Steven D. Penn

Research Professor of Physics, Syracuse University
Associate Professor of Physics, Hobart & William Smith Colleges
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Employment:

2024 – present: Research Professor, Syracuse University
2009 – present: Associate Professor, Hobart & William Smith Colleges
2002 – 2008: Assistant Professor, Hobart & William Smith Colleges
2002 – 2024: Adjunct Research Professor, Syracuse University
1997 – 2002: Post-Doctoral Fellow, Syracuse University
1994 – 1997: Post-Doctoral Fellow, University of Washington

Education:

Massachusetts Institute of Technology — Cambridge, MA
Doctor of Philosophy in Physics, September 1993
Thesis: "An Examination of Two-Nucleon Correlations in ^{12}C via (e,e′p) and (e,e′d) at $X = 2$ and q = 913 MeV/c."
Thesis Supervisor: Professor William Bertozzi

Massachusetts Institute of Technology — Cambridge, MA
Bachelor of Science in Physics, June 1985

Awards:

Special Breakthrough Prize in Physics for LIGO Scientific Collaboration, 2016
Princess of Asturias Award for Technical & Scientific Research for LSC, 2017
The Karl Taylor Compton Award for Overall Excellence, MIT 1992

Research Committees:

LIGO Scientific Collaboration Council Chair, 2019–present
LIGO Scientific Collaboration Coatings Working Group Chair, 2011–2018

Select Publications:

Observation of gravitational waves from a binary black hole merger.
Abbott, B. P., et al. (LIGO and Virgo Collaborations including S Penn)
Phys. Rev. Lett. 116.6 (2016): 061102. *(Front cover article. First detection of GWs.)*

Substrate-transferred GaAs/AlGaAs crystalline coatings for gravitational-wave detectors
G. D. Cole, S. D. Penn, *et al.*
Appl. Phys. Lett, ***122****,* 110502 (2023) doi: 10.1063/5.0140663
(Selected as a Highlight of the Year 2023 by Optics and Photonics News)

Mechanical Ringdown Studies of Large-Area Substrate-Transferred GaAs/AlGaAs Crystalline Coatings
S D Penn, M M Kinley-Hanlon, Ian A. O. MacMillan, *et al.*
Journal Opt. Soc. Am. B, ***36****,* (2019) C15

Frequency and surface dependence of the mechanical loss in fused silica
Steven D Penn, *et al.*, *Phys. Lett. A* **352** No 1-2 (2006) 3-6

Gravitational Wave Detection and Coating Thermal Noise
S. Penn and D Ottaway, in *Optical Coatings for Precision Measurements*, Ed. by G. Harry, T. Bodiya, R. deSalvo, 2010, Cambridge University Press

Mechanical Loss in Silica/Tantala Dielectric Mirror Coatings
S D Penn, Sheila Rowan, *et al.*, *Class. Quantum Grav.* **20** (2003) 2917-2928

Mirror Coating Solution for the Cryogenic Einstein Telescope
Kieran Craig, Jessica Steinlechner, Steve Penn, *et alia*
Phys. Rev. Lett. **122**, 231102 *(Front cover article)*

TEACHING EXPERIENCE:

PROFESSOR, Hobart and William Smith Colleges, 2002-present

- General Relativity (400-level)
- Advanced Physics Laboratory (300-level Lab) ☆
- Electricity & Magnetism (300-level)
- Classical Mechanics (300-level, Lagrangian & Hamiltonian Mechanics)
- Modern Physics & Laboratory (200-level Lab) ☆
- Waves and Optics (200-level) ☆
- Mathematical Methods & Laboratory (200-level)
- Computational Methods / Scientific Computing ☆
- Introduction to Astrophysics (200-level) ☆
- Introduction to Astronomy (100-level, cosmology focus)
- Green Energy, (200-level, Physics & Environmental Studies) ☆
- Energy (100-level, Environmental Studies)
- Principles of Physics, (100-level, physics for nonmajors)
- PhysX (100-level Seminar) ☆
- How Things Work (100-level Seminar) ☆

☆ = New HWS Course developed by me

INSTRUCTOR, Syracuse University, 1998–1999

- Recitation instructor for First year physics (mechanics).
- Laboratory instructor for introductory astronomy.

INSTRUCTOR, University of Washington, 1995-1997

- Tutorial instructor for First-year physics (mechanics, E&M)

SERVICE COMMITTEES:

LIGO Scientific Collaboration Council Chair, 2019–present

LIGO Scientific Collaboration Bylaws Committee, 2012 (Chair), 2018

LIGO Scientific Collaboration Publication & Presentation Committee, 2008-13

APS Topical Group on Gravitation, Executive Board, Jan 2005–2008

NSF Grant Review Panel, Nov 2009

NSF Grant Review Panel for Experimental Gravity, Jan 2006

HWS Faculty Information Technology Committee, 2003–2005

HWS Committee on Standards (Chair), 2015–2019

CONFERENCE ORGANIZED:

First LIGO-Virgo Thermal Noise Meeting, Virgo Observatory, Pisa, Italy 2006

GRANT AWARDS:

NSF MRI Grant (2023): $1.08M with S. Ballmer (SU) & A. Gretarsson (ERAU)

NSF/Moore Foundation, "Center for Coating Research" grant award. $3M for 10 institutions, (Proposal co-authored by S. Penn, M. Fejer, and R. Bassiri). Awards for HWS: $107,738 (2017), $107,464 (2020), $108,714 (2023)

NSF, MPS Division, 9 grants from 2002-2026 totaling $1,985,103

NSF MRI Grant (Jan 2003): Award: $80,000.

NSF MRI Grant (July 2019): Award: $155,000 with Prof. Ballmer, Syracuse

Invited Talks:
Conferences

AlGaAs Coatings: Status, Challenges, & the Prospects for A#
- GWADW 2023, May 2023, LIGO-G2301065

Substrate-transferred GaAs/AlGaAs crystalline coatings for future gravitational wave detectors
- GRASS Conference, June 2022, LIGO-G2200935

Crystalline Coatings for Post-O5 LIGO & 3G Detectors
- Amaldi-14 Conference, July 2021, LIGO-G2101494

Post-O5 LIGO with Crystalline Coatings
- GWADW 2021, May 2021, LIGO-G2101071

From Thin Films to Black Holes: the impact of Thermal Noise in Gravitational Wave Astronomy
- 117th Topical Symposium of the NY State section of APS/AAS Joint Meeting, Union College, Nov 2017

How black holes relate to relaxation phenomena in amorphous oxide thin films
- 8th Symposium on Functional Coatings and Surface Engineering, June 2017

Developing Mirror Coatings for Future Gravitational Wave Detectors
- OSA Optical Interference Coatings Conference, June 2016

Prospects for Better Coatings
- Gravitational Wave Advanced Detector Workshop, May 2015

Wave of the Future: The Status of the LIGO and the Advanced LIGO Detectors
- Miami 2010 Conference, 18 Dec 2010

Status of LIGO and Advanced LIGO
- CHIPP Workshop on Space Time and Gravitation, Swiss Institute of Particle Physics, Lausanne, Switzerland, April 2006

Invited Talks:
Seminars & Colloquia

Gravitational Wave Detectors and the Challenge of Coating Thermal Noise
- CCRG/Astronomy Lunch Talk • RIT • 25 May 2016

How LIGO Detects Gravitational Waves and the Challenge of Coating Thermal Noise
- Ithaca College Physics & Astronomy Research Seminar, 13 Sept 2016

On Further Reflection: The structure of Fused Silica and the design of low loss, high index coatings
- Stanford University Byer-Fejer Group Seminar, 5 March 2014

Avenues for Reducing Coating Thermal Noise
- Institute for Gravitational Research, University of Glasgow, Dec 2013

Amorphous Coatings: Current Status — Future Plans
- Gravitational Wave Advanced Detector Workshop, May 2012

Gravity and Glass: Advanced LIGO, Thermal Noise and the Curious Physics of Fused Silica
- American University Physics Seminar, 20 April 2012

Wave of the Future: Advanced LIGO and the Next Generation of Gravitational Wave Detectors
- Old Dominion University Physics Colloquium, 16 Nov 2010

INVITED TALKS:
Seminars & Colloquia (continued)

Mechanical Loss in Fused Silica Substrates, and **Suspension Thermal Noise in Initial LIGO**
- LIGO-Virgo Thermal Noise Meeting, Virgo Observatory, Pisa, Oct. 2006

LIGO: The Next Wave in Astronomy
- SUNY Geneseo, Geneseo, NY, February 2006

Gravity Waves: The Missing Piece in Einstein's Theory of Relativity is a Window on the Universe
- Hamilton College, Clinton, NY, April 2005
- Ithaca College, Ithaca, NY, April 2005
- Hobart and William Smith Colleges, Geneva, NY, February 2005

Minimizing the Mechanical Loss in Fused Silica & Lowering the Thermal Noise in Advanced LIGO
- APS Spring Meeting, Tampa, FL, April 2005

Gravity Waves and the Wonders of Glass
- University of Glasgow, Glasgow, Scotland, UK, April 2003

Listening for the Ringing of Black Holes and Neutron Stars
- Hobart and William Smith Colleges, Geneva, NY March 2001

Vibrations in Space-Time. Vibrations in Glass: Thermal Noise in Advanced LIGO
- Hofstra University Physics Department, Hempstead, NY March 2000

Parting the Thermal Sea: Taming Thermal Noise for Advanced LIGO
- MIT Physics Department Seminar, Cambridge, MA June 1999

What?! That's Not Relativity! The Work of the Syracuse Experimental Relativity Group
- Syracuse University Relativity Seminar, Syracuse, NY April 1999

INVITED TALKS:
Nuclear Physics

New Techniques in Anelastic Aftereffect Measurements for High Q Mirror Materials
- APS Centennial meeting, Atlanta, GA March 1999

New Developments in Measuring Test Mass Thermal Noise Using the Anelastic Aftereffect
- Eastern Gravity Meeting, Syracuse, NY March 1998
- APS meeting, Columbus, OH April 1998

An Initial Measurement of the PNC Spin Rotation of Cold Neutrons in LHe
- Syracuse University Physics Department Seminar, Syracuse, NY Aug. 1997

The Eötwash Experiments: Tests of Gravity and the Search for Gravity-like Forces
- Syracuse University Physics Department Seminar, Syracuse, NY Aug. 1997

Apparatus to Measure the PNC Spin Rotation of Cold Neutrons in a LHe Target
- APS meeting, Indianapolis, IN April 1996

Exploring Two-Nucleon Correlations with 12C(e,e′d)
- University of New Hampshire, Durham, NH February 1995
- Argonne National Laboratory, Argonne, IL August 1994
- Nuclear Physics Lab., University of Washington, Seattle, WA Aug. 1994
- Saskatchewan Accelerator Lab, Saskatoon SK June 1994
- New Mexico State University, Las Cruces, NM May 1994

PUBLICATIONS:
Advanced LIGO:
Fused Silica Thermal Noise

Low temperature mechanical dissipation of an ion-beam sputtered silica film
I W Martin, R Nawrodt, K Craig, C Schwarz, R Bassiri, G Harry, J Hough, S Penn, S Reid, R Robie and S Rowan
Classical and Quantum Gravity **31.3** (2014): 035019.

Frequency and surface dependence of the mechanical loss in fused silica
Steven D Penn, Alexander Ageev, Dan Busby, Gregory M Harry, Andri M Gretarsson, Kenji Numata, and Phil Willems
Phys. Lett. A **352** No 1-2 (20 March 2006) 3-6

Very high quality factor measured in annealed fused silica
A Ageev, B C Palmer, A De Felice, S D Penn, & P R Saulson
Class. Quantum Grav. **21** No 16 (21 August 2004) 3887-3892

High Quality Factor Measured in Fused Silica
S.D. Penn, G.M. Harry, A.M. Gretarsson, S.E. Kittelberger, P.R. Saulson, J.J. Schiller, J.R. Smith, and S.O. Swords
Review of Scientific Instruments **72** (2001) 3670-3673.

PUBLICATIONS:
Advanced LIGO:
Silica Suspension Thermal Noise

Pendulum Mode Thermal Noise in Advanced Interferometers: A comparison of Fused Silica Fibers and Ribbons in the Presence of Surface Loss
A.M. Gretarsson, G.M. Harry, P.R. Saulson, S.D. Penn, W.J. Startin, S. Rowan, G. Cagnoli, J. Hough
Physics Letters ***A*** **270** (2000) 108-114

Intrinsic mechanical loss of laser-welded fused silica fibers
Gregory Harry, Thomas Corbitt, Marat Freytsis, David Ottaway, Nergis Mavalvala, Steven Penn
Rev. Sci. Instrum. **77** 023906 (2006)

Silica suspension and coating developments for Advanced LIGO
Cagnoli G, Armandula H, Cantley C A, Crooks D R M, Cumming A, Elliffe E, Fejer M M, Gretarsson A M, Harry G M, Heptonstall A, Hough J, Jones R, Mackowski J-M, Martin I, Murray P, Penn S D, Perreur-Lloyd M, Reid S, Route R, Rowan S, Robertson N A, Sneddon P H and Strain K A
J. Phys.: Conf. Ser. **32** (2006) 386-392

Mechanical Loss Associated with Silicate Bonding of Fused Silica
Joshua R. Smith, Peter R.Saulson, Steven D. Penn, Andri M.Gretarsson, Scott E. Kittelberger, Dave Guild, Gregory M. Harry, Joe C. Betzwieser, Michael J. Mortonson, Sheila Rowan, Jim Hough, D. R. M. Crooks
Class. Quantum Grav. **20** (2003) 5039-5047

PUBLICATIONS:
Advanced LIGO:
Mirror Coating Thermal Noise

Substrate-transferred GaAs/AlGaAs crystalline coatings for gravitational-wave detectors
G. Cole, S. Ballmer, G. Billingsley, S. Cataño-Lopez, M. Fejer, P. Fritschel, A. Gretarsson, G. Harry, D. Kedar, T. Legero, C. Makarem, S. Penn, D. Reitze, J. Steinlechner, U. Sterr, S. Tanioka, G-W. Truong, J. Ye, J. Yu
Appl. Phys. Lett, ***122****,* 110502 (2023) doi: 10.1063/5.0140663

Study on electro-optic noise in crystalline coatings toward future gravitational wave detectors
S. Tanioka, D. Vander-Hyde, G. Cole, S. Penn, S. Ballmer
Phys. Rev D, ***107****,* 022003 (2023)

PUBLICATIONS:

Advanced LIGO:
Mirror Coating Thermal Noise

Exploration of Co-Sputtered Ta2O5–ZrO2 Thin Films for Gravitational-Wave Detectors
M Abernathy, a Amato, a Ananyeva, S Angelova, B Baloukas, R Bassiri, G Billingsley, R Birney, G Cagnoli, M Canepa, M Coulon, J Degallaix, a Di Michele, M A Fazio, M M Fejer, D Forest, C Gier, M Granata, a M Gretarsson, e M Gretarsson, e Gustafson, e J Hough, M Irving, É Lalande, C Lévesque, a W Lussier, a Markosyan, i W Martin, L Martinu, B Maynard, C S Menoni, C Michel, P G Murray, C Osthelder, S Penn, L Pinard, K Prasai, S Reid, R Robie, S Rowan, B Sassolas, F Schiettekatte, R Shink, S Tait, J Teillon, G Vajente, M Ward And L Yang
Class. Quantum Grav. **38 (**2021**)** 195021

Effect of Elevated Substrate Temperature Deposition on the Mechanical Losses in Tantala Thin Film Coatings
G Vajente, R Birney, A Ananyeva, S Angelova, R Asselin, B Baloukas, R Bassiri, G Billingsley, M M Fejer, D Gibson, L J Godbout, E Gustafson, A Heptonstall, J Hough, S MacFoy, A Markosyan, I W Martin, L Martinu, P G Murray, S Penn, S Roorda, S Rowan, F Schiettekatte, R Shink, C Torrie, D Vine, S Reid and R X Adhikari
Class. Quantum Grav. **35** (2018) 075001

High Precision Detection of Change in Intermediate Range Order of Amorphous Zirconia-Doped Tantala Thin Films Due to Annealing
Prasai, K., Jiang, J., Mishkin, A., Shyam, B., Angelova, S., Birney, R., Drabold, D. A., Fazio, M., Gustafson, E. K., Harry, G., Hoback, S., Hough, J., Lévesque, C., MacLaren, I., Markosyan, A., Martin, I. W., Menoni, C. S., Murray, P. G., Penn, S., Reid, S., Robie, R., Rowan, S., Schiettekatte, F., Shink, R., Turner, A., Vajente, G., Cheng, H-P., Fejer, M. M., Mehta, A., Bassiri, R.
Phys. Rev. Lett. **123** (2019) 045501

Mirror coating solution for the cryogenic Einstein telescope
Craig, Kieran, Steinlechner, Jessica, Murray, Peter G., Bell, Angus S., Birney, Ross, Haughian, Karen, Hough, Jim, MacLaren, Ian, Penn, Steve, Reid, Stuart, Robie, Raymond, Rowan, Sheila, Martin, Iain W
Phys. Rev. Lett. **122** (2019) 231102 (Front cover article)

Mechanical Ringdown Studies of Large-Area Substrate-Transferred GaAs/AlGaAs Crystalline Coatings
Steven D. Penn, Maya M. Kinley-Hanlon, Ian A. O. MacMillan, Paula Heu, David Follman, Christoph Deutsch, Garrett D. Cole, Gregory M. Harry
*Journal Opt. Soc. Am. B, **36**,* (2019) C15

Effect of elevated substrate temperature deposition on the mechanical losses in tantala thin film coatings
G Vajente, R Birney, A Ananyeva, S Angelova, R Asselin, B Baloukas, R Bassiri, G Billingsley, M M Fejer, D Gibson, L J Godbout, E Gustafson, A Heptonstall, J Hough, S MacFoy, A Markosyan, I W Martin, L Martinu, P G Murray, S Penn, S Roorda, S Rowan, F Schiettekatte, R Shink, C Torrie, D Vine, S Reid, and R X Adhikari
Class. Quantum Grav. **35** (2018) 075001

Bulk and shear mechanical loss of titania-doped tantala
Matthew Abernathy, Gregory Harry, Jonathan Newport, Hannah Fair, Maya Kinley-Hanlon, Samuel Hickey, Isaac Jiffar, Andri Gretarsson, Steve Penn, Riccardo Bassiri, Eric Gustafson, Iain Martin, Sheila Rowan, Jim Hough
Physics Letters A (2017) https://doi.org/10.1016/j.physleta.2017.08.007

PUBLICATIONS:
Advanced LIGO:
Mirror Coating Thermal Noise

The effect of time on optical coating mechanical loss and implications for LIGO-India
Kinley-Hanlon, Maya, Hannah M. Fair, Isaac Jiffar, Jonathan Newport, Louis Gitelman, Gregory Harry, Garilynn Billingsley, and Steve Penn.
Classical and Quantum Gravity 33.14 (2016): 147001.

Al-doped ZnO amorphous films as conductive layers in ultra-low absorptive optical coatings
Ashot Markosyan and Riccardo Bassiri and Robert Faris and Valery Mitrofanov and Leonid Prokhorov and Steven Penn and Brian Lantz and Roger Route and Ric Shimshock and Martin M. Fejer
Optical Interference Coatings 2016, http://www.osapublishing.org/abstract.cfm?URI=OIC-2016-MB.4

Mapping the optical absorption of a substrate-transferred crystalline AlGaAs coating at 1.5 μm
Jessica Steinlechner, Iain W Martin, Angus Bell, Garrett Cole, Jim Hough, Steven Penn, Sheila Rowan and Sebastian Steinlechner
Classical and Quantum Gravity **32.10** (2015): 105008.

Ion-beam sputtered amorphous silicon films for cryogenic precision measurement systems
Peter G. Murray, Iain W. Martin, Kieran Craig, James Hough, Raymond Robie, Sheila Rowan, Matt R. Abernathy, Teal Pershing, and Steven Penn
Physical Review D **92.6** (2015): 062001.

Effect of heat treatment on mechanical dissipation in Ta_2O_5 coatings
Martin, IW; Bassiri, R; Nawrodt, R; Fejer, MM; Gretarsson, A; Gustafson, E; Harry, G; Hough, J; MacLaren, I; Penn, S; Reid, S; Route, R; Rowan, S; Schwarz, C; Seidel, P; Scott, J; Woodcraft, AL,
Class. Quantum Grav. **27**, 22502 (2010)

Cryogenic mechanical loss measurements of heat-treated hafnium dioxide
Abernathy, MR; Reid, S; Chalkley, E; Bassiri, R; Martin, IW; Evans, K; Fejer, MM; Gretarsson, A; Harry, GM; Hough, J; MacLaren, I; Markosyan, A; Murray, P; Nawrodt, R; Penn, S; Route, R; Rowan, S; Seidel, P,
Class. Quantum Grav. **28**, 19501 (2011)

Comparison of the temperature dependence of the mechanical dissipation in thin films of Ta_2O_5 and Ta_2O_5 doped with TiO_2
I Martin, E Chalkley, R Nawrodt, H Armandula, R Bassiri, C Comtet, M M Fejer, A Gretarsson, G Harry, J Hough,I MacLaren, C Michel, J-L Montorio, N Morgado, S Penn, S Reid, R Route, S Rowan, C Schwarz, P Seidel, W Vodel and A Zimmer
Class. Quantum Grav. **26**, 15501 (2009)

Measurements of a low-temperature mechanical dissipation peak in a single layer of Ta_2O_5 doped with TiO_2
I Martin, H Armandula, C Comtet, M M Fejer, A Gretarsson, G Harry, J Hough, J-M M Mackowski, I MacLaren, C Michel, J-L Montorio, N Morgado, R Nawrodt, S Penn, S Reid, A Remillieux, R Route, S Rowan, C Schwarz, P Seidel, W Vodel and A Zimmer
Class. Quantum Grav. **25** (2008) 055005

PUBLICATIONS:
Advanced LIGO:
Mirror Coating Thermal Noise

The effects of heating on mechanical loss in tantala/silica optical coatings
Matthew R. Abernathy, Gregory M. Harry, Flavio Travasso, Iain Martin, Stuart Reid, Sheila Rowan, Jim Hough, Martin M. Fejer, Roger Route, Steve Penn, Helena Armandula, Andri Gretarsson
Physics Letters A. **372** (2008) 87-90

Titania-doped tantala/silica coatings for gravitational-wave detection
Gregory M Harry, Matthew R Abernathy, Andres E Becerra Toledo, Helena Armandula, D R M Crooks, Gianpietro Cagnoli, Jim Hough, Peter Murray, Stuart Reid, Sheila Rowan, Peter H Sneddon, Martin M Fejer, Roger Route, Steven D Penn, Jean-Marie Mackowski, Laurent Pinard, Alban Remillieux
Class. Quantum Grav. **24** No 2 (21 January 2007) 405-415

Experimental measurements of mechanical dissipation associated with dielectric coatings formed using SiO_2, Ta_2O_5 and Al_2O_3
D R M Crooks, G Cagnoli, M M Fejer, G Harry, J Hough, B T Khuri-Yakub, S Penn, R Route, S Rowan, P H Sneddon, I O Wygant and G G Yaralioglu
Class. Quantum Grav. **23** No 15 (7 August 2006) 4953-4965

Thermal noise from optical coatings in gravitational-wave detectors
Gregory M Harry, Helena Armandula, Eric Black, D R M Crooks, Gianpietro Cagnoli, Jim Hough, Peter Murray, Stuart Reid, Sheila Rowan, Peter Sneddon, Martin M Fejer, Roger Route, Steven D Penn
Applied Optics **45** No 7 (1 March 2006) 1569-1574

Thermoelastic dissipation in inhomogeneous media: loss measurements and displacement noise in coated test masses for interferometric gravitational wave detectors
M. M. Fejer, S. Rowan, G. Cagnoli, D. R. M. Crooks, A. Gretarsson, G. M. Harry, J. Hough, S. D. Penn, P. H. Sneddon, and S. P. Vyatchanin
Phys. Rev. D **70**, 082003 (2004)

Experimental measurements of coating mechanical loss factors
D R M Crooks, G Cagnoli, M M Fejer, A Gretarsson, G Harry, J Hough, N Nakagawa, S Penn, R Route, S Rowan and P H Sneddon
Class. Quantum Grav. **21** No 5 (7 March 2004) S1059-S106

Mechanical Loss in Silica/Tantala Dielectric Mirror Coatings
Steven D. Penn, D. R. M. Crooks, Gregory Harry, Sheila Rowan, Andri Gretarsson, Peter Saulson, Jim Hough, Scott Kittelberger, Geppo Ciagnoli, Helena Armandula, Joe C. Betzwieser
Class. Quantum Grav. **20** (2003) 2917-2928

Thermal Noise in Interferometric Gravitational Wave Detectors due to Dielectric Optical Coatings
G.M. Harry, A.M. Gretarsson, S.E. Kittelberger, S.D. Penn, P.R. Saulson, W.J. Startin, S. Rowan, D. Crooks, J. Hough
Class. Quantum Grav. **19** (2002) 897-918.

Effect of Optical Coating and Surface Treatments on Mechanical Loss in Fused Silica
Andri M Gretarsson, Gregory M Harry, Steven D Penn, Peter R Saulson, John J Schiller, William J Startin
Proceedings of the Third Eduardo Amaldi Conference on Gravitational Waves, July 1999

PUBLICATIONS:
Advanced LIGO
Instrument Science

Effects of transients in LIGO suspensions on searches for gravitational waves
M. Walker, et al. (LSC Instrument Authors, including S Penn)
Rev Sci Instr. **88** (2017) 124501, https://doi.org/10.1063/1.5000264

First Demonstration of Electrostatic Damping of Parametric Instability at Advanced LIGO
Blair, Carl and Gras, Slawek, et al. (LSC Instrument Authors, including S Penn)
Phys Rev Lett. 118 (2017) 151102, https://link.aps.org/doi/10.1103/PhysRevLett.118.151102

Calibration of the Advanced LIGO detectors for the discovery of the binary black-hole merger GW150914
Abbott, B. P., et al., (LIGO Scientific Collaboration, including S Penn)
Phys. Rev. D, 95 (2017) 062003, https://link.aps.org/doi/10.1103/PhysRevD.95.062003

Quantum correlation measurements in interferometric gravitational-wave detectors
Martynov, D. V., et al., (LSC Instrument Authors, including S Penn)
Phys. Rev. A, 95 (2017) 043831, *https://link.aps.org/doi/10.1103/PhysRevA.95.043831*

PUBLICATIONS:
Advanced LIGO
GW Detections

S. Penn is a co-author on 270 Observational results papers authored by the LIGO Scientific Collaboration. (See: https://pnp.ligo.org/ppcomm/Papers.html) Listed below are the 20 publications that reported a discovery.

Observation of Gravitational Waves from the Coalescence of a 2.5-4.5 M_sun Compact Object and a Neutron Star
LIGO Scientific, Virgo, and KAGRA Collaborations
Astrophys. J. Lett. **970**, L34 (2024)
doi:10.3847/2041-8213/ad5beb

GWTC-3: Compact Binary Coalescences Observed by LIGO and Virgo During the Second Half of the Third Observing Run
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. X **13**, 041039 (2023)
doi:10.1103/PhysRevX.13.041039

GWTC-2.1: Deep Extended Catalog of Compact Binary Coalescences Observed by LIGO and Virgo During the First Half of the Third Observing Run
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. D **109**, 022001 (2024)
doi:10.1103/PhysRevD.109.022001

Observation of gravitational waves from two neutron star–black hole coalescences
LIGO Scientific, Virgo and KAGRA Collaborations
Astrophys. J. Lett. **915**, L5 (2021)
doi:10.3847/2041-8213/ac082e

GWTC-2: Compact Binary Coalescences Observed by LIGO and Virgo During the First Half of the Third Observing Run,
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. X **11**, 021053 (2021))
doi:10.1103/PhysRevX.11.021053

PUBLICATIONS:
Advanced LIGO
GW Detections

GW190521: A Binary Black Hole Merger with a Total Mass of 150 M_sun
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. Lett. **125**, 101102 (2020)
doi:10.1103/PhysRevLett.125.101102

GW190814: Gravitational Waves from the Coalescence of a 23 Msun Black Hole with a 2.6 Msun Compact Object
LIGO Scientific Collaboration and Virgo Collaboration
Astrophys. J. Lett. **896**, L44 (2020)
doi:10.3847/2041-8213/ab960f

GW190412: Observation of a Binary-Black-Hole Coalescence with Asymmetric Masses
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. D **102**, 043015 (2020)
doi:10.1103/PhysRevD.102.043015

GW190425: Observation of a compact binary coalescence with total mass ~3.4 Msun
LIGO Scientific Collaboration and Virgo Collaboration
Astrophys. J. Lett. **892**, L3 (2020)
doi:10.3847/2041-8213/ab75f5

GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs
LIGO Scientific Collaboration and Virgo Collaboration
Phys. Rev. X **9**, 031040 (2019)
doi:10.1103/PhysRevX.9.031040

GW170608: Observation of a 19-solar-mass binary black hole coalescence
LIGO Scientific Collaboration and Virgo Collaboration
Astrophys. J. Lett. **851**, L35 (2017)
doi:10.3847/2041-8213/aa9f0c

GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral
LIGO Scientific Collaboration and Virgo Collaboration
Phys., Rev. Lett., **119** (2017) 161101
doi:10.1103/PhysRevLett.119.161101

Multi-messenger Observations of a Binary Neutron Star Merger
LIGO Scientific Collaboration and Virgo Collaboration
Astrophysical Journal Letters, **848** (2017) L12
doi:10.3847/2041-8213/aa91c9

Gravitational Waves and Gamma-Rays from a Binary Neutron Star Merger: GW170817 and GRB 170817A
LIGO Scientific, Virgo, Fermi-GBM, and INTEGRAL Collaborations
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