop, S.A, we also published results on variational stability of Kurzweil equations associated with QSDE and its converse. See publications [12, 42, 43].

- **EXISTENCE OF STRONG SOLUTIONS OF QSDE**

Furthermore, I have established the existence, uniqueness and stability of strong solutions of QSDE under a Lipschitz type condition. Extension of the results to the case of QSDE satisfying a general Lipschitz condition was undertaken jointly with Gbolagade, A. W. Our results show that QSDE with continuous coefficients are Lipschitzian in a general sense. This idea has been extended to the establishment of the existence of solutions of Quantum stochastic differential inclusions (QSDI) that satisfy a general Lipschitz condition. The general Lipschitz condition considered here generalized Ekhangere's approach in his pioneering paper of 1992 in this field. I successfully formulated and proved a theorem on the non-uniqueness of solutions and some bounds for the derivatives of the matrix elements of solutions for the present case of the general Lipschitz condition. These results were published by the well- known **Stochastic Analysis and Applications, Applied Mathematic Letters and Dynamic Systems and Applications** See publications [16, 22, 27].

- **CONTINUOUS SELECTIONS OF SOLUTION SETS**

Another very important contribution is the establishment of a continuous selection of a multifunction associated with the set of solutions of Lipschitzian QSDI. As a corollary to the main result, I proved that the solution set map and the reachable set admit some continuous representations. A follow up

result has also been published. This concerns the establishment of a continuous selection of the set of solutions to Lipschitzian QSDI, defined directly on the locally convex space of stochastic processes with values in the space of adapted weakly absolutely continuous solutions. As a corollary, I proved that the reachable set multifunction admits a continuous selection. See publications [21, 26]

Furthermore, jointly with John Adeyeye, we have established that given any finite set of trajectories of a Lipschitzian QSDI, there exists a continuous selection from the complex valued multifunction associated with the solution set of Lipschitzian QSDI interpolating the matrix elements of the given trajectories. This result extends my previous result that concerns only one matrix elements of solutions into a finite number of them. In addition, some bounds in the seminorm of the locally convex space of solutions, for the difference of any two of such trajectories were also established. Results appeared in the **Journal of Applied Mathematics and Stochastic Analysis** [23].

- **TOPOLOGICAL PROPERTIES OF SOLUTIONS OF QSDI**

In continuation of my research work on QSDI, I have established some topological properties of solution sets of QSDI. These properties have been published by a leading Mathematics Springer journal: **Acta Applicandae Mathematicae** [28]. A continuous mapping of the space of the matrix elements of an arbitrary nonempty set of quasi solutions of Lipschitzian QSDI into the space of the matrix elements of its solutions was established. This consequently facilitated the establishment of the space of the matrix elements of solutions as an absolute retract. It was further established that the space is contractible and connected in some sense. As a corollary, a generalization of my previous selection result was furnished by removing the requirement of compactness of the domain of the selection map. See publication [28].

Jointly with my former PhD student, Michael Ogundiran, we studied the Mayer problems for optimal quantum stochastic control. Some significant and interesting results were published in the well-known **Journal of Mathematical Physics** [34]. Interesting existence results on directionally continuous quantum stochastic differential equations, upper semicontinuous quantum stochastic differential inclusions via Kakutani- Fan fixed point theorem were obtained and published. We have also applied Michael selection theorem for establishing selections of solution multifunction associated with quantum stochastic differential inclusions and the establishment of the existence of Caratheodory solution of quantum stochastic differential inclusions under appropriate conditions. See publications [35, 36, 38,39, 40, 41].

- **OSCILLATORY BEHAVIOURS OF SOLUTIONS OF STOCHASTIC DELAY DIFFERENTIAL EQUATIONS**

My contributions in this area concern some qualitative and numerical aspects of classical stochastic differential equations driven by Brownian motions. Jointly with my former doctoral student A.O. Atonuje, we have published some results concerning the non- contribution to the oscillatory behaviour of solutions of stochastic delay differential equations (SDDE). We have proved that even when non-oscillatory solutions exist in the corresponding deterministic delay differential equation, the presence of noise perturbation stimulates an oscillation subject to certain conditions on the delay terms. Furthermore, we have recently shown that in the absence of the noise term, non - oscillatory solutions can occur for the deterministic case. But with the presence of noise, all

solutions of SDDE oscillate almost certainly whenever the feedback intensity is negative. See publications [24, 30, 31]

Furthermore, jointly with my former doctoral student I. N. Njoseh, we have published some results on the finite element method for a strongly damped stochastic wave equation driven by a space - time noise. We provided some error estimates of optimal order for semi discrete and fully discrete finite elements schemes by using L_2 -projections of the initial data as starting values. Please see publication [32,33].

- **CONTRIBUTIONS TO MATHEMATICS OF FINANCE/STATISTICAL MODELING**

A very important area of mathematical research where stochastic analysis has found applications is mathematical finance. My research in this area concerns the study and applications of value-at-risk measurements to some financial returns in Nigerian stock market. Some results have been published in this area jointly with my former PhD student- Dr Kehinde Adelegan. Also with another research student, Mr Akeju, A.O, we have published some results on the Verhult- Logistic Brownian Motion statistical model for pricing options on multiple assets, see [44, 45, 46].

- **CONTRIBUTIONS TO QUANTUM STOCHASTIC PARTIAL DIFFERENTIAL EQUATIONS**

A major breakthrough concerning the formulations and prove of the existence of solutions Of a class of quantum stochastic partial differential equations has been established in a locally convex space whose topology was generated by a strong family of seminorm. See publication [48, 49].

- **CONTRIBUTIONS TO IMPULSIVE QUANTUM STOCHASTIC DIFFERENTIAL INCLUSIONS**

My major contributions together with my doctoral students concern nontrivial proofs of the existence of solutions of diverse kinds of impulsive quantum stochastic differential inclusions with or without local conditions. Results have appeared in the Springer published journal [45, 47, 48].

- **CONTRIBUTION TO VIABILITY THEORY OF QUANTUM STOCHASTIC DIFFERENTIAL INCLUSIONS**

My recent research together with my former PhD student Akinwumi, Titilayo, concerns the establishment of viable solutions of QSDI that are Lipschitzian and those whose coefficients are lower and upper semicontinuous. Some of our recent results have appeared in publications [51, 52].

- **MATHEMATICAL MODELLING**

Multidisciplinary collaborative research in the study of global and sensitivity analysis of unconcerned COVID-19 cases. This has been reported in publication [53].

CURRENT RESEARCH DIRECTION.

They concern:

- A. Further Development of Qualitative and quantitative properties of solutions of Quantum stochastic Differential Equations and Inclusions (Ordinary and Partial),**
- B. Applications of Quantum Computing for Solving QSDE/Inclusion.**

c. Mathematical Modelling of Insurgency and Counter-Insurgency in asymmetric military warfare and social security.

The research shall involve modelling insurgency and counter-insurgency (COIN) operations with a large-scale system of differential equations and a dynamically changing coalition network peculiar to the Nigerian security system.

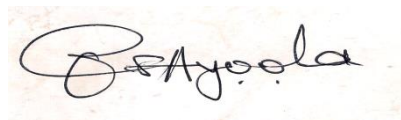
These structures will be used to analyze the components of leadership, promotion, recruitment, financial resources, operational techniques, network communications, coalition cooperation, logistics, security, intelligence, infrastructure development, humanitarian aid, and psychological warfare, with the goal of informing relevant Nigerian decision makers of the options available in COIN tactics, operations, and strategy.

It is well known that in modern conflicts, techniques of asymmetric warfare wreak havoc on the inflexible, regardless of technological or numerical advantage. In order to be more effective, our military forces must improve its COIN capabilities and flexibility to match the adaptability and rapid time-scales of insurgent networks and terror cells. Our simulation model shall combine elements of traditional differential equation force-on-force modeling with modern social science modeling of networks, and coalition cooperation to build a framework that can inform various levels of military decision makers in order to understand and improve COIN strategy.

The research will first demonstrate a test scenario of several stages of COIN operation to show how the model behaves and how it could be used to decide on effective COIN resources and strategies in Nigeria.

The second stage of the research will involve elements of uncertainties and randomness in the Model parameters. Applications of numerous results in stochastic calculus and analysis will be imperative at this level since modern asymmetric military warfare are often uncertain and unpredictable.

SIGNATURE AND DATE



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