OMB No. 0925-0001 and 0925-0002 (Rev. 10/15 Approved Through 10/31/2018)

BIOGRAPHICAL SKETCH

**DO NOT EXCEED FIVE PAGES**.

NAME: Joseph E. Johnson, Ph.D.

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Distinguished Professor Emeritus

EDUCATION/TRAINING:

| INSTITUTION AND LOCATION | DEGREE  (if applicable) | Completion Date  MM/YYYY | FIELD OF STUDY |
| --- | --- | --- | --- |
| Vanderbilt University | B.A. | 05/1961 | Physics & Math |
| State University of Iowa | M.S. | 05/1964 | Physics |
| Stony Brook University | Ph.D. | 05/1968 | Physics |

# A. Personal Statement

My primary research interest is theoretical physics with specialization in the foundations of relativistic quantum theory using Lie algebras and groups where my initial work developed a new formulation of relativistic position operators and a relativistically covariant formulation of the Foldy-Wouthousen transformation for charged spin ½ particles. Later I found a new method of decomposing the Lie group and algebra for the most general linear n-dimensional transformations into a

n-dimensional scaling algebra and an n(n-1)-dimensional Markov type Lie Algebra. This latter algebra, when restricted using a particular Lie basis, generates all possible continuous Markov transformations (a Markov Monoid (MM)). This MM is instrumental in the study of entropy, information theory, and diffusion. One of my most important discoveries is that the MM Lie algebra is exactly isomorphic to all possible networks. This now allows the power of Lie groups and algebras to link to the theory of Markov transformations, and likewise to the full theory of networks and their classifications including a powerful algorithm for network cluster analysis based upon a model of flows of a conserved entity in a network. I recently developed a methodology for transforming numerical data tables (of entities vs. properties) into a pair of networks (one for entities and one for properties). This allows the full power of my clustering algorithm (now developed in Python) to be applied to cluster identification with medical data, engineering, and other scientific data structures for automated cluster analytics. My $2.5 DARPA funding in 2004-2008 allowed me to make the breakthroughs that use Markov Entropy metrics and clustering for analyzing networks. I just completed the design and development and Python programing of a standardization of for numerical data that integrates a numerical value with its units of measurement, uncertainty, and unlimited metadata tags. This standard is optimal in speed and minimal in code size and also allows parallel processing. I developed this MetaNumber Python Code and was PI of an interdisciplinary team comprised of 18 faculty and 22 graduate students studying its applications in multiple domains ([www.metanumber.com](http://www.metanumber.com) ). I continue my research of integrating information theory, Markov Chain Theory, Lie Algebras, Measurement Theory, MetaNumber (MN) structures, and related concepts. Recently, I developed a method for expressing standard Riemannian Geometry as a generalized Lie Algebra based upon the Heisenberg Lie algebra; then I applied this framework to expressing Einstein’s general theory of relativity and Riemannian Geometry in general in terms of this algebraic structure allowing it to be integrated with the Heisenberg and Poincare Lie Algebras of Quantum Theory as well as Yang Mills’ gauge SU(3) x SU(2) x U(1) Lie Algebras of the Standard Model. I devote my time now to a study of this resulting complex system. My university’s R&D team (the Advanced Solutions Group – [www.asg.sc.edu](http://www.asg.sc.edu) ) developed multiple advanced software systems and I was the sole PI for over 120 grants while at USC totaling $14M between 1992 and 2016 making me one of the highest funded faculty at the university.

1. USC Physics Department Colloquium: “*An Integration of General Relativity and Relativistic Quantum Theory*” (May, 2016).
2. American Physical Society, Salt Lake City, Utah “Clustering and Network Analysis as a Data Analytic Tool” (April, 2016).
3. USC Mathematics Department Seminar “*Integration of General Relativity & Quantum Theory Using a Generalized Lie Algebra*” (May 2017).
4. Other Recent presentations (2002-2017) on Lie Algebras, Network Theory, and Cluster Analysis given at Toulouse, France; Sounio, Greece; Rome, Italy (2); St. Petersburg, Russia; Ankara, Turkey; The Netherlands; Ontario, Canada; NIST in USA; Boston, MA Complexity Conference (2); Santé Fe, NM; University of Utah; Arizona State University; and South Dakota State University.

# B. Positions and Honors

## Positions and Employment

1966-1968 (Summer only) Staff of The Physical Review, Brookhaven National Laboratory, Upton, NY

1966-1968 Instructor, Physics Department, State University of NY at Stony Brook, Stony Brook, NY

1968-1974 Assistant Professor, Physics Department, University of South Carolina (USC), Columbia, SC

1974-1998 Associate Professor (w/Tenure), Physics Department, USC, Columbia, SC

1979-1984 Assistant Dean for Graduate Studies, College of Science and Math, USC, Columbia, SC

1884-1993 Associate Dean for Graduate Studies, College of Science and Math, USC, Columbia, SC

1997-1999 Sr. Research Scientist, Energy & Geoscience Institute, University of Utah, Salt Lake City, UT

1993-1998 Associate Chair, Department of Physics, USC, Columbia SC

1998-2009 Distinguished Professor of Physics and Astronomy, USC, Columbia, SC

2009-current Distinguished Professor Emeritus and Distinguished Research Professor, Physics Department, USC, Columbia, SC

**Other Experience and Professional Memberships**

1999- 2018 Member, American Physical Society

## Honors

[U.S. Patent # 8271412B2](https://www.google.com/patents/US8271412) ***Methods and Systems for determining Entropy Metrics for Networks*** (9/18/12).

[U.S. Patent # 6996552](https://books.google.co.uk/patents/WO2001093084A1) ***Apparatus and Methods for Handling Logical and Numeric Uncertainty*** *(12/6/01).*

2012 **USC Research Award for Network Patent # 8271412B2**.

# C. Contribution to Science

* Was principle investigator for over 120 grants and contracts totaling over $14M between 1992 and 2016
* Developed a mathematical extension of the real number system to track numerical uncertainty ([Patent Awarded](https://books.google.co.uk/patents/WO2001093084A1))
* Was principle investigator for $2.5M in DAPRA grants that developed a general mathematical foundation of network analysis, comparison, tracking, and analytics with 8 CoPIs using Lie algebras, Markov theory, and Renyi’ entropies ([Patent Awarded](https://www.google.com/patents/US8271412))
* Was principle investigator on 3 grants that developed an internet classroom student response system with AI and self-correcting (learning) to value (grade) student responses and instructor questions.
* Was principle investigator for a grant that developed a standard which I programed in Python for combining numerical values, their units of measurement, uncertainty, and defining metadata. (18 CoPI senior faculty participated).
* Developed on-line video lectures (YouTube) for both non-calculus and calculus introductory physics with associated class notes, homework, and example exams.
* Developed [on line video lectures](http://www.asg.sc.edu/lecture-videos) (YouTube) along with on line class lecture notes that cover Classical Mechanics, Electromagnetic Theory, Relativistic Quantum Theory, and Lie Algebras & Groups applied to Physics.
* Director of the SC Science Fair Region V 1979 -1993
* Director of the SC US ARMY sponsored Junior Science and Humanities Symposium competition for the State of SC from 1979-1992
* **CoPIs on Dr. Johnson’s Recent Grants and Research:**
* James Knight, Ph.D. Professor of Physics, USC
* Ralph Howard, Ph.D. Professor of Mathematics, USC
* Francisco Blaca Silva, Ph.D. Instructor, Department of Mathematics
* Don Jordan, Ph.D. Professor of Mathematics, USC
* William Hogue, Ph.D. VP of Information Technology and Chief Information Officer, USC
* Phil Moore, Ph.D. Director of USC Research Cyberinfrastructure (RCI)
* Paul Huray, Ph.D. Professor of Electrical Engineering, USC
* Bob Mullen, Ph.D. Professor and Chair of Civil & Environmental Engineering, USC
* Camelia Knapp, Ph.D. Professor of Earth and Ocean Sciences, USC
* Tammi Richardson, Ph.D. Professor of Biological Sciences, USC
* Dwayne Porter, PhD Professor and Chair of Public Health Research Center, USC
* Geoff Scott, PhD Chair of Public Health, USC
* Kendra Albright, Ph.D. Professor, Library and Information Science, USC
* Susan Rathbun, Ph.D. Asst. Professor, Library and Information Science, USC
* Bert Ely, Ph.D. Professor of Biological Sciences & Director of the USC Center for Science Education
* John Rose, Ph.D. Professor of Computer Science
* Gabriel Terejanu Professor of Computer Science
* Eight additional CoPIs on my DARPA grant.

## Published Work:

1. [*Position Operators & Proper Time in Relativistic Quantum Mechanics*](https://journals.aps.org/pr/abstract/10.1103/PhysRev.181.1755), Phys. Rev. Vol 181, No 5 1755-1764 May 1969
2. [*Proper Time Quantum Mechanics II*](https://journals.aps.org/prd/abstract/10.1103/PhysRevD.3.1735)*,*  Phys. Rev. D Vol 3, No 8, 1735-1747 April 1971 1755-1764 May 1969
3. [*Remark on the Isospin Mass Differences*](https://journals.aps.org/prd/abstract/10.1103/PhysRevD.3.2648), Phys. Rev. D Vol 3, No 11, 2648-2651, June 1, 1971
4. [*Exact Diagonalization of the Dirac Hamiltonian in an External Field*](https://journals.aps.org/prd/abstract/10.1103/PhysRevD.10.2421), Phys Rev D, Vol 10, No 8, 2421-2427 October 1974
5. [*Markov-Type Lie Groups in GL*](https://link.springer.com/chapter/10.1007%2F11560326_10)*(n,R)* J. Math Phys. 26 (2) 252-257 February 1985
6. [*Networks, Markov Lie Monoids, and Generalized Entropy*, Computer Networks Security](https://link.springer.com/chapter/10.1007%2F11560326_10) – Third International Workshop on Mathematical Methods, Models, and Architectures for Computer Network Security, St. Petersburg, Russia, September 2005, Proceedings, 129-135
7. [*A Numerical Data Standard Joining Units, Numerical Accuracy and Full Metadata with Numerical Values;* & *Networks and Cluster Analysis* European Project Space on Computational Intelligence, Knowledge Discovery & Systems Engineering](https://re.public.polimi.it/retrieve/handle/11311/1006151/160492/EPS_Rome_2014.pdf); Rome Italy, October 2014 ISBN 978-989-758-154-0
8. [*An Integration of General Relativity, Quantum Theory, and the Standard Model*.](http://asg.sc.edu/integration-general-relative-quantum-theory-0) (May 2017)

# D. Additional Information: Research Support and/or Scholastic Performance

No funding since Dec 31, 2016