**Biographical Sketch and Curriculum Vitae August 2023**

| NAME | POSITION TITLE |
|---|---|
| Larry L. Smarr, Ph.D | Distinguished Professor Emeritus, Computer Science and Engineering, UC San Diego |
| http://lsmarr.calit2.net/ | |

| EDUCATION/TRAINING INSTITUTION AND LOCATION | DEGREE *(if applicable)* | YEAR(s) | FIELD OF STUDY |
|---|---|---|---|
| University of Missouri | B.A. | 1970 | Physics |
| University of Missouri | M.S. | 1970 | Physics |
| Stanford University | M.S. | 1972 | Physics |
| University of Texas at Austin | Ph.D. | 1975 | Physics |

## Ph.D. Dissertation

"The Structure of General Relativity with a Numerical Illustration: The Collision of Two Black Holes," University of Texas at Austin (1975). Ph.D. Advisor Bryce S. DeWitt (Deceased)

## Positions and Employment

2020-present Distinguished Professor Emeritus, Computer Science and Engineering, UC San Diego
2012-2020 Distinguished Professor, Computer Science and Engineering, UCSD
2000-2011 Professor, Computer Science and Engineering, UCSD
2000-2020 Founding Director, California Institute for Telecommunications and Information Technology, UCSD
1997-2000 Founding Director, National Computational Science Alliance, Univ. of Illinois at Urbana-Champaign
1985-2000 Founding Director, National Center for Supercomputing Applications, UIUC
1985-2000 Professor, Astronomy and Physics Departments, UIUC
1981-1985 Associate Professor, Astronomy and Physics Departments, UIUC
1979-1980 Assistant Professor, Astronomy and Physics Departments, UIUC
1978-1979 Research Affiliate, Department of Physics, Yale University
1976-1979 Junior Fellow, Harvard University Society of Fellows, Departments of Physics and Astronomy
1975-1976 Postdoctoral Fellow and Lecturer, Princeton University Observatory

## Honors

- CENIC 2017 Founders Circle Award [with Celeste Anderson, Mark Boolootian, John Dundas III, Sherilyn Evans, Cliff Frost, Tom Hutton, Sidney Karin, Johanna Madjedi, Bill Manning, David Reese, Tad Reynales, Lea Roberts, Michael Sinatra, Wayne Sung, Michael Van Norman, Jim Warner] (2017)
- Fellow, American Association for the Advancement of Science (2016)
- CENIC 2016 Innovations in Networking Award for Experimental Applications: Pacific Research Platform [with Tom DeFanti, Phil Papadopoulos, Frank Wuerthwein, Camille Crittenden, John Graham, John Hess, and Eli Dart] (2016)
- Golden Goose Award (2014)
- Name added to University of Missouri Notable Alumni Wall (2010)
- CENIC 2009 Innovation Award for Experimental/Developmental Applications: GreenLight [with Tom DeFanti and Greg Hidley] (2009)
- Listed as one of 30 Notable Graduate Alumni of the University of Missouri (2009)
- Honorary Ph.D. "Doctor of Science Honoris Causa," by the Univ. Missouri at Columbia. (2008)
- Australia Leadership Dialog Scholar (2008)
- R Systems, a company in Urbana, IL, names their supercomputer 'R Smarr' after Larry Smarr (2008)
- IEEE Computer Society Tsutomu Kanai Award for distributed computing systems achievements (2006)
- ESRI Lifetime Achievement Award (2006)
- USC Annenberg Fellow, May (2006-2008)

- CENIC Innovation Award for Experimental / Developmental Applications – iGrid2005 [with Maxine Brown and Tom DeFanti] (2005)
- Telluride Tech Festival Honoree (2005)
- Harry E. Gruber Endowed Chair, Department of Computer Science and Engineering, UCSD (2002-2020)
- Champaign County Most Valuable Citizen Award, Champaign County Chamber of Commerce (1998)
- Member, National Academy of Engineering, Section 5 (Computer Science and Engineering) (1995)
- Fellow, American Academy of Arts and Sciences (1994)
- Listed in Fortune Magazine, Special Issue, Spring/Summer 1991, "The New Century" in the article "Twenty Five Who Help The U. S. Win" (1991)
- Franklin Institute's Delmer S. Fahrney Gold Medal for Leadership in Science or Technology (1990)
- Fellow, American Physical Society (1988)
- Distinguished Alumnus Award, College of Arts & Science, Univ. Missouri at Columbia (2nd recipient) (1985)
- Included in Esquire magazine's "Register of Outstanding Americans Under Age 40" (272 listed) (1984)
- Alfred P. Sloan Research Fellow (1980-1984)
- Max-Planck Institute for Physics and Astrophysics Fellowship (1982-1983)
- Beckman Fellow, University of Illinois at Urbana-Champaign (1980-82)
- Junior Fellow, Harvard University (1976-1979)
- Lane Scholar [outstanding work in classical physics at U. Texas] (1973-1974)
- National Science Foundation Fellow (1970-1973)
- Woodrow Wilson Independent Study Award [top 10% of W. W. Fellows] (1971)
- Woodrow Wilson Fellow (1970)

## Service

- Member, Computing Sciences and Computational Research Division Review Committee at Lawrence Berkeley National Laboratory (2019)
- Member, Advisory Board to the Director of the Lawrence Berkeley National Laboratory (2016-2022)
- Member, DOE ESnet Policy Board (2012-2015)
- Chair, NSF Advisory Committee for Cyberinfrastructure (2011-2013)
- Member, NSF and Consortium for Ocean Leadership's Ocean Observatories Initiative (OOI) Deans/Directors Oversight Board (2010-2013)
- Chair, Information Technology Subcommittee to the NASA Advisory Council to the NASA Administrator, (2010-2013)
- Member NSF Alan T. Waterman Award Committee (2009-2014)
- Member, ACM Ken Kennedy Award Committee (2010-2013)
- Member, Board of Directors, Institute for the Future (2009-2010)
- Member, DOE Office of Science Advanced Scientific Computing Advisory Committee (2008-2011)
- Member, Encyclopedia of Life Distinguished Advisory Board (2008-2010)
- Member, Editorial Advisory Board, IEEE Spectrum (2006-2012)
- Member, Gov. Schwarzenegger's California Broadband Task Force (2006-2007)
- Chair, NASA Earth System Science & Applications Advisory Committee [ESSAAC] (2003-2005)
- Member, NASA Advisory Council to the NASA Administrator (2001-2005; 2011-2013)
- Member, NewsHour Science Advisors (2004-2009)
- Member, San Diego CONNECT Board of Directors (2006-2016)
- Member, CommNexus San Diego Board of Advisors (2006-2010)
- Member, San Diego Telecom Council Board (2003-2005)
- Outside Director, Board of Directors, Nonprofit Corporation for Education Network Initiatives in California [CENIC] (2001-present)
- Chair of University of Texas at Austin Visiting Committee on Visualization (2001)
- Member, Advisory Committee to the Director, NIH (1998-2005)
- Member, Board of Governors, Argonne National Laboratory (1998 - 2001)
- Member, President's Information Technology Advisory Committee [PITAC] (1997-2000)

- Program Chair, ACM/IEEE Supercomputing '95 (1995)
- Member, National Research Council Committee to Study High Performance Computing and Communications: Status of a Major Initiative, CSTB, (1995)
- Member, National Research Council, Commission on Geosciences, Environment, and Resources (1990-1994)
- Panel Chair, National Research Council Computing and Data Processing, Astronomy and Astrophysics Survey Committee (1990 – 1991)
- Member, Office of Technology Assessment Advisory panel on Basic Research in the 1990s (1990)
- Member, National Research Council, Commission of Physical Sciences, Mathematics, & Resources (1987-1990)
- Member, National Academy of Sciences Government-University-Industry Research Roundtable (1987-1991)
- Member, National Academy of Sciences Panel on Science and Technology Centers, (1987)

## Research Support (last 20 years)

These grants support my research and do not include institutional grants to create/maintain NCSA & Calit2.

### Ongoing Research Support

- Co-PI on the NSF CCRI Enhance/Sustain (ENS) Award for the CHASE-CI grant [NSF Award CNS-2120019, PI Tom DeFanti] (2021-2024, $1,800,000) to support the enhancement and sustainment of the CHASE-CI CISE community infrastructure to enable world-class CISE research opportunities for broad-based communities of CISE researchers.
- PI on the NSF *Toward the National Research Platform* (TNRP) grant [NSF Award OAC-1826967] (2018-2023, $2,500,000) to extend the PRP across the country by federating with four other Regional Optical Networks and Internet2.

### Completed Research Support

- PI on the NSF Community Research Infrastructure (CCRI) *Accomplishment Based Renewal (ABR) for the CHASE-CI* grant [NSF Award CNS-2100237] (2021-2023, $1,000,000) to study various Deep Neural Network, Recurrent Neural Network, and Reinforcement Learning Algorithms on the CHASE-CI platform.
- PI on the NSF *Cognitive Hardware and Software Ecosystem Community Infrastructure (CHASE-CI)* grant [NSF Award CNS-1730158] (2017-2020, $1,200,000) to add machine learning to the PRP platform to enable research by 30 faculty at 10 of the PRP universities.
- PI on NSF *Pacific Research Platform* grant [NSF Award OAC-1541349] (2015-2022, $8,000,000) to create a sub-national scale Big Data Freeway system connecting investigators in their labs to big data sources and big compute at 10-100 Gbps
- PI on the Helmsley Charitable Trust grant *3D Medical Imaging Pilot to Improve Surgical Outcomes for Patients with Crohn's Disease* grant (2018-2021, $1,200,000) to develop novel machine learning algorithms to find the 3D surface of the large intestine in ten patients starting from abdominal MRI slices.
- Co-PI on NSF *WIFIRE: A Scalable Data-Driven Monitoring, Dynamic Prediction and Resilience Cyberinfrastructure for Wildfires* Hazards SEES Type 2 grant [NSF Award OAC-1331615, PI Ilkay Altintas, UCSD] (2014-2016, $2,650,000) to build an end-to-end cyberinfrastructure, called WIFIRE, for real-time and data-driven simulation, prediction, and visualization of wildfire behavior.
- Co-PI on NSF *PRISM@UCSD* grant [NSF Award OAC-1246396, PI Philip Papadopoulos, UCSD] (2013-15, $500,000) to build a UCSD Big Data freeway system for research data.
- PI on NSF *Wildfire Modeling and Prevention Initiative: Developing a Technical Framework for Integrating Research with Public Policy Decision Support* EAGER grant [NSF Award OCI-1126615] (2011-2012, $260,000)
- Co-PI on NSF *GreenLight* grant (2008-2010, $2,000,000) [NSF Award CNS-0821155, PI Thomas DeFanti, UCSD] to develop an instrument called GreenLight which can measure, monitor, and optimize the energy consumption of large-scale scientific computational workloads from many different disciplines.
- PI on Moore Foundation *Community Cyberinfrastructure for Advance Microbial Ecology Research and Analysis (CAMERA)* grant (2005-2014, $25,500,000) to establish a community resource with a central genomic/metagenomics data repository and a suite of tools for analysis/visualization that provides open, easy access to the international scientific community studying marine microbial ecology, the microbial ecology of other natural environments, and evolutionary biology.
- Co-PI on NSF *LOOKING* grant [NSF Award OCE-0427974, PI John Orcutt] (2004-2008, $2,300,000) to develop and prototype new cyberinfrastructure approaches for ocean observing systems.

- Co-PI on NSF *Quartzite* grant [NSF Award CNS-0421555, PI Philip Papadopoulos, UCSD] (2004-2007, $1,200,000) to build a campus wide ultra-high-speed optical fiber network that supports data-intensive scientific application, develops an experimental next-generation instrument to efficiently investigate and compare campus-scale terabit-class lambda network architectures that span from optical-circuits-only to packet-switched-only networks
- PI on NSF *OptIPuter* grant [NSF Award OAC-0225642] (2002-2009, $13,500,000) to design and build an "OptIPuter," which is a "virtual" parallel computer in which the individual "processors" are widely distributed clusters; the "backplane" is provided by IP delivered over multiple dedicated lambdas (each 1-10 Gbps); and, the "mass storage systems" are large distributed scientific data repositories, fed by scientific instruments as OptIPuter peripheral devices, operated in near real-time.

## Private Sector Engagement

- Kazuhm, Technology Evangelist (2020-21)
- Member, Analytic Ventures Lab Advisory Board (2017-2021)
- Member, Scientific Advisory Board, Arivale (2015-2019)
- San Diego Xconomy Xconomist (2008-2019)
- Member, Scientific Advisory Board, MDRevolution (2012-2015)
- Member, Complete Genomics Inc. Scientific Advisory Board (2010-2014)
- Advisor to the CEO, MedExpert International, Inc. (2000-2017)
- Member, Qualcomm Life Advisory Council (2012-2014)
- Member, Future in Review Advisory Board (2008-2010)
- Member, Seattle OVP Venture Partners Technology Advisory Group (2006-2010)
- Fellow, Price Waterhouse Coopers Exchange (2010-2020)
- Fellow, Diamond Management & Technology Consultants, Inc. DiamondExchange Program (2009-2010)
- Advisory Board Member, Kintera, Inc. (2000-2008)
- Member, InterWest MedTech Advisory Committee (1999-2010)
- Member, Board of Directors, and Chair, Scientific Advisory Board, Entropia, Inc. (1998-2003)
- Member, Technical Advisory Board, WebEx Communications, Inc. (1999-2003)
- Consultant, SAIC (2000-2003)
- Member, Fisher Scientific Biotechnology Council (1993-1998)
- Consultant to Ab Initio, Boston, MA (1996-1998)
- Member, Vanguard Advisory Board, Computer Sciences Corporation, 1993-1997; Technology Transfer Institute 1998-1999 [Created quarterly IT frontier programs for Industrial CIOs]
- Executive Committee, World Space Center (1977 - 1980)

## Courses taught

- "The Interstellar Medium," Senior Level Undergraduate Semester Course, Department of Astrophysical Sciences, Princeton University, Spring 1975.
- "Black Holes," Undergraduate Semester Course, Department of Astronomy, University of Illinois, Fall 1983 and 1984.
- "General Relativity," Graduate Semester Course, Departments of Physics and Astronomy, University of Illinois, Fall 1981 and 1983.
- "The Physical Universe," Undergraduate Semester Course, Department of Astronomy, University of Illinois, Spring 1980, 1981 and 1983.
- "Descriptive Astronomy," Undergraduate Semester Course, Department of Astronomy, University of Illinois, Spring 1982 and Fall 1982.
- "Thought and Structure in Physical Science," Undergraduate Semester Course, Department of Astronomy, University of Illinois, Fall 1979 and 1980

## Contributions to Science

A summary of the major phases in my research career with selected publications. Those with * at the end currently have between 10 and 50 citations each in Google Scholar and those with ** have between 50 and 700 citations. https://scholar.google.com/citations?user=oZafLf4AAAAJ&hl=en).

For my full set of publications, government reports, other works, presentations, interviews and profiles, see http://lsmarr.calit2.net.

**Analytic and Computational General Relativity.** I began my scientific career in 1970, just two years after the term "black hole" was coined. This early entry into the rapidly developing field enabled me to discover what is now termed the Smarr Mass Formula for black holes. I was also the first to determine the intrinsic curvature deformation caused by rotation in black holes. Although the numerical solution of perturbations of spherical and rotating black holes had been well developed, the solution of the full nonlinear Einstein equations utilizing Cauchy evolution by computational solution of partial differential equations required a number of Riemannian geometry innovations that my co-workers and I developed. Working under the mentorship of general relativity and quantum gravity pioneer Bryce DeWitt, I helped found the field of numerical relativity by amalgamating techniques from differential geometry, general relativity, numerical analysis, and computer graphics and applying them to the two-body problem in general relativity in the form of the head-on collision of two black holes. This led to the first computation of the gravitational radiation from colliding black holes. With my students and colleagues, I also also computationally investigated black hole dynamics, gravitational collapse, and black hole/gravitational wave interactions.

1. "Surface Geometry of Charged Rotating Black Holes," L. Smarr, Physical Review D7, 289-295 (1973). **
2. "Mass Formula for Kerr Black Holes," L. Smarr, Physical Review Letters, 30, 71-73 (1973). **
3. "Maximally Slicing a Black Hole," F. Estabrook, H. Wahlquist, S. Christensen, B. DeWitt, L. Smarr and E. Tsiang, Physical Review D7, 2814-2817, (1973). **
4. "Collision of Two Black Holes: Theoretical Framework," L. Smarr, A. Cadez, B. DeWitt, and K. Eppley, Physical Review D14, 2443-2452 (1976) **
5. "Spacetimes Generated by Computers: Black Holes with Gravitational Radiation," L. Smarr, Ann. N.Y. Acad. of Sciences, 302, 569-604 (1977) **
6. "Gravitational Radiation from Distant Encounters and Head-On Collisions of Black Holes: The Zero Frequency Limit," L. Smarr, Physical Review D15, 2069-2077 (1977). **
7. "Are There Geon Analogues in Sourceless Gauge-Field Theories?" S. Coleman and L. Smarr, Comm. Math. Phys., 56, 1-9 (1977). *
8. "The Radiation Gauge in General Relativity," L. Smarr and J. W. York, Jr., Physical Review D17, 1945-1956 (1978). **
9. "Kinematic Conditions in the Construction of Spacetime," L. Smarr and J. W. York, Jr., Physical Review D17, 2529-2551 (1978). **
10. "Sources of Gravitational Radiation," ed. L. Smarr (Cambridge University Press) (1979). **
11. "Gauge Conditions, Radiation Formulae, and the Two Black Hole Collision," in Sources of Gravitational Radiation, 245-274, ed. L. Smarr (Cambridge University Press) (1979). *
12. "Time Functions in Numerical Relativity: I. Marginally Bound Dust Collapse," D. Eardley and L. Smarr, Physical Review D19, 2239-2259 (1979). **
13. "Gravitational Waves and Red Shifts: A Space Experiment for Testing Relativistic Gravity Using Multiple Time-Correlated Radio Signals," L. Smarr, R. F. C. Vessot, C. A. Lundquist, R. Decker and T. Piran, General Relativity and Gravitation, 15, 129-163 (1983). *
14. "The Contribution of Bryce DeWitt to Classical General Relativity," in Ahead of His Time: Bryce S. DeWitt. Essays on the Quantum Theory of Gravity in Honor of his 60th Birthday, ed. S. Christensen (Adam Hilger, Lmt.: Bristol, England) (1984).
15. "Computational Relativity: Numerical and Algebraic Approaches," L. Smarr, in The Proceedings of the 10th International Conference on General Relativity and Gravitation, 163-183, ed. B. Berotti et al. (Reidel: Dordrecht) (1984).
16. "Numerical Construction of Spacetime," L. Smarr, Proc. R. Soc. Lond., 368, 15-16, (1979).

17. “Numerical Relativistic Gravitational Collapse with Spatial Time Slices,” C.R. Evans, L.L. Smarr and J.R. Wilson, in Astrophysical Radiation Hydrodynamics, 481-519, ed. K.-H. Winkler and M. Norman (Reidel: Dordrecht) (1986).
18. "Black Hole Spacetimes: Testing Numerical Relativity," D. Bernstein, D. Hobill, L. Smarr, in Frontiers in Numerical Relativity, 57-73, ed. C. Evans, L. Finn, and D. Hobill (Cambridge University Press: Cambridge) (1989). *
19. "Supercomputing and Numerical Relativity: A Look at the Past, Present and Future," L. Smarr in Frontiers in Numerical Relativity, 1-17, ed. C. Evans, L. Finn, and D. Hobill (Cambridge University Press: Cambridge), with D. Hobill (1989).
20. “Shedding Light on Black Holes,” L. Smarr, D. Hobill and D. Bernstein, Future Generation Computer Systems, 5, 225-242 (1989)
21. “Numerical Relativity: Black Hole Spacetimes," L. Smarr, D. Hobill, D. Bernstein, D. Cox, and R. Idaszak, SIGGRAPH Video Review: Visualization State of the Art, 49, (1989).
22. "Numerically Generated Black Hole Spacetimes: Interaction with Gravitational Waves," A. Abrahams, D. Bernstein, D. Hobill, E. Seidel, and L. Smarr, Physical Review D15, 45, 3544, (1992). **
23. "Computing Dynamical Black Hole Spacetimes", D. Bernstein, D. Hobill, E. Seidel, L. Smarr, and J. Towns, in Proceedings of Supercomputer Symposium '92, Ottawa, Ontario, (1992).
24. "Numerically Generated Black Hole Spacetimes", D. Bernstein, D. Hobill, E. Seidel, and L. Smarr, in Proceedings of the 6th Marcel Grossmann Meeting on General Relativity, (1993).
25. "The Collision of Two Black Holes," P. Anninos, D. Hobill, E. Seidel, and L. Smarr, and W.-M. Suen, Physical Review Letters, 71, 2851 (1993). **
26. "Numerically Generated Axisymmetric Black Hole Spacetimes: Numerical Methods and Code Tests," D. Bernstein, D. Hobill, E. Seidel, L. Smarr, and J. Towns, Physical Review D15, 50, 5000, (1994). **
27. "Initial Data for The Black Hole Plus Brill Wave Spacetime," D. Bernstein, D. Hobill, E. Seidel and L. Smarr. Physical Review D15, 50, 3760, (1994). *
28. "Gravitational Waves from Oscillating Black Holes", P. Anninos, D. Bernstein, D. Hobill, J. Towns, E. Seidel, and L. Smarr, in Computational Astrophysics, Eds. J. Barnes et al. (Springer-Verlag: Berlin) (1994).
29. "Dynamics of Black Hole Apparent Horizons," P. Anninos, D. Bernstein, S. R. Brandt, D. Hobill, E. Seidel, and L. Smarr, Physical Review D15, 50, 3801, (1994). **
30. "Event Horizons in Numerical Relativity", P. Anninos, D. Bernstein, S. Brandt, J. Libson, J. Massó, E. Seidel, L. Smarr, W.-M. Suen, and P. Walker, in Proceedings of the 7th Marcel Grossmann Meeting on General Relativity, (1995).
31. "Dynamics of Apparent and Event Horizons," P. Anninos, D. Bernstein, S. Brandt, J. Libson, Joan Masso, E. Seidel, L. Smarr, W.-M. Suen, and P. Walker. Physical Review Letters, 74, 630 (1995) **
32. “Oscillating Apparent Horizons in Numerically Generated Spacetimes,” P. Anninos, D. Bernstein, S. Brandt, D. Hobill, E. Seidel, and L. Smarr, Australian Journal of Physics, 48, 1027, (1995). *
33. "The Head-On Collision of Two Equal Mass Black Holes," P. Anninos, D. Hobill, E. Seidel, L. Smarr, and W.-M. Suen. Physical Review D15, 52, 2044, (1995). **
34. "Geometry of a Black Hole Collision," R. Matzner, E. Seidel, S. L. Shapiro, L. Smarr, W.-M. Suen, S. Teukolsky, J. Winicour, Science 270, 941 (1995). **
35. "When Black Holes Collide,” P. Anninos, D. Hobill, E. Seidel, L. Smarr, and W.-M. Suen, in Proceedings of the Sixth Canadian Conference on General Relativity and Relativistic Astrophysics, Fields Institute Communications (1996).
36. “Head-on Collisions of Two Black Holes,” D. W. Hobill, P. Anninos, E. Seidel, L. Smarr, W.-M. Suen, in Computational Astrophysics; 12th Kingston Meeting on Theoretical Astrophysics; ASP Conference Series #123, edited by D. A. Clarke and M. J. West., p. 314 (1997).
37. "Gravitational Wave Extraction and Outer Boundary Conditions by Perturbative Matching,” A. M. Abrahams, L. Rezzolla, M. E. Rupright, A. Anderson, P. Anninos, T. W. Baumgarte, N. T. Bishop, S. R. Brandt, J. C. Browne, K. Camarda , M. W. Choptuik, G. B. Cook, C. R. Evans, L. S. Finn, G. Fox, R. Gomez, T. Haupt, M. F. Huq, L. E. Kidder, S. Klasky, P. Laguna , W. Landry, L. Lehner, J. Lenaghan, R. L. Marsa, J. Masso, R. A. Matzner, S. Mitra, P. Papadopoulos, M. Parashar, F. Saied, P. E. Saylor, M. A. Scheel, E. Seidel, S. L. Shapiro,

D. Shoemaker, L. Smarr, B. Szil´agyi, S. A. Teukolsky, M. H. P. M. van Putten, P. Walker, J. Winicour, J. W. York Jr., Physical Review Letters, 80, 1812 (1998). **

38. "Boosted Three-Dimensional Black-Hole Evolutions with Singularity Excision," G. B. Cook, M. F. Huq, S. A. Klasky, M. A. Scheel, A. M. Abrahams, A. Anderson, P. Anninos, T. W. Baumgarte, N. T. Bishop, S. R. Brandt, J. C. Browne, K. Camarda, M. W. Choptuik, C. R. Evans , L. S. Finni G. C. Fox, R. G´omez, T. Haupt, L. E. Kidder, P. Laguna, W. Landry, L. Lehner, J. Lenaghan , R. L. Marsa, J. Masso, R. A. Matzner, S. Mitra, P. Papadopoulos, M. Parashar, L. Rezzolla, M. E. Rupright , F. Saied, P. E. Saylor, E. Seidel, S. L. Shapiro, D. Shoemaker, L. Smarr, W. M. Suen , B. Szil´agyi, S. A. Teukolsky, Physical Review Letters, 80, 2512-2516 (1998). **
39. "Stable Characteristic Evolution of Generic 3-Dimensional Single-Black-Hole Spacetimes," R. Gomez, L. Lehner, R. L. Marsa, J. Winicour, A. M. Abrahams, A. Anderson, P. Anninos, T. W. Baumgarte, N. T. Bishop, S. R. Brandt, J. C. Browne, K. Camarda , M. W. Choptuik, R. R. Correl, G. B. Cook, C. R. Evans, L. S. Finn, G. C. Fox, T. Haupt, M. F. Huq, L. E. Kidder, S. A. Klasky, P. Laguna, W. Landry, J. Lenaghan, J. Masso, R. A. Matzner, S. Mitra, P. Papadopoulos, M. Parashar, L. Rezzolla, M. E. Rupright, F. Saied, P. E. Saylor, M. A. Scheel, E. Seidel, S. L. Shapiro, D. Shoemaker, L. Smarr, B. Szilagyi, S. A. Teukolsky, M. H. P. M. van Putten, P. Walker, J. W. York Jr., Physical Review Letters, 80, 3915-3918 (1998). **

**Computational Astrophysics.** My students and co-workers were able to extend these computational methods to include general relativistic hydrodynamics and magnetohydrodynamics and apply this new capability to the solution of fundamental problems such as accretion onto black holes, which powers galactic nuclei. My colleagues and I later used supercomputers to perform the first computations of colliding neutron stars, non-spherical supernova collapse, and extragalactic radio jets. All of these areas are flourishing computational astrophysical science fields today.

1. "Basic Concepts in Finite Differencing of Partial Differential Equations," in Sources of Gravitational Radiation, 139-159, ed. L. Smarr (Cambridge University Press) (1979). *
2. "General Relativistic Hydrodynamics: The Comoving, Eulerian, and Velocity Potential Formalism," L. Smarr, C. Taub, and J. R. Wilson, in Essays in General Relativity: A Festschrift for Abraham Taub, ed. F. Tipler, (Academic Press) (1980). *
3. "Rayleigh-Taylor Overturn in Supernova Core Collapse," L. Smarr, J. R. Wilson, R. T. Barton, and R. L. Bowers, Astrophysical Journal, 246, 515-525 (1981). **
4. "Hydrodynamical Formation of Twin-Exhaust Jets," M. L. Norman, L. Smarr, J. R. Wilson, and M. D. Smith, Astrophysical Journal, 247, 52-58 (1981). **
5. "Can the Twin-Exhaust Model Explain Radio Jets?" M. D. Smith, L. Smarr, M. L. Norman, and J. R. Wilson, Nature, 293, 277-279 (1981). *
6. "Structure and Dynamics of Supersonic Jets," M. Norman, K.-H. Winkler, L. Smarr, and M. Smith, Astron. & Astrophys., 113, 285-302, (1982). **
7. "Propagation and Morphology of Pressure-Confined Supersonic Jets, in Astrophysical Jets," M. Norman, K.-H. Winkler, and L. Smarr, 227-251, in Astrophysical jets; Proceedings of the International Workshop, Turin, Italy, ed. A. Ferrari and A. G. Pacholczyk (D. Reidel: Dordrecht) (1983). *
8. "Bubbles, Jets and Clouds in Active Galactic Nuclei," M. D. Smith, L. Smarr, M. L. Norman, and J. R. Wilson, Astrophysical Journal, 264, 432-445 (1983). *
9. "A Numerical Study of Non-Spherical Black Hole Accretion. I. Equations and Test Problems," J. Hawley, J. R. Wilson, and L. Smarr, Astrophysical Journal, 277, 296-311 (1983). **
10. "A Numerical Study of Nonspherical Black Hole Accretion. II. Finite Differencing and Code Calibration," J. Hawley, J. R. Wilson, and L. Smarr, Astrophysical Journal Suppl., 55, 211-246 (1984).
11. "General Relativistic Hydrodynamics and Accretion Physics: A Numerical Approach," J. Hawley and L. Smarr, 256-269, in Problems of Collapse and Numerical Relativity, ed. D. Bancel and M. Signore (Reidel: Dordrecht) (1984).
12. "Shocks, Interfaces and Patterns in Supersonic Jets," Smarr, L., Norman, M., Winkler, K.-H.. Physica 12D, 83-106. (1984)

13. “Knot Production and Jet Disruption via Nonlinear Kelvin-Helmholtz Pinch Instabilities,” M. Norman, K.-H. Winkler, and L. Smarr, in Physics of Energy Transport in Extragalactic Radio Sources, 150-168, ed. A. Bridle and J. Eilek (NRAO: Green Bank) (1985).
14. “Hot Spots in Radio Galaxies: A Comparison with Hydrodynamic Beam Cap Simulations,” M. Smith, M. Norman, K.-H. Winkler, and L. Smarr, Mon. Not. Royal Astronomical Soc., 214, 67-85 (1985). **
15. “Fluid Dynamical Mechanisms for Knots in Astrophysical Jets,” M. Norman, L. Smarr, and K.-H. Winkler, in Numerical Astrophysics, 88-126, ed. J. Centrella, J. LeBlanc, and R. Bowers (Jones and Bartlett: Boston) (1985). *
16. “General Relativistic Magnetohydrodynamics,” J. H. Sloan and L. L. Smarr, in Numerical Astrophysics, 52-68, ed. J. Centrella, J. LeBlanc, and R. Bowers (Jones and Bartlett: Boston) (1985).
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**Theoretical and Observational Astronomy Studies.** The lifetime evolution of binary stellar systems, including both changes in the component stars and the binary system itself, were studied with a focus on compact objects and gravitational radiation. With colleagues, I carried out astronomical observations with ground-based radio (VLA) and optical (Kitt Peak) telescopes at the NSF national observatories, as well as space-based x-ray (Einstein) satellites and integrated the findings into an updated understanding of our neighbor Andromeda galaxy.

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**Supercomputing Computational Science.** My experience in the 1970s and early 1980s using supercomputers at Department of Energy labs and European centers convinced me that the National Science Foundation (NSF) needed to

make this capability widely available to university researchers. My unsolicited NSF proposal in 1983 helped define the need for what became the NSF Supercomputer Center program. In 1985 my proposal was funded and I became the founding director of the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. I oversaw bringing successive generations of high-performance computers to the national research community, first with vectors [Cray X-MP, Cray Y-MP, Convex], then massively parallel [Alliant, CM-2, CM-5], shared memory [SGI Challenge, Power Challenge, Origin], and finally large-scale superclusters. Based on these experiences, I co-authored a book on the scientific underpinnings of the many disciplines of science and engineering that were being transformed by this computational methodology.

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**Building Scientific Visualization, Virtual Reality, CineGrid, Telepresence, and Collaboratories.** For 50 years I have used visualization in computational science. At NCSA we set up a pioneering scientific visualization team. My partnership with the leaders of UIC’s Electronic Visualization Lab for 35 years has enabled us to build a sequence of world-leading capabilities in virtual reality, telepresence, and collaboratories, including the StarCAVE and VROOM at Calit2. We partnered with the cinema industry to create the CineGrid workshops which has had presentations on the leading-edge work on high resolution, globally streaming media.

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**Developing a Distributed Machine Learning Cyberinfrastructure for Big Data Scientific Research.** By 1988 the Internet had enabled building distributed “virtual” computers, by connecting different architectures of computers, large distributed data stores, visualization devices, and scientific instruments, forming what I termed “Metacomputers” or later “The Grid.” My 2002 OptIPuter NSF grant demonstrated that the wide-area bandwidth could be as fast as the backplane of a cluster, essentially eliminating distance for collaborative Big Data scientific research. This was followed by two NSF grants, Quartzite (2004) and Prism (2013), which demonstrated how to create high-speed “Big Data Freeways” on university campuses. The 2008 NSF GreenLight grant enabled us to research how such systems can be made more energy-efficient. In 2015, the NSF funded the Pacific Research Platform (PRP) grant to interconnect several dozen of these campus systems, built on four Regional Optical Networks (RONs: CENIC, PNWGP, FRGP, and MREN), enabling researchers to quickly move data between collaborators labs, supercomputer centers, instruments, and data repositories. The distributed PRP, driven by dozens of science and engineering applications, creates a metacomputer that allows the data to traverse multiple, heterogeneous networks with minimal performance degradation. Machine learning was added to the PRP in 2017 when NSF funded the Cognitive Hardware and Software Ecosystem Community Infrastructure (CHASE-CI) grant. In 2018, NSF funded Toward the National Research Platform (TNRP) to extend the PRP across the country by federating with four midwestern/eastern RONs and Internet2.

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**Investigating Microbial Communities.** I was fortunate to have Carl Woese, the Father of the microbial Tree of Life, as a mentor on microbes at UIUC in the 1990s. In 2005, the Gordon and Betty Moore Foundation funded me to create a Calit2 computational and storage Community Cyberinfrastructure for Advanced Microbial Ecology Research and Analysis (CAMERA) to become a global repository for microbiome ecology datasets. Then in 2014, I helped recruit Rob Knight to UCSD and have been a close collaborator of his since. With his Center for Microbiome Innovation's extraordinarily talented team, as well as other UCSD collaborators, I have helped investigate many frontier areas of the exploding field of microbiomes and how they interact with their hosts or environments.

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2. "A Community Resource for Metagenomics: CAMERA," R. Seshadri, S.A. Kravitz, L. Smarr, P. Gilna, M. Frazier, PLoS Biol 5(3): e75 (2007) **
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**Quantifying My Body in Health and Disease.** One of the Calit2's original interdisciplinary themes in 2000 was "Digitally Enabled Genomic Medicine," which envisioned a future in which both the human genomics and wireless sensor "read out" of individuals would be routine, as they have come to be 20 years later. I decided that to better understand these evolving trends I should try to live as a Future Patient in what Lee Hood has termed Predictive, Preventive, Personalized and Participatory (P4) Medicine. I had my full human genome sequenced and became actively involved with quantifying the state of my body, creating multi-year time-series of over 150 biomarkers from my blood and stool, with the later revealing the dynamics of gut microbiome genomics. In addition, I became an early member of Harvard's Personal Genome Project led by George Church and of Lee Hood's Pioneer 100 Wellness Project. By 2011, using these time series, I discovered that I was chronically inflamed, caused by an autoimmune disease [inflammatory bowel disease (IBD)-colonic Crohn's disease] that both my doctors and I were unaware I had. The progression of the disease caused massive dysbiosis in my gut microbiome and eventually a stricture in my sigmoid colon. My team has worked for several years with Rob Knight's team to analyze my gut microbiome time-series, while I developed close collaborations with UCSD doctors in surgery, radiology, gastroenterology, and other specialties. My Calit2@UCSD software development team has developed interactive visualization tools and environments for analyzing large amounts of human-generated biomedical data, including most recently 3D visualizations of individual patients derived from MRI/CAT scans to personalize pre-planning of robotically-assisted surgery, which I was able to help prototype with a sigmoid resection in November 2016.

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