Russell Keanini, PhD

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Education

University of California at Berkeley **PhD, 1992**
Mechanical Engineering

University of Colorado at Denver **MS, 1987**
Mechanical Engineering

Colorado School of Mines **BSc, 1983**
Chemical Engineering

Professional Experience

University of North Carolina at Charlotte **1992-present**

- Assistant Professor, 1992-98; Associate Professor, 1998-2007; Professor, 2007-present

NASA Graduate Student Researcher, NASA Ames Research Center **1988-89**

- Photophysics Group; Experimental development of laser diagnostic for velocity and density measurements in Mach 10 hypersonic windtunnel flow

Grad. Research Assist., Mechanical Engineering, University of California, Berkeley **1987-92**

- Application of nonlinear dynamics to acoustic combustion instability in ramjets
- Finite element and numerical modeling of materials processing and bioengineering problems
- Theoretical modeling of thermocapillary and buioyancy-driven flow in fluid collars

Grad. Research Assist., Mechanical Engineering, University of Colorado, Denver **1986-87**

- Experimental studies of stress-induced growth responses of large, single-cell organisms: Phycomyces

Member US Navy, Inactive Ready Reserve **1984-90**

Technical Consulting [with outcomes]

During the first 15 years of my career, most of my research derived from short term consultancies, working on a fairly wide range of (interesting) problems:

Technical Expert, Picadio Sneath Miller & Norton, Pittsburgh, PA **2010-2013**

- Assessed technical claims concerning ultrasonic fluid flow meters [outcome subject to NDA]

A2 Wind Tunnel, Mooresville, NC **2006-2008**

- Assisted in flow modeling and design of the A2 (low speed) wind tunnel [A2 Wind Tunnel]

NASA Marshall Spaceflight Center, Huntsville, AL **2001-2007**

- Modelled altitude-dependent turbulent boundary layer separation and attendant random rocket dynamics in Saturn-V-scale rockets [Nozzle paper 1; Nozzle paper 2; Rocket dynamics paper 1; Rocket dynamics paper 2; Rocket dynamics paper 3]

Department of Biomaterials, Baylor College of Dentistry, Dallas, TX **2000-2007**

- Modelled dental casting processes and specie transport due dental amalgam degradation [Dental amalgams paper 1; Dental amalgams paper 2; Dental amalgams paper 3; Dental amalgams paper 4]

Electric Power Research Institute, Charlotte, NC **1997-2000**

- Designed forced-air curtain device enabling in-air quality underwater welding/ship repair at large depths (U.S. Navy contract to EPRI) [U.S. Patent, Keanini et al.]

Alcoa Technical Center, Pittsburgh, PA **1995-1998**

- Developed theoretical and inverse methods for predicting and monitoring heat transfer during high-speed metal rolling processes [Metal rolling paper 1; Metal rolling paper 2]

Catawba Nuclear Power Plant, Duke Power, Charlotte, NC **1995-1997**

- Supervised MS and PhD projects that modeled and optimized post-accident flow and heat transfer to the auxiliary cooling pond at the Catawba nuclear power plant [Post-accident cooling pond paper]

Center for Marine Science Research, UNC Wilmington, Wilmington, NC **1992-1995**

- Developed first predictive model of circulation-driven, in-bone nutrient/mass transfer (in chicken embryos) [Bone fluid flow paper]

Center for Precision Metrology, UNC Charlotte, Charlotte, NC **1992-present**

- Modelled high-precision, packed-bed thermal attenuators/controllers [Precision temperature control paper 1; Precision temperature control paper 2]
- Modelled and applied PIV velocimetry to vibratory finishing processes [Vibrational finishing paper 1; Vibrational finishing paper 2; Vibrational finishing paper 3; Vibrational finishing paper 4]

Principle Scientific Contributions

Since 2005, working on fundamental fluid physics and math problems, with teams of engineers and scientists at UNC Charlotte, I've made three significant contributions:

Physical Modeling of Single Molecule Dynamics in Nonpolar Liquids **2012-present**

- Focusing on liquid state, single molecule dynamics taking place on microsecond to femtosecond $\left(10^{-6}\ \mathrm{s} - 10^{-15}\ \mathrm{s}\right)$ time-scales, this work uses nonequilibrium statistical and quantum mechanical arguments to expose, for the first time: a) viscosity emergence, and b) (phonon-driven) self-diffusive (random) molecular hopping in liquids. The work also presents and tests a self-consistent Langevin model of single molecule, liquid state dynamics, applicable over all time-scales. The physical and mathematical models explain and successfully predict temperature-dependent self-diffusion and viscosity emergence in non-metallic, nonpolar liquids, thus potentially solving centuries-old problems in fundamental liquid state physics. [2021 Scientific Reports paper; 2021 Non-technical overview]

Bootstrap technique for (stochastically) estimating Green's functions **2005-present**

- This project introduces a new, potentially powerful technique for solving physical problems governed by linear partial differential equations. Famous examples include Schrodinger's equation (quantum mechanics), Maxwell's equations (classical electromagnetism) and the linearized Navier-Stokes equations (fluid mechanics). In principle, such problems can be solved using Green's (impulse-response) functions, which when combined with boundary and initial conditions/data, provide the space-time response, e.g., the electric field, at a given point and time, produced by the given data. Historically, however, use of Green's function techniques has been limited due to the immense difficulties of constructing GF's. This project solves this problem by using stochastic processes (random walkers) to estimate high-accuracy, non-problem-specific Green's functions, applicable in any geometry. For a reverse chronological picture of the steps taken, see: [2023 Applied Mathematics and Computation paper]; [2011 paper connecting (mathematical) random walkers to fluid and quantum (physical) entities]; [2007 paper geometrically interpreting stochastic solutions of problems governed by linear partial differential equations]

Development of an accessible, dynamically equivalent molecular hydrodynamic analog **2013-19**

- A series of experimental and theoretical studies carried out at UNC Charlotte demonstrated that vibrated beds of high restitution (ceramic) grains - from short interparticle collision time and length scales to long, multiparticle flow scales - are dynamically equivalent to dense (liquid state) molecular hydrodynamic systems. This means that experimentally accessible vibrating grain systems can be used to *rigorously* study difficult-to-measure single molecule- to collective molecule-scale dynamics in liquids. The theoretical framework is laid out and tested here: [Macroscopic liquid-state molecular hydrodynamics, 2017]. Experimental methods are described here, [Macroscopic molecular hydrodynamics: experimental methods 1, 2017] and here, [Macroscopic molecular hydrodynamics: experimental methods 2, 2016] Application of the theoretical framework to predict observed grain flow patterns is described here, [Kinematic viscosity measurement of granular flows, 2019], and here [Application of computational fluid dynamics to vibratory finishing processes, 2017]

Other Contributions

For details on the following, please see my Google Scholar or ResearchGate pages.

- **Physical modeling of environmentally-driven fracture processes in rock (in collaboration with Professor Missy Eppes, UNC Charlotte) 2013-present**
- **Development of computational and theoretical, direct and inverse models of various materials processing operations, 1992-2004**
- **Analytical modeling of (continuum) fluid flow problems, including secondary streaming flow, thermocapillary and buoyancy driven flow in fluid collars, linear and nonlinear waves on cylindrical menisci, supersonic and hypersonic flows in various geometries, shock train evolution in supersonic nozzles, and turbulent boundary layer separation in rocket nozzles, 1992-present**
- **Analytical modeling of (continuum) mass and heat transfer problems, 1992-present**
- **Development (in collaboration with others) of experimental methods for studying fluid mechanic and heat transfer problems, including a non-infrared, visible imaging CCD for measuring dynamic surface temperature fields, a temperature resistant pitot tube sensor for measuring velocities in liquid metal flows, and an infrared technique for monitoring subdermal blood flow 1995-2015**
- **Early application of computational optimization for planning noninvasive cryosurgeries, 1992**

Research, Teaching and Academic Awards

Research Achievement

- **Kirk Bryan Award (2020)**, with Professor Missy Eppes, given by the Geological Society of America, to "...the author or authors of a published paper of distinction advancing the science of geomorphology or some related field, such as [Pleistocene] Quaternary geology." For: M Eppes and R G Keanini (2017) "Mechanical weathering and rock erosion by climate-dependent subcritical cracking," Reviews of Geophysics, 55, pp. 470-508.
- **Finalist, Melosh Medal Competition in Finite Element Analysis (1993)**, Duke University. For: R G Keanini and B. Rubinsky (1993), "Three-dimensional simulation of the plasma arc welding process" Int. J Heat Mass Transfer, 36, pp. 3283-3298.

Research and Academic Development

- **Research Initiation Grant, Engineering Foundation & American Soc.Mechanical Engineers (1993-94)**
- **Oak Ridge Associated Universities Junior Faculty Enhancement Award (Engineering) (1995-96).** This and previous awarded for development of numerical and experimental tools for studying materials joining processes.
- **NASA Graduate Student Researcher Fellowship (1988-89)**, NASA Ames Research Center, Experimental development of laser diagnostic for hypersonic velocity and density measurements in Mach 10 Hypersonic Windtunnel Facility.
- **Colorado Scholars Scholarship, Colorado School of Mines, 1981-83**

Teaching

- **Nominee William States Lee College of Engineering Excellence in Teaching Award (2006, 2010, 2012)**, UNC Charlotte, for excellence in undergraduate or graduate teaching

Funded DoD and Project-Related Research (Last Eight Years)

- **Engaging Military Veterans to Increase Engineering Enrollment and BS, MS, and PhD Degrees Awarded**, $750,000, DOD Office of Naval Research, PT Tkacik, PI, RG Keanini et al., co-PI's (9/04/2018-9/30/21)
- **Engaging Military Veterans to Increase STEM Enrollment and Degrees Awarded**, $600,000, DOD Department of the Navy, PT Tkacik, PI, RG Keanini et al., co-PI's (10/1/2014-12/31/17)

Thumbnail Sketch of Research Productivity & Grad Student Supervision

- **52 refereed journal publications; 36 refereed conference papers**
- **Google Scholar: citations: 1139, h-index = 18, i10-index=26**
- **US Patent: "Apparatus and Method for Creating Dry Underwater Welds," 1999, U.S. Patent No. 5,981,896. RG Keanini, M Newman, G Lowery and G Fredericks**
- **Dissertation Supervisor to 5 PhD students**
- **Thesis Supervisor to 31 Masters students**
- **Three former graduate students are tenure track faculty at Georgia Tech, Colorado State Univ., Gaston (NC) Community College**