Keith Julien, world renowned CU applied mathematician, passes away at 58. His more than 30-year career at CU-Boulder included service as Chair of the Department of Applied Mathematics from 2015 to 2024. Keith Julien died unexpectedly at St. Joseph's Hospital after a short illness on Sunday April 14, 2024. Keith is survived by his loving wife Susan, sons Simon and Theodore, father O'Neill and mother Agnes, older brother Kelvin, younger sisters Sandra and Sherma, and a wide circle of friends.

Beloved Contributor: Famous for his disarming laugh, clear-eyed judgment, and potent intellect, Keith Julien was: a world-renowned scholar; an insightful and inventive researcher; an energetic, generous, and productive collaborator; an engaging and effective teacher and mentor; a visionary administrator for the Department of Applied Mathematics; a devoted husband, loving father, and cherished friend.

CU-Boulder Affiliation: Keith's 33-year affiliation with CU-Boulder began in 1991 as a Postdoctoral Research Associate in JILA (1991-1994). After an Advanced Study Postdoctoral Fellowship at NCAR (1994-1996), Keith joined the Applied Mathematics Department (APPM) as an instructor in 1997. He moved through the ranks from assistant professor in 1998 to obtain tenure and promotion to associate professor in 2003 and was promoted to full professor in 2008. Keith was elected Department Chair in 2015, a role in which he served until his passing.

Keith was an exceptional mentor, leader on campus, and internationally recognized scholar who touched the lives of countless students, collaborators, colleagues, and peers. His sudden passing is a shock to APPM, the University, and the wider academic community. He advised 12 PhD students and 8 postdoctoral scholars, several of whom have become prominent scientific researchers. Keith inspired and skillfully bolstered the careers of APPM faculty and colleagues around the world.

Early Life and Academic Success: Born on 12 June 1965, Keith grew up in London, England, the second of four children of first-generation immigrant parents from Grenada. A vigorous and exceptional student-athlete, in addition to his studies, Keith was accomplished in both soccer and cricket. He also had musical interests, playing the electric bass. His academic trajectory took shape when he received his BSc degree in Mathematics and Physics with 1st Class Honors from King's College, University of London, in 1986. Keith subsequently moved to the

University of Cambridge, where he received his Part III Certificate of Advanced Studies in 1987, on the basis of which he was accepted into the Cambridge doctoral program. He was awarded the J.T. Knight Prize in 1988, and received his PhD degree in Applied Mathematics and Theoretical Physics in 1991 for a dissertation on "Strong Spatial Resonances in Convection," studying under Professor M.R.E. Proctor.

Administrative Leadership: As an administrator, Keith's visionary leadership has left an indelible imprint on APPM and the university. First, he substantially shaped the reorganization of the College of Arts and Sciences in 2022 with a new system that strengthens the authority of the three Deans of Division, an idea originally articulated in the *Cumalat-Julien Academic Futures White Paper* (2018). Second, he played a major role in the development of multiple new or pending degrees, including the BA and BS in Statistics and Data Science, the BS in Applied Mathematics, and the Professional MS in Applied Mathematics. Third, for over a decade, Keith relentlessly pursued a project to unify departmental space so that APPM PhD students would no longer be scattered across different buildings on campus, as they have been since 1989. Even before serving as APPM Chair, Keith led a committee to develop a plan, which culminated in the CU Board of Regents' approval to construct a new shared Chemistry and Applied Mathematics facility on 11 April 2024, just three days before his passing. This new facility represents a major milestone for APPM, with construction scheduled to begin this fall, and occupancy planned for late 2026.

Preeminent Research: Keith's Applied Mathematics research has had major impacts on the understanding of fundamental geophysical and astrophysical fluid dynamical phenomena. He is recognized as a world expert in the instability, dynamics, evolution, and simulation of important fluid processes, including rapidly rotating convection, magneto convection, fluid turbulence, and the coherent structures that spontaneously appear in these flows. Keith authored more than 80 research papers, appearing in leading international journals, and his work is cited more than 4000 times according to Google Scholar.

One of Keith's most important and consequential contributions to the field of geophysical and astrophysical fluid dynamics is the development of reduced or simplified partial differential equations valid in the limit of rapid rotation. Many important flows are strongly affected by rotation, such as: thermal convection in the ocean, which regulates overturning rates that bear on climate change; convective flows in the outer core of the Earth, responsible for Earth's magnetic field; and flows in the Sun's turbulent outer layer, which is an important region for solar magnetic activity, such as solar flares and coronal-mass ejections. In a seminal series of papers, Keith pioneered the development of multi-scale asymptotic methods and fast numerical algorithms to derive and simulate a reduced set of equations that approximate the governing Navier-Stokes equations for rapidly rotating convection; this enabled the exploration of extreme parameter regimes that are otherwise inaccessible to either state-of-the-art high performance computing hardware or laboratory investigation. These developments led to the discovery of the spontaneous emergence of large-scale structures such as vortices and jets in turbulent rapidly rotating convection, predictions that were subsequently confirmed by direct numerical simulations of the full equations, albeit under much more modest conditions. These advances

attracted, in turn, a number of groups to this research area, in both experiment and theory, all motivated by Keith's pioneering work. Together with many collaborators, Keith extended these ideas to the study of accretion disks in astrophysics, convection in a strong magnetic field, shear-flow instability, wind-driven circulation, and more recently, to ocean mixing by the doubly diffusive salt-finger instability. Taken together these applications demonstrate that highly anisotropic but fully three-dimensional turbulence is susceptible to instabilities generating large-scale coherent structures resembling those present in geophysical and astrophysical fluid dynamical systems.

Awards and Recognition: Keith received multiple awards recognizing his achievements, including CU's Creative Research and Creative Works Junior Faculty Development Award in 1998 and Faculty Fellowship Award in 2004. In 2017, Keith was elected Fellow of the American Physical Society, and in 2022 he was awarded the Kirk Distinguished Fellowship at the Isaac Newton Institute, University of Cambridge. In 2024 Keith was slated to be a Principal Lecturer for the Geophysical Fluid Dynamics Summer Program, Woods Hole Oceanographic Institution.

Service to the Scientific Community: Over the years, Keith tirelessly served the scientific community. He co-directed two NCAR/IMAGe Theme-of-the-Year Programs for "Geophysical Turbulent Phenomena" in 2008 and "Rotating Stratified Flows" in 2012. He served on the Committee of Visitors for External Evaluation of the Division of Ocean Sciences for the National Science Foundation in 2015 and 2019. In 2014 he co-organized a 14-week program on the Mathematics of Turbulence at the NSF Institute for Pure and Applied Mathematics (IPAM), UCLA, and since 2014 he served as an Associate Editor for the journal *Nonlinearity*. In the summer of 2018, Keith co-organized an international workshop on Rotating Convection at the Lorentz Center, Netherlands, and he was the lead organizer of a 2025 IPAM, UCLA workshop titled "Rotating Turbulence: Interplay and Separability of Bulk and Boundary Dynamics." Keith also served numerous times on scientific panels for NSF and NASA, and as Principal Investigator and/or Co-Principal Investigator on research grants in the mathematical sciences, atmospheric sciences, solar physics, and ocean sciences.