Sheperd Doeleman - Curriculum Vitae

Center for Astrophysics | Harvard & Smithsonian
60 Garden St., MS-42
Cambridge, Mass. 02138
(617) 496-7762

Email: sdoeleman@cfa.harvard.edu
Web site: https://projects.iq.harvard.edu/sdoeleman

Education

1986 BA in Physics, Reed College, Portland, OR.
1995 PhD in Physics, Massachusetts Institute of Technology, Cambridge, MA

Employment/Positions

1986-1988	Research Fellow, Bartol Research Institute, McMurdo Station Antarctica
1995-1998	Postdoctoral Fellow, MIT Haystack Observatory
1998-2009	Research Scientist, MIT Haystack Observatory
2009-2016	Principal Research Scientist, MIT Haystack Observatory
2010-2016	Assistant Director, MIT Haystack Observatory
2012-2016	Astrophysicist, Harvard-Smithsonian Center for Astrophysics
2016-present	Senior Research Fellow, Harvard University, Astronomy Dept.
2016-present	Senior General Engineer, Smithsonian Astrophysical Observatory
2016-present	Assistant Director, Black Hole Initiative – Harvard University
2016-2019	Director, Event Horizon Telescope Consortium
2019-present	Founding Director, Event Horizon Telescope Consortium

Teaching/Mentoring

1991 – 1994	Graduate Teaching Assistant, MIT Physics Department
Spring 1993	Recitation Instructor, Introductory Mechanics, MIT Physics Department
Spring 2002	Recitation Instructor, Introductory E+M, MIT School of Engineering
Spring 2004	Course Instructor, Introductory E+M, MIT School of Engineering
1998-present	Mentor for 12 Undergraduate Students through the REU, UROP and SAO Research Intern programs.
2008-present	Postdoctoral Fellows: Vincent Fish, Rusen Lu, Laura Vertatschitsch, Michael Johnson, Lindy Blackburn, Andre Young, Hotaka Shiokawa, Kazu Akiyama, Katie Bouman, Alex Raymond, Dominic Pesce, Maciek Wielgus, Mislav Balokovic, Christian Fromm.
2012-present	Graduate Students: Katherine Rosenfeld, Andrew Chael, Daniel Palumbo.

Awards

MIT Buechner Teaching Prize, 1993.
DAAD Grant for Research Visit to Max Planck Institut für Radioastronomie in Bonn, 1996.
MIT Excellence Award – Awarded for Community Outreach, 2003.
Guggenheim Fellowship, 2012: "Building an event horizon telescope"
NSF Diamond Achievement Award (to the EHT collaboration - 2019)
AAS Lancelot M. Berkeley Prize, 2020
Breakthrough Prize in Fundamental Physics (to the EHT Collaboration - 2020)
Smithsonian American Ingenuity Award (to SD and the EHT Collaboration - 2019)
AAS HEAD Bruno Rossi Prize (to SD and the EHT Collaboration - 2020)

Professional Activities

Peer Reviewer: *Astrophysical Journal, Science, PASJ, Nature, MNRAS*
NSF Grant Reviewer: AST, OPP divisions
VLBI Future Committee (2003-2004)
Arecibo Users and Scientific Advisory Committee 2006-2008 (chair 2008)
NRAO Users Committee (2012 - 2015)
ALMA North America Science Advisory Committee – ANASAC (2012 – 2015)
Breakthrough Prize Committee (2020 - present)

Grant History: More than $50M to launch and sustain the EHT.

(Past Awards)

NSF AST-0096454
"Astronomical Research and Technical Support of Millimeter-Wavelength VLBI"
PI: A.E.E. Rogers co-PI: S.S. Doeleman, R.B. Phillips
May 2001 to April 2004, total amount $1.2M

NSF AST-0352953
"Ultra High Sensitivity VLBI: A Leap in Bandwidth"
PI: S.S. Doeleman co-PI: C.J. Lonsdale, A.R. Whitney
August 2004 to July 2008, total amount $950K

NSF AST-0521233
"Development of a Flexible Wideband Digital Backend for Radio Interferometry"
PI: A. Whitney co-PI: S.S. Doeleman, A.E.E. Rogers
April 2006 to April 2009, total amount $631K

NSF AST-0603971
"Advanced Correlation Techniques for Next-Generation Radio Arrays"
PI: C. Lonsdale co-PI: S.S. Doeleman, D. Oberoi
May 2006 to May 2009, total amount $400K

NSF AST-0705062
"Development of a Burst Mode Data Recorder for Radio Astronomy"
PI: A. Whitney co-PI: S.S. Doeleman
June 2007 to June 2010, total amount $540K

NSF AST-0722168
"Development of a Cooled Sapphire Oscillator Frequency Standard for VLBI"
PI: A. Whitney co-PI: S.S. Doeleman
Aug 2007 to Aug 2011, total amount $460K

NSF AST-0807843
"Techniques of Submm-VLBI: Observing an Event Horizon"
PI: S.S. Doeleman co-PI: A. Rogers
June 2008 to June 2011, total amount $335K

NSF AST-0905844
"High Sensitivity VLBI Arrays: Towards Imaging an Event Horizon"
PI: S.S. Doeleman co-PI: A. Rogers, A. Whitney
Aug 2009 to July 2013, total amount $2.7M

NSF AST-0908731
"Ultra Wideband VLBI: Origins of Extragalactic Jets"
PI: S.S. Doeleman
July 2009 to July 2012, total amount $363K

NSF OIA-0922984
"MRI: Acquisition of a Stable Hydrogen Maser Frequency Standard for mm/submm VLBI Observations of a Black Hole Event Horizon"
PI: S.S. Doeleman
Sept 2009 to Sept 2012, total amount $288K (plus $123K international cost-sharing)

MIT International Science & Technology Initiatives (MISTI) Grant
"Phasing the Atacama Large Telescope Array for Observing a Black Hole Event Horizon"
PI: S.S. Doeleman
Jan 2012 – March 2015, total amount $30K

Smithsonian Astrophysical Observatory
"Chandra HETG Ultra-deep Gratings Spectroscopy of SgrA* (CHUGSS)"
PI: F. Baganoff (MIT) co-PI: (multiple, including S.S. Doeleman)
Jan 2012 to Jan 2015, total amount $4K

NSF OIA-1126433
"MRI: Development of an ALMA Beamformer for Ultra High Resolution VLBI and High Frequency Phased Array Science"
PI: S.S. Doeleman co-PI: A. Whitney
Aug 2011 to Aug 2015, total amount $2.76M (plus $1.3M international cost-sharing)

NSF AST-1207704
"Collaborative Research: Building an Event Horizon Telescope: (Sub)millimeter VLBI from the South Pole Telescope"
PI: S.S. Doeleman
July 2012 to July 2015, total amount $191K

NSF AST-1211539
"Spatially Resolving the Black Hole Event Horizon: (sub)mm VLBI of SgrA* and M87"
PI: S.S. Doeleman co-PI: V. Fish
July 2012 to July 2015, total amount $382K

NRAO ALMA Development Program
"ALMA Phasing Project Augmentation"
PI: S.S. Doeleman
Feb 2013 to Aug 2015, total amount $260K

Gordon & Betty Moore Foundation: GBMF-3561
"Imaging supermassive black holes with an Earth-sized radio telescope"
PI: S.S. Doeleman co-PI: J. Weintroub
Feb 2013 to Feb 2017, total amount $1.8M

NSF AST-1310896
"Building the Event Horizon Telescope: Observing Black Holes with Schwarzschild Radius Resolution"
PI: S.S. Doeleman
August 2013 to August 2017, total amount $2.29M

NSF AST-1337663
"Acquisition of Stable Hydrogen Maser Frequency Standards for Millimeter/Submillimeter VLBI Observations of a Black Hole Event Horizon"
PI: S.S. Doeleman co-PI: J. Weintroub
August 2013 to present, total amount $411K (plus $176K institutional cost-sharing from SAO).

MIT International Science & Technology Initiatives (MISTI) Grant
"Imaging Black Holes with the Gran Telescopio Milimetrico"
PI: S.S. Doeleman
Jan 2014 – Jan 2016, total amount $30K

Smithsonian Institution Competitive Grants Program for Science (CGPS) Grant
"VLBI with the LMT: Bringing Black Holes into Focus"
PI: S.S. Doeleman
Jan 2014 – Jan 2016, total amount $100K

Smithsonian Institution Competitive Grants Program for Science (CGPS) Grant
"Weighing the neutrino with Radio Frequency Techniques"
PI: S.S. Doeleman
Jan 2015 – Jan 2017, total amount $60K

NSF AST-1555365
"MRI: Development of an ALMA Beamformer for Ultra High Resolution VLBI and High Frequency Phased Array Science [Extension]"
PI: S.S. Doeleman
Sept 2015 – Sept 2016, total projected amount $315K

NRAO: ALMA-NA Development Fund
"Digital Correlator and Phased Array Architectures for Upgrading ALMA"
PI: J. Weintroub co-PI's: S. Doeleman, R. Escoffier, A. Baudry, R. Lacasse, B. Carlson
Apr 2016 – Sept 2017, total amount $148K

NRAO: ALMA-NA Development Fund
"Pulsars, Magnetars, and Transients with Phased ALMA"
PI: J. Cordes co-PI's: S. Doeleman, M. Kramer, S. Ransom
Feb 2016 – June 2017, total amount $185K

NRAO: ALMA-NA Development Fund
"ALMA Study Project: Extensions and Enhancements to the ALMA Phasing System"
PI: L. Matthews co-PI's: S. Doeleman, G. Crew, V. Fish, M. Hecht
Feb 2016 – June 2017, total amount $200K

John Templeton Foundation (Grant #60477)
"The Black Hole Initiative: Towards a Center for Interdisciplinary Research"
PI: S. Doeleman co-I's: A. Loeb, R. Narayan, A. Strominger, P. Galison, S.T. Yau
Sept 2016 – Sept 2019, total amount $7.2M

(Current Awards)

NSF AST- 1440254 & AST-1952099 (Mid-Scale Innovation Program)
"The Event Horizon Telescope Experiment"
PI: S.S. Doeleman co-I's: N. Erickson, V. Fish, D. Marrone, G. Narayanan
Jan 2015 – Jun 2021, total projected amount $7.8M

Gordon & Betty Moore Foundation: GBMF-5278
"Enhancing the Event Horizon Telescope: Sharpening Our Views of Black Holes"
PI: S.S. Doeleman co-PI: J. Weintroub, M. Johnson
Nov 2016 - Jan 2022, total projected amount $2.0M

NSF AST – 1716536 (Astronomy & Astrophysics Research Grants)
"Collaborative Research: Connecting 3D Simulations of Magnetized Disks and Jets with Direct Event Horizon Telescope Observations"
PI: S. Doeleman co-PI: M. Johnson
May 2017 – May 2020, total projected amount $126K

NSF AST- 1726637 (Major Research Instrumentation)
"MRI: Development of Next Generation Digital Signal Processing Platforms for Astronomy"
PI: S.S. Doeleman co-PI: J. Weintroub
Aug 2017 – Aug 2020, total projected amount $1.2M ($371K SAO cost-sharing included).

NSF AST-1743747 (Partnership for International Research and Education)
"PIRE: Black Hole Astrophysics in the Era of Distributed Resources and Expertise"
PI: D. Psaltis co-PI's: S. Doeleman, D. Marrone, F. Ozel, C. Gammie
Aug 2017 – Aug 2022, total projected amount $5.7M ($790K sub-award to SAO, PI Doeleman).

NSF AST- 1828513 (Major Research Instrumentation)
"MRI: Development of a Cloud Computing Platform for Interferometric Processing"
PI: S.S. Doeleman co-PI: J. Weintroub
Aug 2018 – Aug 2021, total projected amount $1.2M ($363K SAO cost-sharing included).

John Templeton Foundation (Grant #61497)
"The Black Hole Initiative: Phase II"
PI: S. Doeleman co-I's: A. Loeb, R. Narayan, A. Strominger, P. Galison, S.T. Yau
Sept 2019 – Sept 2022, total projected amount $3.6M

NSF Mid-Scale Research Infrastructure (MSRI-I)
"Mid-scale RI-1 (M1:DP): Next Generation Event Horizon Telescope Design"
PI: S. Doeleman co-I's: M. Johnson, L. Blackburn, J. Weintroub
Oct 2019 – Oct 2023, total projected amount $12.7M

(Pending Awards)

NSF Mid-Scale Innovation Program (MSIP)
"The Event Horizon Telescope: Resolving Black Holes in Time and Space"
PI: V. Fish co-I's: S. Doeleman, D. Marrone
Oct 2020 – Aug 2024, total requested amount $11.6M

Refereed Journal Publications

1. Kim, J-Y., Krichbaum, T. P., Broderick, A. E., et al. "Event Horizon Telescope imaging of the archetypal blazar 3C 279 at an extreme 20 microarcsecond resolution," *A&A*, **640**, A69, (2020).
2. Gold, R., Broderick, A. E., Younsi, Z., et al. "Verification of Radiative Transfer Schemes for the EHT," *ApJ*, **897**, 148, (2020).
3. Broderick, A. E., Gold, R., Karami, M., et al. "THEMIS: A Parameter Estimation Framework for the Event Horizon Telescope," *ApJ*, **897**, 139, (2020).
4. Blackburn, L., Pesce, D. W., Johnson, M. D., Wielgus, M., Chael, A. A., Christian, P., & Doeleman, S. S., "Closure Statistics in Interferometric Data," *ApJ*, **894**, 31, (2020).
5. Roelofs, F., Janssen, M., Natarajan, I., et al. "SYMBA: An end-to-end VLBI synthetic data generation pipeline. Simulating Event Horizon Telescope observations of M 87," *A&A*, **636**, A5, (2020).
6. Johnson, M. D., Lupsasca, A., Strominger, A., et al. "Universal interferometric signatures of a black hole's photon ring," *Science Advances*, **6**, eaaz1310, (2020).
7. Doeleman, S., Blackburn, L., et al., "Studying Black Holes on Horizon Scales with VLBI Ground Arrays," *BAAS*, **51**, 256, (2019). https://ui.adsabs.harvard.edu/abs/2019BAAS...51g.256D/abstract
8. Johnson, M. et al., "Studying black holes on horizon scales with space-VLBI," *BAAS*, **51**, 235, (2019). https://ui.adsabs.harvard.edu/abs/2019BAAS...51g.235J/abstract
9. Liu, K. et al., "Detection of Pulses from the Vela Pulsar at Millimeter Wavelengths with Phased ALMA," ApJL, **885**, 10, (2019).
10. Gill, A., Blackburn, L., Roshanineshat, A., Chan, C-K., Doeleman, S., Johnson, M., Raymond, A. & Weintroub, J., "Prospects for Wideband VLBI Correlation in the Cloud," *PASP,* **131**, 124501, (2019).
11. Palumbo, D., Doeleman, S., Johnson, M., Bouman, K. & Chael, A., "Metrics and Motivations for Earth-Space VLBI: Time-Resolving SgrA* with the Event Horizon Telescope," *ApJ*, **881**, 62, (2019). *https://arxiv.org/pdf/1906.08828.pdf*
12. Blackburn, L. et al., "EHT-HOPS pipeline for millimeter VLBI data reduction," *ApJ*, **882**, 23, (2019). *https://arxiv.org/abs/1903.08832*
13. Doeleman, S. et al., "Black Hole Physics on Horizon Scales," *BAAS* , **51** , 537, (2019). *https://baas.aas.org/wp-content/uploads/2019/05/537_doeleman.pdf*
14. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. VI. The Shadow and Mass of the Central Black Hole," *ApJL,* **875**, 6, (2019).

15. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. V. Physical Origin of the Asymmetric Ring," *ApJL,* **875**, 5, (2019).

16. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. IV. Imaging the Central Supermassive Black Hole," *ApJL,* **875**, 4, (2019).

17. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. III. Data Processing and Calibration," *ApJL,* **875**, 3, (2019).

18. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. II. Array and Instrumentation," *ApJL,* **875**, 2, (2019).

19. Event Horizon Telescope Collaboration et al., "First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole," *ApJL,* **875**, 1, (2019).

20. Doeleman, S. et al, "Focus on the First Event Horizon Telescope Results," *ApJL Focus Issue, https://iopscience.iop.org/journal/2041-8205/page/Focus_on_EHT*

21. Issaoun, S. et al, "The Size, Shape and Scattering of Sagittarius A* at 86GHz: First VLBI with ALMA," *ApJ,* **871,** 30, (2019). https://arxiv.org/abs/1901.06226

22. Brinkerink, C. et al, "Micro-arcsecond structure of Sagittarius A* revealed by high-sensitivity 86GHz VLBI observations," *A&A*, ***621,*** A119, (2019). *https://arxiv.org/abs/1811.08394*

23. Bower, G. et al, "ALMA Polarimetry of SgrA*: Probing the Accretion Flow from the Event Horizon to the Bondi Radius," *ApJ,* **868**, 101, (2018). *https://arxiv.org/abs/1810.07317*

24. Kim, J. et al, "A VLBI receiving system for the South Pole Telescope," *Proc. SPIE*, **10708**, 19, (2018). DOI: 10.1117/12.2301005

25. Kubo, D. et al, "Electronics instrumentation for the Greenland Telescope," *Proc. SPIE*, **10708**, 19, (2018). DOI: 10.1117/12.2312241

26. Nishioka, H. et al, "Control and monitoring system for the Greenland Telescope: computers, network and software," *Proc. SPIE*, **10700**, 11, (2018). DOI: 10.1117/12.2313104

27. Matsushita, S. et al, "Commissioning status of the Greenland Telescope (GLT)," *Proc. SPIE*, **10700**, 10, (2018). DOI: 10.1117/12.2310046

28. Chen, M-T. et al, "The Greenland telescope: Thule operations," *Proc. SPIE*, **10700**, 12, (2018). DOI: 10.1117/12.2313378

29. Kim, J. et al, "The 1.4mm Core of Centaurus A: First VLBI Results with the South Pole Telescope," *ApJ*, **861**, 129, (2018). *https://arxiv.org/abs/1805.09344*

30. Lu, R-S., Krichbaum, T., Roy, A., Fish, V., Doeleman, S. et al, " Detection of Intrinsic Source Structure at ~3 Schwarzschild Radii with Millimeter-VLBI Observations of Sagittarius A*," *ApJ*, **859**, 60, (2018). *https://arxiv.org/abs/1805.09223*

31. Matthews, L., Crew, G., Doeleman, S. et al, "The ALMA Phasing System: A Beamforming Capability for Ultra-high-resolution Science at (Sub)Millimeter Wavelengths," *PASP*, **130**, 015002, (2018). *https://arxiv.org/abs/1711.06770*

32. Bouman, K. et al, "Reconstructing Video from Interferometric Measurements of Time-Varying Sources," *in IEEE Transactions on Computational Imaging,* **4**, 512, (2018). *https://arxiv.org/abs/1711.01357*

33. Johnson, M. et al, "Dynamical Imaging with Interferometry," *ApJ,* **850**, 172, (2017). *https://arxiv.org/abs/1711.01286*

34. Doeleman, S., "Seeing the Unseeable," *NatAs*, **1**, 646, (2017). *https://arxiv.org/abs/1710.03104*

35. Roelofs, F., Johnson, M., Shiokawa, H., Doeleman, S. & Falcke, H., "Quantifying Intrinsic Variability of Sagittarius A* Using Closure Phase Measurements of the Event Horizon Telescope," *ApJ*, **847**, 55, (2017). *https://arxiv.org/abs/1708.01056*

36. Shiokawa, H., Gammie, C. & Doeleman, S., "Time Domain Filtering of Resolved Images of SgrA*," *ApJ*, **846**, 29, (2017). *https://arxiv.org/abs/1708.02577*

37. Akiyama, K. et al, "Superresolution Full-polarimetric Imaging for Radio Interferometry with Sparse Modeling," *AJ*, **153**, 159, (2017). *https://arxiv.org/abs/1702.00424*

38. Akiyama, K. et al, "Imaging the Schwarzschild-radius-scale Structure of M87 with the Event Horizon Telescope Using Sparse Modeling," *ApJ*, **838**, 1, (2017). *https://arxiv.org/abs/1702.07361*

39. Gold, R., McKinney, J., Johnson, M.D. & Doeleman, S.S., "Probing the magnetic field structure in Sgr A* on Black Hole Horizon Scales with Polarized Radiative Transfer Simulations," *ApJ,* **837**, 180, (2017). *http://arxiv.org/abs/1601.05550*

40. Brinkerink, C. et al, "Asymmetric structure in SgrA* at 3mm from closure phase measurements with VLBA, GBT and LMT," *MNRAS*, **462**, 1382, (2016). *https://arxiv.org/abs/1608.06515*

41. Fish, V. et al, "Observing – and Imaging – Active Galactic Nuclei with the Event Horizon Telescope," *Galaxies,* **4**, 54, (2016). *https://arxiv.org/abs/1607.03034*

42. Chael, A., Johnson, M., Narayan, R., Doeleman, S., Wardle, J. & Bouman, K., "High-resolution Linear Polarimetric Imaging for the Event Horizon Telescope," *ApJ*, **829**, 11, (2016). *https://arxiv.org/abs/1605.06156*

43. Ortiz-Leon, G., Johnson, M.D., Doeleman, S.S., et al, "The Intrinsic Shape of Sagittarius A* at 3.5mm Wavelength," *ApJ,* **824**, 40, (2016). *http://arxiv.org/abs/1601.06571*

44. Johannsen, T., Wang, C., Broderick, A., Doeleman, S., et al, "Testing General Relativity with Accretion-Flow Imaging of SgrA*," *PhRvL*, **116**, 091101, (2016).

45. Bouman, K.L., Johnson, M.D., Zoran, D., Fish, V.L., Doeleman, S.S. & Freeman, W.T., "Computational Imaging for VLBI Image Reconstruction," *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR),* p. 913-922, (2016). *http://arxiv.org/abs/1512.01413*

46. Broderick, A.E., Fish, V.L., Johnson, M., Rosenfeld, K., Wang, C., Doeleman, S.S., et al, "Modeling Seven Years of Event Horizon Telescope Observations with Radiatively Inefficient Accretion Flow Models," *ApJ*, **820**, 137, (2016).

47. Fish, V.L., Johnson, M.J., Doeleman, S.S., et al, "Persistent Asymmetric Structure of Sagittarius A* on Event Horizon Scales," *ApJ*, **820**, 90, (2016).

48. Lu, R., Roelofs, F., Fish, V., Shiokawa, H., Doeleman, S.S., et al, "Imaging an Event Horizon: Mitigation of Source Variability of Sagittarius A*," *ApJ*, **817***,* 173, (2016).

49. Johannsen, T., Broderick, A.E., Plewa, P.M., Chatzopoulos, S., Doeleman, S.S., et al, "Testing general relativity with the shadow size of SgrA*," *Phys Rev. Let,* **116**, 031101, (2016).

50. Vertatschitsch, L., et al, "R2DBE: A Wideband Digital Backend for the Event Horizon Telescope," *PASP*, **127**, 1226, (2015).

51. Johnson, M., Fish, V., Doeleman, S., et al, "Resolved Magnetic-Field Structure and Variability Near the Event Horizon of Sagittarius A*," *Science*, **350**, 1242, (2015).

52. Johnson, M., Loeb, A., Shiokawa, H., Chael, A. & Doeleman, S.S., "Measuring the Direction and Angular Velocity of a Black Hole Accretion Disk via Lagged Interferometric Covariance," *ApJ,* **813**, 132, (2015).

53. Wagner, J., et al "First 230 GHz VLBI Fringes on 3C 279 using the APEX Telescope," *A&A*, **581**, 32, (2015).

54. Akiyama, K., Ru-Sen, L., Fish, V., Doeleman, S.S., et al, "230 GHz VLBI observations of M87: event-horizon-scale structure at the enhanced very-high-energy gamma-ray state in 2012," *ApJ,* **807**, 150, (2015).

55. Broderick, A., Narayan, R., Kormendy, J., Perlman, E., Rieke, M. & Doeleman, S.S., "The Event Horizon of M87," *ApJ*, **805**, 179*,* (2015).

56. Bower, G.C., et al "The Proper Motion of the Galactic Center Pulsar Relative to Sagittarius A*," *ApJ*, **798**, 120, (2015).

57. Psaltis, D., Narayan, R., Fish, V.L., Broderick, A., Loeb, A. & Doeleman, S.S., "Event Horizon Telescope Evidence for Alignment of the Black Hole in the Center of the Milky Way with the Inner Stellar Disk," *ApJ*, **798**, 15, (2015).

58. Plambeck, R., Bower, G.C., Rao, R., Marrone, D., Jorstad, S.G., Marcher, A., Doeleman, S.S., Fish, V.L. & Johnson, M.D., "Probing the Parsec-scale Accretion Flow of 3C 84 with Millimeter Wavelength Polarimetry," *ApJ*, **797**, 66, (2014).

59. Inoue, M. et al, "Greenland telescope project: Direct confirmation of black hole with sub-millimeter VLBI," *Radio Science*, **49**, 564, (2014). https://arxiv.org/abs/1407.2450

60. Fish, V.L., Johnson, M.D., Lu, R.-S., Doeleman, S.S., Bouman, K., Zoran, D., Freeman, W., Psaltis, D., Narayan, R., Pankratius, V., Broderick, A., Gwinn, C. & Vertatschitsch, L., "Imaging an Event Horizon: Mitigation of Scattering toward Sagittarius A*," *ApJ*, **795**, 134, (2014).

61. Johnson, M.D., Fish, V.L, Doeleman, S.S., Broderick, A.E., Wardle, J.F.C. & Marrone, D.P., "Relative Astrometry of Compact Flaring Structures in SgrA* with Polarimetric Very Long Baseline Interferometry," *ApJ*, **794**, 150, (2014).

62. Lu, R.-S., Broderick, Avery, A.E., Baron, F., Monnier, J.D., Fish, V.L., Doeleman, S.S. & Pankratius, V., "Imaging the Supermassive Black Hole Shadow and Jet Base of M87 with the Event Horizon Telescope," *ApJ*, **788**, 120L, (2014).

63. Lu, R.-S., Fish, V.L, Akiyama, K., Doeleman, S.S., et al, "Fine-scale structure of the quasar 3C279 measured with 1.3mm Very Long Baseline Interferometry," *ApJ,* **772**, 13L, (2013).

64. Whitney, A.R., Beaudoin, C.J., Cappallo, R.J., Corey, B.E., Crew, G.B., Doeleman, S.S., et al, "Demonstration of a 16 Gbps per Station Broadband-RF VLBI System," *PASP*, **125**, 196, (2013).

65. Doeleman, S.S., et al, "Jet launching structure resolved near the supermassive black hole in M87," *Science,* **338**, 355, (2012).

66. Johannsen, T., Psaltis, D., Gillessen, S., Marrone, D., Özel, F., Doeleman, S. & Fish, V., "Masses of Nearby Supermassive Black Holes with Very-Long Baseline Interferometry," *ApJ,* 758, 30, (2012).

67. Lu, R.-S., Fish, V., Weintroub, J., Doeleman, S., et al, "Resolving the Inner Jet Structure of 1924-292 with the Event Horizon Telescope," *ApJL*, **757**, L14, (2012).

68. Doeleman, S.S., Mai, T., Rogers, A.E.E., Hartnett, J.G., Tobar, M.E. & Nand, N., "Adapting a Cryogenic Sapphire Oscillator for Very Long Baseline Interferometry," *PASP*, **123**, 582, (2011).

69. Broderick, A.E., Fish, V.L., Doeleman, S.S., & Loeb, A., "Constraining the Structure of Sagittarius A*'s Accretion Flow with Millimeter Very Long Baseline Interferometry Closure Phases," *ApJ*, **738**, 38, (2011).

70. Broderick, A.E., Fish, V.L., Doeleman, S.S. & Loeb, A., "Evidence for Low Black Hole Spin and Physically Motivated Accretion Models from Millimeter VLBI Observations of Sagittarius A*," *ApJ*., **735**, 110, (2011).

71. Fish, V.L., Doeleman, S.S., et al, "1.3 mm Wavelength VLBI of Sagittarius A*: Detection of Time-Variable Emission on Event Horizon Scales," *ApJL*, **727**, L36, (2011).

72. Fish, V.L., Doeleman, S.S., Broderick, A.E., Loeb, A. & Rogers, A.E.E., "Detecting Changing Polarization Structures in Sagittarius A* with High Frequency VLBI," *ApJ*, **706**, 1353, (2009).

73. Broderick, A., Fish, V., Doeleman, S., Loeb, A., "Estimating the Parameters of SgrA*'s Accretion Flow via Millimeter VLBI", *ApJ*, **697**, 45, 2009.

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