Princeton University

HONORS FACULTY MEMBERS RECEIVING EMERITUS STATUS

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The biographical sketches were written by staff and colleagues in the departments of those honored.

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Faculty Members Honored in 2019
for Receiving Emeritus Status

JAMES MCLELLAN STONE

James McLellan Stone, the Lyman Spitzer Jr., Professor of Theoretical Astrophysics and professor of astrophysical sciences and applied and computational mathematics, will transfer to emeritus status at the end of the academic year.

Jim was born in Redruth, Cornwall, England, on November 29, 1962. He moved with his family to Canada in 1965, and for most of his youth lived in Alberta and British Columbia. Growing up he was an avid rugby player, winning the city championship in Victoria in 1978. Jim chose to go east for his higher education; he matriculated at Queen's University in Kingston, Ontario, and received his B.Sc. in 1984 and M.Sc. in 1985, in physics. Attracted by reporting from NASA planetary missions, he enrolled in a graduate program in the Department of Astronomy at the University of Illinois-Urbana in 1986. Jim married fellow Queen's student Penny Rose shortly after graduation, and their two daughters, Heather and Shannon, were born in Urbana.

Shortly before Jim began his Ph.D. at Illinois, the National Center for Supercomputing Applications (NCSA) was created and moved into the same building as the astronomy department, installing its first CRAY supercomputer. Excitement about the future of computing ran high, and Jim caught the fever. His doctoral work was advised by Dimitri Mihalas and Michael Norman. From Mihalas, who was a world-renowned figure in the field of radiative transfer and radiation hydrodynamics, Jim learned that the true path to fundamental knowledge is by including all the necessary physics and solving difficult problems, rather than by fashioning "cartoon" models. From Norman, a code-builder and field-builder in computational astrophysics, Jim embraced the vision that ever-larger computing platforms can transform science, provided that ever-better algorithms and codes are built to harness that power. Fittingly, given the emphasis on rigorous numerical analysis and code testing that has been a hallmark of Jim's subsequent career, his earliest first-author publication was titled "A test suite for magnetohydrodynamical simulations."

Jim's scientific studies for his dissertation were of the propagation of protostellar outflows (winds and jets), and at the same time he began studying the effects of magnetic fields in driving accretion via internal turbulent disk torques and external laminar wind torques. Having completed his doctoral thesis, "Numerical Simulations of

Protostellar Mass Outflows," Jim received his Ph.D. in 1990. With a Prize Postdoctoral Fellowship from the National Science Foundation, Jim chose to stay at NCSA in Illinois for two years. He used this time to complete code development and writing of three papers, co-authored by Norman and Mihalas. These papers describe the algorithms and tests for the ZEUS-2D code for magnetohydrodynamics (MHD) and radiation hydrodynamics (RHD); they have become amongst the most cited code papers on computational fluid dynamics in the astrophysics literature. The public release of the subsequent 3-D version of the ZEUS MHD code led to its widespread adoption by the community and application in nearly every area in contemporary astrophysics involving gas flows.

Jim's early interest in computational methods for MHD and RHD set in motion the defining technical focus of his career. Most of the matter in the Universe can be treated as a compressible fluid, which is pervaded by magnetic fields and interacts strongly with radiation. The structure and evolution of a vast range of astronomical systems can therefore be described by partial differential equations, and while analytic solutions exist in idealized cases, in full generality the solutions of these equations are complex. Capturing this complexity is crucial to gaining physical understanding of the Cosmos. As Jim himself has pointed out, "Approximate solutions to the exact equations found by numerical methods often provide far more insight than exact solutions to approximate equations that can be solved analytically."

Indeed, in many gaseous astrophysical systems, magnetization and interaction with radiation completely change the dynamical evolution, but until the time Jim started his graduate work these effects were considered by most theoretical astrophysicists too difficult to include in time-dependent models.

Jim set out as a graduate student to change the way theoretical astrophysics is conducted. To this end, he has devoted much of his career to developing, implementing, and testing computational methods that produce fully general solutions to the equations of MHD and RHD with the highest accuracy, greatest robustness, and lowest cost possible, while allowing for the broadest range of astronomical applications. As the subsequent record shows, this endeavor succeeded.

After a short postdoctoral period, Jim was recruited to the University of Maryland-College Park, joining the faculty in 1992 as an assistant professor; he was the first of several hires in a new group in theoretical astrophysics within the Department of Astronomy. Jim earned tenure and promotion to the rank of associate professor in 1997, and was promoted to professor in 2001. While at Maryland he was also a leader in a campus initiative that created a new graduate program in applied mathematics and statistics and scientific computation, of which he served as associate director from 2001–02. During his years at Maryland, Jim worked on a variety of scientific topics that made use of the power of the versions of the ZEUS code he developed, and at the same time he began working on new algorithms and implementation frameworks for subsequent MHD and RHD codes. Among the most influential of Jim's scientific papers from his years at Maryland were his work with co-authors John Hawley, Steve Balbus, and Charles Gammie on the nonlinear development of instabilities in stratified, magnetized disks to create turbulence that drives accretion, and his work with Gammie and Eve Ostriker on the dynamical evolution and structural properties of magnetized, turbulent interstellar clouds where stars form.

During a sabbatical leave from Maryland in 1998-99, Jim and his family travelled to Cambridge, England. While in the UK, he and collaborators at the Institute of Astronomy worked on non-radiative hot accretion flows, and he continued work begun earlier with collaborators Daniel Proga and Janet Drew at Imperial College on radiation-driven winds; both effects are important to understanding supermassive black holes — how they grow, how they impact their environment, and how they are observed (or escape detection). In 2002, Jim returned to the UK as professor of mathematical physics in the Department of Applied Mathematics and Theoretical Physics at Cambridge. However, that appointment was to prove brief, as he was recruited back to the United States within a year.

Jim joined the Princeton University faculty in 2003, jointly appointed as professor in the Department of Astrophysical Sciences and the Program in Applied and Computational Mathematics (PACM). He also served as the associate chair in astrophysics (2007–09), and as associate director and then director of the Princeton Institute for Computational Science and Engineering (PICSciE) from 2009–17. The years that he co-led PICSciE, with Jeroen Tromp of geosciences, saw tremendous growth in the impact of the institute as a nexus for the support of computational science on campus. In 2016, Jim was appointed to the Lyman Spitzer, Jr. Chair of Theoretical Astrophysics, and became department chair of astrophysical sciences.

In the 16 years he has been on the Princeton faculty as a researcher and educator, Jim's impact here—and in the astrophysics and computational science communities beyond our campus—has been immense. Teaching in both astrophysics and PACM, he instilled in our students the proper way to implement algorithms as computer programs, conduct numerical analysis, and to develop complex scientific software packages, and also inspired them with the ever-fascinating variety of magnetized astrophysical plasmas. At the same time as he cultivated in his students a profound respect for technical rigor, Jim treated them to his contagious spirit of scientific adventure and optimism. Several of the Ph.D. students and postdocs that Jim advised at Princeton are among the brightest stars in the rising generation.

In 2008, Jim and his collaborators published the first code paper on Athena, the successor to ZEUS, and currently under development is Athena++. These codes employ Godunov-type conservative algorithms, provide generalized grid geometries and mesh refinement, and are designed to maximize performance on current massively-parallel hardware. With the capabilities built into these new codes has also come new science. The number and variety of scientific questions Jim has investigated while at Princeton has been vast, but one ongoing focus has been on modeling the detailed properties of magnetized accretion disks and outflows. The systems Jim and his group have studied range from protostars to white dwarfs to supermassive black holes, taking into account physics elements (resistivity, ion-neutral drift, Hall effect, solid particles, radiation, special/general relativity, collisionless plasma effects, and more) that are technically challenging to implement but essential to capturing key physical processes. These effects include damping and growth of instabilities that were not previously seen, which radically alter the character of the system compared to previous understanding. Beyond accreting systems, he has also made important contributions to understanding the structure and evolution of the interstellar and intergalactic medium.

As with ZEUS, Jim made Athena freely available to the larger community. The clean and superbly documented code packages that Jim and his collaborators have shared have enabled thousands of papers in fields of astrophysics ranging from the lowest to highest energies (interstellar clouds to accreting black holes) and the smallest to largest scales (planet-forming disks to galaxy clusters). Many projects have used features particular to Jim's codes and would have been impossible without his generosity in making the packages available to the community. In no small part due to Jim's efforts, computational fluid dynamics modeling is now the de facto standard tool for research in many areas of astronomy.

While modest and quintessentially "Canadian" in manner, Jim is a towering figure in theoretical astrophysics. He has a long record of pathbreaking scientific and technical accomplishments, has supported the University and field by service, and has trained students and set an example for peers of how computational astrophysics should be practiced. Jim's contributions have been nationally recognized, including with the 2011 Aneesur Rahman Prize for Computational Physics from the American Physical Society, and with the 2018 Dirk Brouwer Career Award in Dynamical Astronomy from the American Astronomical Society.

While Jim is transferring to emeritus status at Princeton, happily he is not moving far. As professor in the School of Natural Sciences at the Institute for Advanced Study, Jim will continue to be our close colleague and to play a leading role in the Princeton and international astrophysics community.