

# Mankei Tsang

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<https://blog.nus.edu.sg/mankei/>

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## RESEARCH INTERESTS

- ◇ Quantum Metrology, Quantum Optics, Sensing and Imaging, Superresolution.

## SELECTED INFLUENTIAL WORKS

- ◇ Pioneered the field of *quantum-inspired superresolution* for incoherent imaging.
  - First paper of the field: Tsang, Nair, and Lu, *Physical Review X* **6**, 031033 (2016).
  - Review paper: Tsang, *Contemporary Physics*, **60**, 279–298 (2019).
  - See <https://blog.nus.edu.sg/mankei/superresolution/> for subsequent work in this field, including 40+ experiments.
- ◇ Proposed the use of *spectral photon counting* to enhance noise spectroscopy with optical interferometers.
  - Ng *et al.*, *Physical Review A* **93**, 042121 (2016).
  - Caltech, JPL, and Fermilab scientists will build an experiment based on this idea to detect signatures of quantum gravity under the GQuEST project; see McCuller, <https://arxiv.org/abs/2211.04016> and <https://gquest.fnal.gov/>.
- ◇ Proposed the use of *cavity quantum electro-optics* for quantum transduction between optical and microwave photons.
  - Tsang, *Physical Review A* **81**, 063837 (2010); **84**, 043845 (2011).
  - See <https://blog.nus.edu.sg/mankei/cavity-quantum-electro-optics/> for 10+ experiments based on this idea.

## RESEARCH AND TEACHING EXPERIENCE

- ◇ **Associate Professor (with tenure)**, Jul 2017–present)  
**Assistant Professor** (Aug 2011–Jun 2017)  
Department of Electrical and Computer Engineering (joint appointment with Department of Physics), National University of Singapore, Singapore
  - Taught courses:
    - \* EE5517 Optical Engineering (Part I, Lectures, 2012–present)
    - \* EE4002/EE4002D B.Eng. Dissertation/Design Capstone (2012–present)
    - \* PC2134/PC2174A Mathematical Methods in Physics I (Lectures and Tutorials, 2021–2023)
    - \* EE2012/EE2012A Analytic Methods in ECE (Tutorials, 2019–2022)
    - \* EE6440 Advanced Topics in Photonics (Part II, Lectures, 2018–2022)
    - \* MA2501 Differential Equations and Systems (Part II, Lectures and Tutorials, 2017–2018)
    - \* PC2232 Physics for Electrical Engineers (Lectures, 2015–2017)
  - Faculty of Engineering Teaching Commendation List for Academic Year 2017/2018.
  - Supervised graduate students:
    - \* Xiaojie Tan (Ph.D. in EE, Aug 2021–Sep 2023)

- \* Kenneth Y. W. Ng (M.Eng. in EE, Jan 2019–Jan 2022)
- \* Shilin Ng (Ph.D. in Physics, Jan 2013–May 2017)
- \* Shan Zheng Ang (Ph.D. in EE, Aug 2012–Dec 2016)
- \* Soham Sataparno Saha (M.Eng. in EE, co-supervised with Aaron Danner, Jan 2014–Aug 2015)
- \* Dan Li (M.Sc. in Physics, Aug 2013–Aug 2015)
- Supervised postdoctoral fellows: Xiaojie Tan (2023–present), Aparna Bisht (co-supervised with Aaron Danner, 2021–2022), Luo Qi (co-supervised with Aaron Danner, 2019–present), Wei Wang (co-supervised with Pakorn Kanchanawong, 2020–present), Lianwei Chen (co-supervised with Minghui Hong and Aaron Danner, 2019–2021), Samuel Barnett (co-supervised with Pakorn Kanchanawong, 2019), Shibdas Roy (2015–2016), Jun Deng (co-supervised with Aaron Danner, 2014–2015), Alexander Crosse (2014–2015), Cong Son Ho (co-supervised with Mansoor B. A. Jalil, 2014–2016), Xiao-Ming Lu (2014–2016), Adam Zaman Chaudhry (2013–2014), Davide Girolami (2013–2014), Sumei Huang (2013–2015), Brent Yen (2012), Andy Chia (2012), and Ranjith Nair (2012–2018).
- ◇ **Adjunct Research Professor** (Oct 2010–Aug 2011)  
**Postdoctoral Fellow** (Jan 2010–Aug 2011)  
 Center for Quantum Information and Control (CQIc), Department of Physics and Astronomy, University of New Mexico, USA
  - Advisor: Prof. **Carlton M. Caves**
  - Investigated fundamental problems concerning estimation, control, and limits in quantum sensing.
- ◇ **Postdoctoral Fellow** (Jan 2008–Dec 2009)  
 Keck Foundation Center for Extreme Quantum Information Theory (xQIT), Research Laboratory of Electronics, Massachusetts Institute of Technology, USA
  - Advisors: Prof. **Jeffrey H. Shapiro** and Prof. **Seth Lloyd**
  - Developed estimation techniques for quantum sensing and imaging.
- ◇ **Postdoctoral Scholar** (Jul 2006–Dec 2007)  
**Graduate Researcher** (Sep 2002–Jun 2006)  
 Optical Information Processing Group, Department of Electrical Engineering, California Institute of Technology, USA
  - Advisor: Prof. **Demetri Psaltis**
  - performed fundamental and applied research in quantum optics, nano-optics, and nonlinear optics.
  - gave lectures for the *Electromagnetic Engineering* course.
- ◇ **Teaching Assistant** (Sep 2002–Jun 2003)  
 Department of Electrical Engineering, California Institute of Technology, USA
  - gave review lectures, answered students' questions, and graded homeworks for the courses *Fourier Optics*, *Electromagnetic Engineering*, and *Optics in Nano-structures*.
- ◇ **Undergraduate Researcher** (Jun 2001–Jun 2002)  
 Electro-Physical Integration Group, Electrical Engineering Department, University of California - Los Angeles, USA
  - Advisor: Prof. Elliott R. Brown
  - performed analytic modeling and numerical analysis for the Acoustic Dental Imaging Project.

## EDUCATION

- ◇ **Doctor of Philosophy (Ph.D.)** in Electrical Engineering, 2006
- Master of Science (M.S.)** in Electrical Engineering, 2004  
 California Institute of Technology, USA (Sep 2002–Jun 2006)
  - Advisor: Prof. Demetri Psaltis
  - Ph.D. Thesis Title: Classical and Quantum Nonlinear Optical Information Processing

- ◇ **Bachelor of Science (B.S.)** in Electrical Engineering, 2002
- Bachelor of Science (B.S.)** in Physics, 2002
- University of California–Los Angeles, USA (Oct 1998–Jun 2002)
  - Double major, Summa Cum Laude

### GRANTS

- ◇ Quantum Engineering Programme, Singapore National Research Foundation (Apr 2019–Mar 2024)
  - Project title: “Quantum Photonics for Superresolution Confocal Fluorescence Microscopy”
  - Total direct cost: SGD 2,137,700<sup>1</sup>
  - Lead PI (co-PIs: Aaron Danner, Minghui Hong, Pakorn Kanchanawong, Alexander Ling)
- ◇ Academic Research Fund Tier 1 Grant, Singapore Ministry of Education (Mar 2016–Feb 2019)
  - Project title: “Optimal Quantum Photonics for Imaging and Spectroscopy”
  - Total direct cost: SGD 170,000
  - Sole PI
- ◇ Singapore National Research Foundation Fellowship (Aug 2011–Aug 2016)
  - Project title: “General Theory of Quantum Sensors: Estimation, Control, and Fundamental Limit”
  - Total direct cost: SGD 2,818,000
  - Sole PI

### SERVICES

- ◇ **Manuscript Referee** for many journals, including Physical Review Letters, Physical Review X, other Physical Review journals, Quantum, New Journal of Physics, The Astrophysical Journal, The Astronomical Journal, Optica, Optics Letters, Optics Express, JOSA A, JOSA B, EPJ Quantum Technology, IEEE Transactions on Automatic Control, IEEE Journal of Selected Topics in Signal Processing, Nature Photonics, Nature Physics, and Nature Communications.
- ◇ **Proposal Referee** for the US National Science Foundation, the UK Royal Society, the UK Engineering and Physical Sciences Research Council (EPSRC), the Austrian Science Fund, and the Singapore Ministry of Education.
- ◇ **Advisory Editorial Board** member for Quantum Measurements and Quantum Metrology, De Gruyter (Apr 2012–Dec 2020).
- ◇ **Organizer and President** of the Workshop on Quantum-Inspired Superresolution (virtual).
  2. 2nd edition on Aug 9–11, 2023, 14 speakers, ~ 60 participants.
  1. 1st edition on Jul 1–2, 2021, 16 speakers, ~ 60 participants.
- ◇ **Program Committee** member for Optica Quantum 2.0 Conference (Boston, Massachusetts, USA, Jun 2022), PRAC-QSYS 2019 (Hong Kong, China, Dec 2019), and SPIE/COS Photonics Asia (Beijing, China, Oct 2016, Oct 2014).
- ◇ **President** for Optica Quantum 2.0 Conference (Denver, Colorado, USA, Jun 2023), QCMC (Baton Rouge, Louisiana, USA, Mar 2018), PQE (Snowbird, Utah, USA, Jan 2017), PRACQSYS (Sydney, Australia, Jul 2015; Tokyo, Japan, Sep 2012), SPIE/COS Photonics Asia (Beijing, China, Oct 2014), APS March Meeting (Denver, Colorado, USA, Mar 2014), Croucher Advanced Study Institute (Hong Kong, China, Dec 2011), and CLEO/IQEC (Baltimore, Maryland, USA, Jun 2009).
- ◇ **Graduate Admissions Committee** (2016–present), **Academic Committee** (2018–2019), and **Social Committee** (2012–present) member in the ECE department of NUS.
- ◇ **Thesis Committee** member and **Chair of PhD Oral Defence** for many students.

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<sup>1</sup> 1 SGD  $\approx$  1.0 CAD  $\approx$  0.73 USD  $\approx$  0.68 EUR  $\approx$  0.59 GBP as of Nov 2023.

## JOURNAL PUBLICATIONS

70. Xiao-Jie Tan and Mankei Tsang,  
“Quantum limit to subdiffraction incoherent optical imaging. III. Numerical analysis,”  
*Physical Review A* **108**, 052416 (2023).
69. Mankei Tsang,  
“Operational meanings of a generalized conditional expectation in quantum metrology,”  
*Quantum* **7**, 1162 (2023).
68. Xiao-Jie Tan, Luo Qi, Lianwei Chen, Aaron J. Danner, Pakorn Kanchanawong, and Mankei Tsang,  
“Quantum-inspired superresolution for incoherent imaging,”  
*Optica* **10**, 1189–1194 (2023).
67. Mankei Tsang,  
“Efficient superoscillation measurement for incoherent optical imaging,”  
*IEEE Journal of Selected Topics in Signal Processing* **11**, 513–524 (2023).  
  
 ◇ Special Issue on Recent Advances in Wideband Signal Processing for Classical and Quantum Synthetic Apertures.
66. Mankei Tsang,  
“Quantum noise spectroscopy as an incoherent imaging problem,”  
*Physical Review A* **107**, 012611 (2023).
65. Mankei Tsang,  
“Generalized conditional expectations for quantum retrodiction and smoothing,”  
*Physical Review A* **105**, 042213 (2022).
64. Mankei Tsang,  
“Quantum limit to subdiffraction incoherent optical imaging. II. A parametric-submodel approach,”  
*Physical Review A* **104**, 052411 (2021).
63. Mankei Tsang,  
“Poisson Quantum Information,”  
*Quantum* **5**, 527 (2021).  
  
 ◇ Selected for a Perspective article on the *Quantum Views* website [1].
62. Mankei Tsang,  
“Physics-inspired forms of the Bayesian Cramér-Rao bound,”  
*Physical Review A* **102**, 062217 (2020).  
  
 ◇ Editors’ Suggestion [2].
61. Mankei Tsang, Francesco Albarelli, and Animesh Datta,  
“Quantum Semiparametric Estimation,”  
*Physical Review X* **10**, 031023 (2020).
60. Mankei Tsang,  
“Resolving starlight: a quantum perspective,”  
*Contemporary Physics* **60**, 279–298 (2019).  
  
 ◇ Invited.
59. Mankei Tsang,  
“Semiparametric estimation for incoherent optical imaging,”  
*Physical Review Research* **1**, 033006 (2019).
58. Mankei Tsang and Ranjith Nair,  
“Resurgence of Rayleigh’s curse in the presence of partial coherence: comment,”  
*Optica* **6**, 400 (2019).

57. Mankei Tsang,  
 “Quantum limit to subdiffraction incoherent optical imaging,”  
*Physical Review A* **99**, 012305 (2019).  
 ◇ Editors’ Suggestion [2].  
 ◇ Covered by the APS *Physics Buzz* website [3].
56. Mankei Tsang,  
 “Subdiffraction incoherent optical imaging via spatial-mode demultiplexing: Semiclassical treatment,”  
*Physical Review A* **97**, 023830 (2018).
55. Mankei Tsang,  
 “Quantum limits on the time-bandwidth product of an optical resonator,”  
*Optics Letters* **43**, 150 (2018).
54. Fan Yang, Ranjith Nair, Mankei Tsang, Christoph Simon, and Alexander I. Lvovsky,  
 “Fisher information for far-field linear optical superresolution via homodyne or heterodyne detection in a higher-order local oscillator mode,”  
*Physical Review A* **96**, 063829 (2017).
53. Mankei Tsang,  
 “Conservative classical and quantum resolution limits for incoherent imaging,”  
*Journal of Modern Optics* **65**, 1385–1391 (2018).  
 ◇ Special issue for the 47th Winter Colloquium on the Physics of Quantum Electronics (PQE).
52. Shan Zheng Ang, Ranjith Nair, and Mankei Tsang,  
 “Quantum limit for two-dimensional resolution of two incoherent optical point sources,”  
*Physical Review A* **95**, 063847 (2017).
51. Mankei Tsang,  
 “Subdiffraction incoherent optical imaging via spatial-mode demultiplexing,”  
*New Journal of Physics* **19**, 023054 (2017).
50. Ranjith Nair and Mankei Tsang,  
 “Far-field Superresolution of Thermal Electromagnetic Sources at the Quantum Limit,”  
*Physical Review Letters* **117**, 190801 (2016).  
 ◇ Editors’ Suggestion [4].
49. Mankei Tsang, Ranjith Nair, and Xiao-Ming Lu,  
 “Quantum Theory of Superresolution for Two Incoherent Optical Point Sources,”  
*Physical Review X* **6**, 031033 (2016).  
 ◇ Selected for a Viewpoint article on the APS *Physics* website [5, 6].  
 ◇ Covered by the APS *Physics Buzz* website [7], the IoP *Physics World* website [8], and the *Phys.org* website [9, 10].  
 ◇ Mentioned by articles on the OSA *Optics & Photonics News* website [11], the AAAS *EurekaAlert!* website [12], and the *N+I* website [13, 14].  
 ◇ Chosen as #2 of top physics breakthroughs of 2016 by the Foundational Questions Institute (FQXi) podcast [15].
48. Xiao-Ming Lu and Mankei Tsang,  
 “Quantum Weiss-Weinstein bounds for quantum metrology,”  
*Quantum Science and Technology* **1**, 015002 (2016).
47. Shilin Ng, Shan Zheng Ang, Trevor A. Wheatley, Hidehiro Yonezawa, Akira Furusawa, Elanor H. Huntington, and Mankei Tsang,  
 “Spectrum analysis with quantum dynamical systems,”  
*Physical Review A* **93**, 042121 (2016).

46. Ranjith Nair and Mankei Tsang,  
“Interferometric superlocalization of two incoherent optical point sources,”  
*Optics Express*, **24**, 3684 (2016).
- ◇ Covered by a news article in the *Laser Focus World* magazine [16].
45. Shawn Y. Siew, Soham S. Saha, Mankei Tsang, and Aaron J. Danner,  
“Rib Microring Resonators in Lithium Niobate on Insulator,”  
*IEEE Photonics Technology Letters* **28**, 573 (2016).
44. Mankei Tsang,  
“Volterra filters for quantum estimation and detection,”  
*Physical Review A* **92**, 062119 (2015).
43. Dominic W. Berry, Mankei Tsang, Michael J. W. Hall, and Howard M. Wiseman,  
“The quantum Bell-Ziv-Zakai bounds and Heisenberg limits for waveform estimation,”  
*Physical Review X* **5**, 031018 (2015).
42. Ranjith Nair and Mankei Tsang,  
“Quantum Optimality of Photon Counting for Temperature Measurement of Thermal Astronomical Sources,”  
*The Astrophysical Journal* **808**, 125 (2015).
41. Mankei Tsang,  
“Quantum limits to optical point-source localization,”  
*Optica* **2**, 646 (2015).
40. Trevor A. Wheatley, Mankei Tsang, Ian R. Petersen, and Elanor H. Huntington,  
“Improved mirror position estimation using resonant quantum smoothing,”  
*EPJ Quantum Technology* **2**, 13 (2015).
39. Shilin Ng and Mankei Tsang,  
“Optimal signal processing for continuous qubit readout,”  
*Physical Review A* **90**, 022325 (2014).
38. Mankei Tsang,  
“Microwave photonics: Optomechanics sets the beat,”  
*Nature Physics* **10**, 245–246 (2014).
- ◇ Invited News & Views article.
37. Mankei Tsang,  
“Testing quantum mechanics: a statistical approach,”  
*Quantum Measurements and Quantum Metrology* **1**, 84–109 (2013).
- ◇ Invited.
36. Shan Zheng Ang, Glen I. Harris, Warwick P. Bowen, and Mankei Tsang,  
“Optomechanical parameter estimation,”  
*New Journal of Physics* **15**, 103028 (2013).
35. Kohjiro Iwasawa, Kenzo Makino, Hidehiro Yonezawa, Mankei Tsang, Aleksandar Davidovic, Elanor Huntington, and Akira Furusawa,  
“Quantum-Limited Mirror-Motion Estimation,”  
*Physical Review Letters* **111**, 163602 (2013).
34. Mankei Tsang,  
“Quantum transition-edge detectors,”  
*Physical Review A* **88**, 021801(R) (2013).
- ◇ Rapid Communication.

33. Mankei Tsang,  
“Quantum metrology with open dynamical systems,”  
New Journal of Physics **15**, 073005 (2013).
32. Mankei Tsang and Ranjith Nair,  
“Fundamental quantum limits to waveform detection,”  
Physical Review A **86**, 042115 (2012).
31. Mankei Tsang and Carlton M. Caves,  
“Evading Quantum Mechanics: Engineering a Classical Subsystem within a Quantum Environment,”  
Physical Review X **2**, 031016 (2012).
  - ◇ Covered by an article on the *Ars Technica* website [17].
30. Mankei Tsang,  
“Ziv-Zakai Error Bounds for Quantum Parameter Estimation,”  
Physical Review Letters **108**, 230401 (2012).
29. Mankei Tsang,  
“Continuous Quantum Hypothesis Testing,”  
Physical Review Letters **108**, 170502 (2012).
  - ◇ Editors’ Suggestion [4].
  - ◇ Selected for a Synopsis on the APS *Physics* website [6, 18].
28. Mankei Tsang,  
“Quantum Nonlocality in Weak-Thermal-Light Interferometry,”  
Physical Review Letters **107**, 270402 (2011).
27. Mankei Tsang,  
“Cavity quantum electro-optics. II. Input-output relations between traveling optical and microwave fields,”  
Physical Review A **84**, 043845 (2011).
26. Mankei Tsang, Howard M. Wiseman, and Carlton M. Caves,  
“Fundamental Quantum Limit to Waveform Estimation,”  
Physical Review Letters **106**, 090401 (2011).
25. Laura Waller, Mankei Tsang, Sameera Ponda, Se Young Yang, and George Barbastathis,  
“Phase and amplitude imaging from noisy images by Kalman filtering,”  
Optics Express **19**, 2805 (2011).
24. Mankei Tsang and Carlton M. Caves,  
“Coherent Quantum-Noise Cancellation for Optomechanical Sensors,”  
Physical Review Letters **105**, 123601 (2010).
  - ◇ Featured in the “Editors’ Choice” section of the *Science* magazine [19].
23. Mankei Tsang,  
“Cavity quantum electro-optics,”  
Physical Review A **81**, 063837 (2010).
22. Mankei Tsang,  
“Optimal waveform estimation for classical and quantum systems via time-symmetric smoothing. II. Applications to atomic magnetometry and Hardy’s paradox,”  
Physical Review A **81**, 013824 (2010).
21. Mankei Tsang,  
“Optimal waveform estimation for classical and quantum systems via time-symmetric smoothing,”  
Physical Review A **80**, 033840 (2009).

20. Mankei Tsang,  
“Time-Symmetric Quantum Theory of Smoothing,”  
Physical Review Letters **102**, 250403 (2009).
19. Mankei Tsang,  
“Quantum Imaging beyond the Diffraction Limit by Optical Centroid Measurements,”  
Physical Review Letters **102**, 253601 (2009).
  - ◇ Editors’ Suggestion [4].
  - ◇ Selected for a Viewpoint article on the APS *Physics* website [6, 20].
18. Mankei Tsang, Jeffrey H. Shapiro, and Seth Lloyd,  
“Quantum theory of optical temporal phase and instantaneous frequency. II. Continuous time limit and state-variable approach to phase-locked loop design,”  
Physical Review A **79**, 053843 (2009).
17. Mankei Tsang, Jeffrey H. Shapiro, and Seth Lloyd,  
“Quantum theory of optical temporal phase and instantaneous frequency,”  
Physical Review A **78**, 053820 (2008).
16. Mankei Tsang,  
“Fundamental Quantum Limit to Multiphoton Absorption Rate for Monochromatic Light,”  
Physical Review Letters **101**, 033602 (2008).
15. Mankei Tsang and Demetri Psaltis,  
“Magnifying perfect lens and superlens design by coordinate transformation,”  
Physical Review B **77**, 035122 (2008).
14. Ye Pu, Jie Wu, Mankei Tsang, and Demetri Psaltis,  
“Optical parametric generation in periodically poled  $\text{KTiOPO}_4$  via extended phase matching,”  
Applied Physics Letters **91**, 131120 (2007).
13. Mankei Tsang and Demetri Psaltis,  
“Theory of resonantly enhanced near-field imaging,”  
Optics Express **15**, 11959 (2007).
12. Mankei Tsang,  
“Decoherence of quantum-enhanced timing accuracy,”  
Physical Review A **75**, 063809 (2007).
11. Mankei Tsang,  
“Relationship between resolution enhancement and multiphoton absorption rate in quantum lithography,”  
Physical Review A **75**, 043813 (2007).
10. Mankei Tsang and Demetri Psaltis,  
“Reflectionless evanescent wave amplification via two dielectric planar waveguides,”  
Optics Letters **31**, 2741 (2006); Erratum: **32**, 86 (2007).
9. Mankei Tsang,  
“Quantum Temporal Correlations and Entanglement via Adiabatic Control of Vector Solitons,”  
Physical Review Letters **97**, 023902 (2006); Erratum: **99**, 049901(E) (2007).
8. Mankei Tsang,  
“Spectral phase conjugation via extended phase matching,”  
Journal of the Optical Society of America B **23**, 861 (2006).
7. Mankei Tsang and Demetri Psaltis,  
“Propagation of temporal entanglement,”  
Physical Review A **73**, 013822 (2006).



6. Martin Centurion, Ye Pu, Mankei Tsang, and Demetri Psaltis,  
“Dynamics of filament formation in a Kerr medium,”  
*Physical Review A* **71**, 063811 (2005); Erratum: **74**, 069902(E) (2006).
5. Mankei Tsang and Demetri Psaltis,  
“Spontaneous spectral phase conjugation for coincident frequency entanglement,”  
*Physical Review A* **71**, 043806 (2005).
4. Mankei Tsang and Demetri Psaltis,  
“Spectral phase conjugation by quasi-phase-matched three-wave mixing,”  
*Optics Communications* **242**, 659 (2004).
3. Mankei Tsang and Demetri Psaltis,  
“Spectral phase conjugation with cross-phase modulation compensation,”  
*Optics Express* **12**, 2207 (2004).
2. Mankei Tsang, Demetri Psaltis, and Fiorenzo G. Omenetto,  
“Reverse propagation of femtosecond pulses in optical fibers,”  
*Optics Letters* **28**, 1873 (2003).
1. Mankei Tsang and Demetri Psaltis,  
“Dispersion and nonlinearity compensation by spectral phase conjugation,”  
*Optics Letters* **28**, 1558 (2003).

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- [1] Cosmo Lupo, “Poisson states in quantum information,” *Quantum Views* **5**, 59 (2021), <https://doi.org/10.22331/qv-2021-09-02-59>.
  - [2] PRA Editors’ Suggestions are “a small number of papers published in *Physical Review A* that the editors and referees find of particular interest, importance, or clarity;” see <http://doi.org/10.1103/PhysRevA.88.020001>.
  - [3] Kendra Redmond, “We’re Nowhere Near the Limit on Telescope Resolution, According to New Physics,” APS Physics Central – Physics Buzz Blog (2018), <https://web.archive.org/web/20181213122714/http://physicsbuzz.physicscentral.com/2018/12/were-nowhere-near-limit-on-telescope.html>, retrieved Dec 13, 2018.
  - [4] To promote reading across fields, the editors of *Physical Review Letters* offer “Suggestions” each week of papers that they hope will lead readers to explore other areas of physics; see <http://doi.org/10.1103/PhysRevLett.118.030001>.
  - [5] Gabriel Durkin, “Viewpoint: Unlocking the hidden information in starlight,” *Physics* **9**, 100 (2016), <https://doi.org/10.1103/Physics.9.100>.
  - [6] *Physics* is an online American Physical Society publication that “spotlights exceptional research;” see <http://physics.aps.org/> and <https://doi.org/10.1103/PhysRevLett.101.120001>.
  - [7] Kendra Redmond, “Resolving Starlight with Quantum Technology,” APS Physics Central – Physics Buzz Blog (2016), <https://web.archive.org/web/20160902185219/http://physicsbuzz.physicscentral.com/2016/08/resolving-starlight-with-quantum.html>, retrieved Sep 2, 2016.
  - [8] Edwin Cartledge, “Tapping into light’s hidden information to push fundamental diffraction limit,” IoP Physics World and nanotechweb.org (2016), <https://physicsworld.com/a/tapping-into-lights-hidden-information-to-push-fundamental-diffraction-limit/>, retrieved Jul 16, 2022.
  - [9] Bob Yirka, “Quantum mechanics technique allows for pushing past ‘Rayleigh’s curse’,” *Phys.org* (2016), <https://phys.org/news/2016-09-quantum-mechanics-technique-rayleigh-curse.html>, retrieved Jul 16, 2022.
  - [10] Ingrid Fadelli, “A new theory to test hypotheses and methods for exoplanet detection,” *Phys.org* (2021), <https://phys.org/news/2021-10-theory-methods-exoplanet.html>, retrieved Jul 16, 2022.
  - [11] Patricia Daukantas, “Beating Rayleigh with quantum mechanics,” *OSA Optics & Photonics News* (2016), <https://www.optica-opn.org/news/rayleigh-limit/>, retrieved Jul 16, 2022.
  - [12] University of Toronto, “Physicists harness neglected properties of light,” *AAAS EurekAlert!* (2017), <https://www.eurekalert.org/news-releases/573130>, retrieved Jul 16, 2022.
  - [13] Oksana Borzenkova, “Ultra-high resolution in microscopy made possible without fluorescence,” *N+1* (2021), <https://nplus1.ru/news/2021/05/21/Super-resolution-imaging>, in Russian, retrieved Jul 16, 2022.
  - [14] Alexander Dubov, “Invisible—physicist Alexander Lvovsky on how to look beyond the limit of diffraction,” *N+1* (2021), <https://nplus1.ru/material/2021/06/30/lvovsky-enhance>, in Russian, retrieved Jul 16, 2022.
  - [15] The Foundational Questions Institute (FQXi), “December 31, 2016 Podcast – 2016 Countdown Part 2,” *Online* (2016), <https://fqxi.org/community/podcast/2016.12.31>, retrieved Jul 16, 2022.

- [16] John Wallace, “SLIVER to determine separation of two sources closer than Rayleigh limit,” *Laser Focus World* **52** (2016), <https://www.laserfocusworld.com/test-measurement/test-measurement/article/16546922/sliver-to-determine-separation-of-two-sources-closer-than-rayleigh-limit>, retrieved Jul 16, 2022.
- [17] Chris Lee, “Demolishing Heisenberg with clever math and experiments,” *Ars Technica* (2012), <http://arstechnica.com/science/2012/09/demolishing-heisenberg-with-clever-math-and-experiments/>, retrieved Jul 16, 2022.
- [18] David Voss, “Synopsis: Quantum Testing,” *Physics* **5**, s65 (2012), <https://physics.aps.org/articles/v5/s65>.
- [19] Ian S. Osborne, “Calling for a Quantum Hush,” *Science* **330**, 13 (2010), <https://doi.org/10.1126/science.2010.330.6000.twil>.
- [20] Petr M. Anisimov and Jonathan P. Dowling, “Viewpoint: Super resolution with superposition,” *Physics* **2**, 52 (2009), <http://doi.org/10.1103/Physics.2.52>.

## CONFERENCES

Each **bold name** in this section denotes the presenter.

### Invited

41. **Mankei Tsang**,  
“Quantum noise spectroscopy as an incoherent imaging problem,”  
Oral Presentation, the 53rd Winter Colloquium on the Physics of Quantum Electronics (PQE), Snowbird, Utah, USA, Jan 10, 2024.
40. **Mankei Tsang**,  
“Quantum noise spectroscopy,”  
Workshop on Continuously Monitored Quantum Systems (CMONS 2023), Warsaw, Poland, Dec 13, 2023.
39. **Mankei Tsang**,  
“Quantum waveform estimation, detection, and noise spectroscopy,”  
Oral Presentation, Kavli Institute for Theoretical Physics (KITP) Conference: Frontiers of Quantum Metrology, Santa Barbara, California, USA, Oct 12, 2023.
38. **Mankei Tsang**,  
“Quantum-inspired superresolution for incoherent imaging,”  
Oral Presentation, International Conference on Squeezed States and Uncertainty Relations 2023, Taipei, Taiwan, Republic of China, Jun 28, 2023.
37. **Mankei Tsang**,  
“Quantum-inspired superresolution for incoherent imaging,”  
Oral Presentation, Optica Quantum 2.0 Conference, Denver, Colorado, USA, Jun 21, 2023, Presentation Number QW3A.1.
36. **Mankei Tsang**,  
“Quantum nonlocality in stellar interferometry,”  
Oral Presentation, Quantum-Enhanced Telescoping Workshop, Denver, Colorado, USA, Jun 18, 2023.
35. **Mankei Tsang**,  
“Resolving starlight: a quantum perspective,”  
Oral Presentation (virtual), the 51st Winter Colloquium on the Physics of Quantum Electronics (PQE), Snowbird, Utah, USA, Jan 12, 2022.
34. **Mankei Tsang**, Francesco Albarelli, and Animesh Datta,  
“Quantum semiparametric estimation,”  
Oral Presentation (virtual), Paris-Singapore-Tokyo Workshop on Quantum Metrology, Networks and Cryptography, Online, May 21, 2021.
33. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Resolving starlight: a quantum perspective,”  
Oral Presentation, the First Quantum Science, Engineering and Technology Conference (qSET), Canberra, Australia, Apr 9, 2019.

32. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum-inspired measurements for subdiffraction incoherent optical imaging,”  
Oral Presentation, the Fifth Workshop on Scalable Information Processing with Quantum Nano-Photonics (SIPQNP), Tucson, Arizona, USA, Mar 26, 2019.
31. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum metrology for subdiffraction incoherent optical imaging,”  
Oral Presentation, Symposium on Novel Perspectives in Quantum Metrology, German Physical Society (DPG) Spring Meeting, Rostock, Germany, Mar 15, 2019, SYQM 1.1.
30. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Seize the moments: enhancing moment estimation for subdiffraction incoherent imaging,”  
Oral Presentation, the Fourteenth Singapore-China Physics Frontier Symposium, Shanghai, China, Sep 26, 2018.
29. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Seize the moments: enhancing moment estimation for subdiffraction incoherent imaging,”  
Oral Presentation, the Twelfth International Workshop on Principles and Applications of Control in Quantum Systems (PRACQSYS), Paris, France, Jul 5, 2018.
28. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Seize the moments: enhancing moment estimation for subdiffraction incoherent imaging,”  
Oral Presentation, the Fourteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Baton Rouge, Louisiana, USA, Mar 15, 2018.
27. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Subdiffraction incoherent imaging: statistical and quantum approaches,”  
Oral Presentation, the 39th Progress in Electromagnetics Research Symposium (PIERS), Singapore, Nov 21, 2017.
26. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum information kills Rayleigh’s criterion,”  
Oral Presentation, Conference on Quantum Information and Quantum Control VII, Toronto, Canada, Aug 29, 2017.
25. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum information kills Rayleigh’s criterion,”  
Oral Presentation, the 26th Annual International Laser Physics Workshop (LPHYS), Kazan, Russia, Jul 19, 2017.
24. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum theory of superresolution for incoherent optical imaging,”  
Oral Presentation, American Physical Society March Meeting 2017, New Orleans, Louisiana, USA, Mar 17, 2017, abstract X51.00001.
23. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum theory of superresolution for incoherent optical imaging,”  
Oral Presentation, WE-Heraeus Seminar on Quantum-Limited Metrology and Sensing, Bad Honnef, Germany, Feb 7, 2017.
22. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum theory of superresolution for incoherent optical imaging,”  
Plenary Talk, the 47th Winter Colloquium on the Physics of Quantum Electronics, Snowbird, Utah, USA, Jan 12, 2017.
21. **Mankei Tsang**, Ranjith Nair, and Xiao-Ming Lu,  
“Quantum information for semiclassical optics,”  
Oral Presentation, Quantum and Nonlinear Optics IV Conference, SPIE/COS Photonics Asia 2016, Beijing, China, Oct 12, 2016.  
  
    ◇ Invited paper in Proc. SPIE **10029**, Quantum and Nonlinear Optics IV, 1002903 (2016).
20. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum metrology kills Rayleigh’s criterion,”  
Oral Presentation, the Fourth Biennial China-Australia Quantum Control Workshop, Hefei, China, Sep 28, 2016.

19. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum metrology kills Rayleigh’s criterion,”  
Oral Presentation, Advances in Optical Metrology Symposium, Nottingham, UK, Jun 14, 2016.
18. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum metrology kills Rayleigh’s criterion,”  
Oral Presentation, Recent Advances in Quantum Metrology Workshop, Warsaw, Poland, Mar 4, 2016.
17. Shilin Ng, Shan Zheng Ang, and **Mankei Tsang**,  
“Quantum spectroscopy,”  
Oral Presentation, the Tenth International Workshop on Principles and Applications of Control in Quantum Systems (PRACQSYS), Sydney, Australia, Jul 20, 2015.
16. **Mankei Tsang**,  
“Evading quantum mechanics,”  
Oral Presentation, EQU S Optomechanics Incubator, Sydney, Australia, Dec 3, 2014.
15. **Mankei Tsang**,  
“Quantum theory of optical sensing: estimation, control, and fundamental limits,”  
Oral Presentation, Quantum and Nonlinear Optics III Conference, SPIE/COS Photonics Asia 2014, Beijing, China, Oct 9, 2014.
14. **Mankei Tsang**,  
“Continuous quantum hypothesis testing,”  
Keynote Talk, the Third Biennial China-Australia Quantum Control Workshop, Brisbane, Australia, Sep 30, 2014.
13. **Mankei Tsang**,  
“Quantum transition-edge detectors,”  
Oral Presentation, the Eighth International Workshop on Principles and Applications of Control in Quantum Systems (PRACQSYS), Monterey, California, USA, Aug 23, 2013.
12. **Mankei Tsang**,  
“Quantum Waveform Detection Theory,”  
“Quantum Waveform Estimation Theory,”  
“Quantum Microwave Photonics,”  
Oral Presentations, the Seventh Winter School on Quantum Information Science, National Cheng Kung University, Taiwan, Republic of China, Feb 28–Mar 2, 2013.
11. **Mankei Tsang**,  
“Fundamental quantum limits to waveform sensing,”  
Oral Presentation, the Fourth Workshop on Quantum Information Science, Hong Kong, China, Dec 28, 2012.
10. **Mankei Tsang**,  
“Fundamental quantum limits to waveform sensing,”  
Oral Presentation, the Seventh International Workshop on Principles and Applications of Control in Quantum Systems (PRACQSYS), Tokyo, Japan, Sep 13, 2012.
9. **Mankei Tsang**,  
“Quantum limits on sensing and imaging,”  
Oral Presentation, the Keck Institute for Space Studies (KISS) Workshop on Quantum Communication, Sensing and Measurement in Space, Pasadena, California, USA, Jun 28, 2012.
8. **Mankei Tsang**,  
“Quantum limit to waveform estimation,”  
Oral Presentation, MIT Center for Extreme Quantum Information Theory Conference 2011, Cambridge, Massachusetts, USA, May 3, 2011.
7. **Mankei Tsang** and Carlton M. Caves,  
“Coherent quantum noise cancellation for opto-mechanical sensors,”  
Oral Presentation, Los Alamos National Laboratory Quantum Workshop 2010, Los Alamos, New Mexico, USA, Apr 28, 2010.

6. **Mankei Tsang**,  
“Quantum sensing and imaging,”  
Oral Presentation, Office of Naval Research Conference on Entanglement beyond the Optical Regime, Anaheim, California, USA, Feb 8, 2010.
5. **Mankei Tsang**, Jeffrey H. Shapiro, and Seth Lloyd,  
“Quantum optical phase estimation by phase-locked loops,”  
Oral Presentation, MIT Center for Extreme Quantum Information Theory Conference 2008, Cambridge, Massachusetts, USA, Nov 20, 2008.
4. **Mankei Tsang**, Martin Centurion, Demetri Psaltis, Jeffrey H. Shapiro, and Seth Lloyd,  
“Optical hydrodynamics,”  
Oral Presentation, Frontiers in Optics/Laser Science, Rochester, New York, USA, Oct 22, 2008, paper FWO3.
3. **Mankei Tsang**,  
“Particle, wave, and fluid properties of light,”  
Oral Presentation, the 38th Winter Colloquium on the Physics of Quantum Electronics (PQE), Snowbird, Utah, USA, Jan 10, 2008.
2. **Martin Centurion**, Mankei Tsang, and Demetri Psaltis,  
“Nonlinear signal processing,”  
Oral Presentation, IEEE Lasers and Electro-Optics Society (LEOS) Annual Meeting, Sydney, Australia, Oct 1, 2005, paper TuEE2.
1. Mankei Tsang and **Demetri Psaltis**,  
“Metaphoric optical computing for fluid dynamics,”  
Oral Presentation, Photonics West, San Jose, California, USA, Jan 25, 2005.  
  
  - ◇ Invited paper in Proc. SPIE **5735**, Advanced Optical and Quantum Memories and Computing II, 1 (2005).

#### Peer-Reviewed

41. **Luo Qi**, Xiaojie Tan, Lianwei Chen, Kenneth Yu Wei Ng, Aaron Danner, and Mankei Tsang,  
“Quantum-inspired superresolution for multiple incoherent optical point sources,”  
Poster Presentation, Conference on Lasers and Electro-Optics (CLEO), San Jose, California, May 17, 2022, paper JTu3A.22.
40. Ranjith Nair, Xiao-Ming Lu, Shan Zheng Ang, and **Mankei Tsang**,  
“Resolving starlight: a quantum perspective,”  
Oral Presentation, Institute of Physics Singapore Meeting 2021, Singapore, Oct 1, 2021, code T13.75.
39. **Ranjith Nair** and Mankei Tsang,  
“Beating Rayleigh’s criterion: superresolution of thermal sources with linear optics,”  
Oral Presentation, OSA Quantum Information and Measurement 2017, Paris, France, Apr 6, 2017, paper QT5C.5.
38. **Shawn Y. Siew**, Eric J. H. Cheung, Mankei Tsang, and Aaron J. Danner,  
“Integrated nonlinear optics: lithium niobate-on-insulator waveguides and resonators,”  
Oral Presentation, Integrated Optics: Devices, Materials, and Technologies XXI, SPIE Photonics West, San Francisco, California, Jan 28, 2017.  
  
  - ◇ Paper in Proc. SPIE **10106**, Integrated Optics: Devices, Materials, and Technologies XXI, 101060B (2017).
37. **Shawn Y. Siew**, Eric J. H. Cheung, Mankei Tsang, and Aaron J. Danner,  
“Loss characterization of waveguides in lithium niobate on insulator,”  
Oral Presentation, 2016 IEEE International Conference on Optical MEMS and Nanophotonics (OMN), Singapore, Aug 1, 2016, paper Mo4.3.

36. **Shan Zheng Ang**, Ranjith Nair, and Mankei Tsang,  
 “Quantum theory of two-dimensional resolution for two incoherent optical point sources,”  
 Poster Presentation, the Thirteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Singapore, Jul 5, 2016, paper P2-195.
35. **Ranjith Nair** and Mankei Tsang,  
 “Interferometric resolution of incoherent optical point sources near the quantum limit,”  
 Poster Presentation, the Thirteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Singapore, Jul 5, 2016, paper P2-153.
34. **Mankei Tsang**, Ranjith Nair, and Xiao-Ming Lu,  
 “Semiclassical theory of superresolution for two incoherent optical point sources,”  
 Poster Presentation, the Thirteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Singapore, Jul 4, 2016, paper P1-12.
33. **Shilin Ng**, Shan Zheng Ang, Mankei Tsang, Wheatley Trevor, Hidehiro Yonezawa, Akira Furusawa, and Elanor Huntington,  
 “Spectrum analysis with quantum dynamical systems,”  
 Poster Presentation, the Thirteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Singapore, Jul 4, 2016, paper P1-126.
32. **Xiao-Ming Lu** and Mankei Tsang,  
 “Weiss-Weinstein error bounds for quantum parameter estimation,”  
 Poster Presentation, the Thirteenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Singapore, Jul 4, 2016, paper P1-32.
31. **Mankei Tsang**, Ranjith Nair, and Xiao-Ming Lu,  
 “Rayleigh’s criterion is irrelevant to the localization of two incoherent optical point sources,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, Jun 10, 2016, paper FF1C.1.
30. **Shan Zheng Ang**, Ranjith Nair, and Mankei Tsang,  
 “Quantum limit for two-dimensional resolution of two incoherent optical point sources,”  
 Poster Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, Jun 7, 2016, paper JTU5A.21.
29. **Shawn Y. Siew**, Soham S. Saha, Mankei Tsang, and Aaron J. Danner,  
 “Rib microring resonators in lithium niobate on insulator,”  
 Oral Presentation, 2015 IEEE International Conference on Optical MEMS and Nanophotonics (OMN), Jerusalem, Israel, Aug 3, 2015, paper Mo2.2.
28. **Soham S. Saha**, Shawn Y. Siew, Jun Deng, Aaron J. Danner, and Mankei Tsang,  
 “Fabrication and characterization of optical devices on lithium niobate on insulator chips,”  
 Oral Presentation, the Eighth International Conference on Materials for Advanced Technologies (ICMAT), Singapore, Jul 1, 2015, paper ICMAT15-A-3942.  
  - ◇ Soham S. Saha, Shawn Y. Siew, Jun Deng, Aaron J. Danner, and Mankei Tsang, *Procedia Engineering* **140**, 183–186 (2016).
27. **Shawn Y. Siew**, Jun Deng, Soham S. Saha, Sajid Hussain, Mankei Tsang, and Aaron J. Danner,  
 “Fabrication and characterization of microring resonators in titanium diffused lithium niobate,”  
 Oral Presentation, 2014 IEEE International Conference on Optical MEMS and Nanophotonics (OMN), Glasgow, United Kingdom, Aug 19, 2014, paper pp. 45–46.
26. **Mankei Tsang**,  
 “Mismatched quantum filtering and entropic information,”  
 Oral Presentation, 2014 IEEE International Symposium on Information Theory (ISIT), Honolulu, Hawaii, USA, Jun 30, 2014, paper pp. 321–325.

25. **Mankei Tsang**,  
 “Mismatched quantum filtering and entropic information,”  
 Oral Presentation, American Physical Society March Meeting 2014, Denver, Colorado, USA, Mar 4, 2014, abstract G35.00004.
24. **Mankei Tsang**,  
 “Mismatched quantum filtering and entropic information,”  
 Oral Presentation, the 16th Annual Southwest Quantum Information and Technology (SQuInT) Workshop, Santa Fe, New Mexico, USA, Feb 21, 2014.
23. **Jun Deng**, Sajid Hussian, Soham S. Saha, Ching Eng Png, Mankei Tsang, and Aaron J. Danner,  
 “Optical microring resonators in lithium niobate for classical and quantum microwave photonics,”  
 Oral Presentation, 2013 IEEE International Conference on Optical MEMS and Nanophotonics (OMN), Kanazawa, Japan, Aug 21, 2013, paper pp. 89–90.
22. **Mankei Tsang** and Carlton M. Caves,  
 “Evading quantum mechanics,”  
 Poster, the Eleventh International Conference on Quantum Communication, Measurement and Computing (QCMC), Vienna, Austria, Aug 2, 2012.
21. **Mankei Tsang**,  
 “Coupling quantum microwave circuits to quantum optics via cavity electro-optic modulators,”  
 Oral Presentation, American Physical Society March Meeting 2012, Boston, Massachusetts, USA, Feb 27, 2012, abstract A4.00006.
20. **Mankei Tsang**, Howard M. Wiseman, and Carlton M. Caves,  
 “Fundamental quantum limit to waveform estimation,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), Baltimore, Maryland, USA, May 6, 2011, paper QFD4.
19. **Mankei Tsang**, Howard M. Wiseman, and Carlton M. Caves,  
 “Fundamental quantum limit to waveform estimation,”  
 Oral Presentation, the 13th Annual Southwest Quantum Information and Technology (SQuInT) Workshop, Boulder, Colorado, USA, Feb 18, 2011.
18. **Laura Waller**, Mankei Tsang, Sameera Ponda, and George Barbastathis,  
 “Phase and amplitude imaging from noisy intensity measurements using a Kalman filter,”  
 Oral Presentation, Frontiers in Optics/Laser Science, Rochester, New York, USA, Oct 26, 2010, paper FTuK3.
17. **Mankei Tsang**,  
 “Cavity quantum electro-optics,”  
 Poster, the Tenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Brisbane, Australia, Jul 22, 2010.
  - ◇ Mankei Tsang, “Cavity quantum electro-optic transduction,” in Proceedings of the Tenth International Conference on Quantum Communication, Measurement and Computing (QCMC), edited by T. C. Ralph and P. K. Lam, AIP Conf. Proc. **1363**, 21 (2011).
16. **Mankei Tsang** and Carlton M. Caves,  
 “Coherent quantum noise cancellation for opto-mechanical sensors,”  
 Oral Presentation, the Tenth International Conference on Quantum Communication, Measurement and Computing (QCMC), Brisbane, Australia, Jul 21, 2010.
  - ◇ Mankei Tsang, “Quantum backaction noise cancellation for linear systems,” in Proceedings of the Tenth International Conference on Quantum Communication, Measurement and Computing (QCMC), edited by T. C. Ralph and P. K. Lam, AIP Conf. Proc. **1363**, 93 (2011).
15. **Mankei Tsang**,  
 “Time-symmetric quantum smoothing: a general theory of optimal quantum sensing,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, May 20, 2010, paper QThN7.

14. **Mankei Tsang** and Carlton M. Caves,  
 “Coherent quantum noise cancellation for opto-mechanical sensors,”  
 Poster, Gordon Research Conference on Mechanical Systems in the Quantum Regime, Galveston, Texas, USA, Mar 22, 2010.
13. **Mankei Tsang**,  
 “Time-symmetric quantum smoothing: a general theory of optimal quantum sensing,”  
 Oral Presentation, the 12th Annual Southwest Quantum Information and Technology (SQuInT) Workshop, Santa Fe, New Mexico, USA, Feb 20, 2010.
12. **Mankei Tsang**, Jeffrey H. Shapiro, and Seth Lloyd,  
 “Quantum optical temporal phase estimation by homodyne phase-locked loops,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/International Quantum Electronics Conference (CLEO/IQEC), Baltimore, Maryland, USA, Jun 2, 2009, paper ITuI6.
11. **Mankei Tsang**, Jeffrey H. Shapiro, and Seth Lloyd,  
 “Quantum optical phase and instantaneous frequency in the time domain,”  
 Poster, the Ninth International Conference on Quantum Communication, Measurement and Computing (QCMC), Calgary, Canada, Aug 20, 2008.  
  - ◇ Mankei Tsang, Jeffrey H. Shapiro, and Seth Lloyd, “Quantum theory of optical temporal phase in the continuous time limit,” in Proceedings of the Ninth International Conference on Quantum Communication, Measurement and Computing (QCMC), edited by A. Lvovsky, AIP Conf. Proc. No. 1110 (AIP, Melville, 2009), pp. 29-32.
10. **Mankei Tsang** and Demetri Psaltis,  
 “Magnifying metamaterial lens design by coordinate transformation,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, May 9, 2008, paper QFL5.
9. **Mankei Tsang**,  
 “Quantum enhancement of beam position accuracy by self-focusing,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, May 7, 2008, paper QWD5.
8. **Mankei Tsang** and Demetri Psaltis,  
 “Resonantly enhanced near-field lithography,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), San Jose, California, USA, May 6, 2008, paper QTuG1.
7. **Ye Pu**, Jie Wu, Mankei Tsang, and Demetri Psaltis,  
 “Ultrafast mirrorless optical parametric oscillator in periodically poled  $\text{KTiOPO}_4$  via extended phase matching,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), Baltimore, Maryland, USA, May 1, 2007, paper CMB5.
6. **Mankei Tsang** and Demetri Psaltis,  
 “Quantum lithography has a reduced multiphoton absorption rate,”  
 Oral Presentation, Frontiers in Optics/Laser Science, Rochester, New York, USA, Oct 11, 2006, paper LWH3.
5. **Mankei Tsang** and Demetri Psaltis,  
 “Reflectionless evanescent wave amplification by two dielectric slabs,”  
 Oral Presentation, Frontiers in Optics/Laser Science, Rochester, New York, USA, Oct 9, 2006, paper FMB4.
4. **Mankei Tsang** and Demetri Psaltis,  
 “Quantum temporal imaging,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), Long Beach, California, USA, May 24, 2006, paper QWB5.
3. **Mankei Tsang** and Demetri Psaltis,  
 “Metaphoric optical computing of fluid dynamics,”  
 Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS), Baltimore, Maryland, USA, May 23, 2005, paper QML6.



2. **Martin Centurion**, Ye Pu, Mankei Tsang, and Demetri Psaltis,  
“Phase transition in the filament generation process in a Kerr medium,”  
Oral Presentation, Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference (CLEO/QELS),  
Baltimore, Maryland, USA, May 23, 2005, paper QMI3.
1. **Mankei Tsang** and Demetri Psaltis,  
“Spectral phase conjugation with cross-phase modulation compensation,”  
Poster, Frontiers in Optics/Laser Science, Rochester, New York, USA, Oct 13, 2004, paper FWH44.

#### INVITED COLLOQUIA AND SEMINARS

37. “Quantum-Inspired Incoherent Imaging and Optomechanical Sensing,”  
IQIM Seminar, California Institute of Technology, USA, Jan 12, 2024.
36. “Quantum Waveform Estimation, Detection, and Noise Spectroscopy,”  
CQIQC/QO/AMO Seminar, Department of Physics, University of Toronto, Canada, Nov 24, 2023.
35. “Quantum Conditional Expectations,”  
CQIQC/QO/AMO Seminar, Department of Physics, University of Toronto, Canada, Nov 10, 2023.
34. “Resolving Starlight: A Quantum Perspective,”  
PME Distinguished Quantum Colloquium, University of Chicago, USA, Nov 7, 2023.
33. “Resolving Starlight: A Quantum Perspective,”  
CQIQC/QO/AMO Seminar, Department of Physics, University of Toronto, Canada, Oct 20, 2023.
32. “Resolving Starlight, A Quantum Perspective,”  
Seminar, Kavli Institute for Theoretical Physics (KITP) Program: New Directions in Quantum Metrology, University of  
California–Santa Barbara, USA, Sep 13, 2023.
31. “Quantum Conditional Expectations,”  
Centre for Quantum Technologies Seminar, Singapore, May 29, 2023.
30. “Resolving Starlight: A Quantum Perspective,”  
Atomic and Laser Physics Seminar, University of Oxford, UK, Dec 2, 2022.
29. “Resolving Starlight: A Quantum Information Perspective,”  
Quantum Information and Metrology Seminar (virtual), University of Nottingham, UK, Jul 27, 2022.
28. “Resolving Starlight: A Quantum Perspective,”  
IQUIST Seminar (virtual), University of Illinois Urbana-Champaign, USA, Sep 21, 2021.
27. “Resolving Starlight: A Quantum Perspective,”  
AP 483 Seminar (virtual), Ginzton Laboratory, Stanford University, USA, Nov 16, 2020.
26. “Resolving Starlight: A Quantum Perspective,”  
Special Lecture, College of Optical Sciences, University of Arizona, USA, Mar 28, 2019.
25. “Seize the Moments: Enhancing Moment Estimation for Subdiffraction Incoherent Imaging,”  
Seminar, Kastler Brossel Laboratory, Paris, France, Jul 3, 2018.
24. “Seize the Moments: Enhancing Moment Estimation for Subdiffraction Incoherent Imaging,”  
Seminar, Department of Physics, University of Toronto, Canada, Sep 5, 2017.
23. “Quantum Metrology Kills Rayleigh’s Criterion,”  
Seminar, Institute of Fundamental and Frontier Sciences, University of Electronic Science and Technology, Chengdu,  
China, Sep 28, 2016.
22. “Quantum Theory of Superresolution for Incoherent Optical Imaging,”  
Seminar, Department of Mathematics, National University of Singapore, Singapore, Sep 14, 2016.

21. "Introduction to Quantum Metrology,"  
Lecture, University of Nottingham, UK, Jun 13, 2016.
20. "Killing Rayleigh's Criterion by Farfield Linear Photonics,"  
Seminar, Department of EECS, University of California - Berkeley, USA, Jun 2, 2016.
19. "Killing Rayleigh's Criterion by Quantum Measurements,"  
Seminar, Centre for Quantum Technologies, Singapore, Nov 18, 2015.
18. "Resonantly Enhanced Microwave Photonics: Coupling Microwave Circuits and Optics via Cavity Electro-Optic Modulators,"  
Seminar, Institute of Modern Optics, Peking University, Beijing, China, Oct 12, 2014.
17. "Quantum Metrology for Dynamical Systems,"  
Seminar, Center for Quantum Information and Control, University of New Mexico, USA, Feb 27, 2014.
16. "Quantum Microwave Photonics,"  
"Quantum Waveform Detection Theory,"  
"Quantum Waveform Estimation Theory,"  
Seminars, RIKEN Institute, Wako, Japan, Feb 14, 21, 25, 2013.
15. "Continuous Quantum Hypothesis Testing,"  
Colloquium, Department of Applied Mathematics, the Hong Kong Polytechnic University, China, Jan 7, 2013.
14. "Quantum Microwave Photonics,"  
Seminar, A\*STAR Data Storage Institute, Singapore, Apr 20, 2012.
13. "Theory of Quantum Sensing: Fundamental Limits, Estimation, and Control,"  
Seminar, Centre for Quantum Technologies, Singapore, Oct 18, 2011.
12. "Theory of Quantum Sensing: Estimation, Control, and Fundamental Limits,"  
Seminar, Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Feb 28, 2011.
11. "Theory of Quantum Sensing: Estimation, Control, and Fundamental Limits,"  
Seminar, JILA, Boulder, Colorado, USA, Feb 21, 2011.
10. "Theory of Quantum Sensing: Fundamental Limits, Estimation, and Control,"  
Seminar, A\*STAR Data Storage Institute, Singapore, Jan 21, 2011.
9. "General Theory of Quantum Sensors: Estimation, Control, and Fundamental Limits,"  
National Research Foundation Fellowship Presentation, National University of Singapore, Singapore, Jan 19, 2011.
8. "General Theory of Quantum Sensors: Estimation, Control, and Fundamental Limits,"  
National Research Foundation Fellowship Presentation, Nanyang Technological University, Singapore, Jan 17, 2011.
7. "Using Hindsight to Improve Quantum Sensing,"  
Seminar, Department of Physics, Chinese University of Hong Kong, China, Jan 10, 2011.
6. "Theory of Quantum Sensing: Fundamental Limits, Estimation, and Control,"  
Colloquium, Department of Physics, Chinese University of Hong Kong, China, Jan 7, 2011.
5. "Estimation, Control, and Fundamental Limit of Quantum Sensing,"  
Seminar, School of Engineering and Information Technology, University of New South Wales at the Australian Defence Force Academy, Canberra, Australia, Aug 4, 2010.
4. "Fundamental Quantum Limit to Waveform Estimation,"  
Seminar, Center for Quantum Dynamics, Griffith University, Brisbane, Australia, Jul 27, 2010.
3. "Reversing Time and Space in Classical and Quantum Optics,"  
Seminar, Center for Quantum Information and Control, University of New Mexico, USA, Oct 8, 2009.
2. "Beating Classical and Quantum Limits in Optics,"  
EE 590 Colloquium, Pennsylvania State University, USA, May 3, 2007.
1. "Beating Classical and Quantum Limits in Optics,"  
ECE 294/296 Seminar, University of California - San Diego, USA, Mar 2, 2007.

## PREPRINTS

12. Mankei Tsang,  
“Quantum Onsager relations,”  
arXiv:2403.12896 (2024).
11. Mankei Tsang,  
“Quantum reversal: a general theory of coherent quantum absorbers,”  
arXiv:2402.02502 (2024).
10. Mankei Tsang,  
“Ziv-Zakai-type error bounds for general statistical models,”  
arXiv:2306.08660 (2023).
9. Mankei Tsang,  
“A time-symmetric generalization of quantum mechanics,”  
arXiv:2206.05058 (2022).
8. Mankei Tsang,  
“The Holevo Cramér-Rao bound is at most thrice the Helstrom version,”  
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