Stanford



Arogyaswami Paulraj

Professor (Research) of Electrical Engineering, Emeritus

Electrical Engineering - Information Systems Laboratory

Curriculum Vitae available Online

Bio

BIO

Prof. Arogyaswami Paulraj is an Emeritus Professor at Stanford University. Paulraj's legacy is deeply intertwined with the evolution of wireless communication. His groundbreaking work on MIMO (multiple input, multiple output) technology laid the foundation for today's ubiquitous 4G/5G networks and high-speed Wi-Fi.

Paulraj's journey began in the Indian Navy, where he served from 1965 to 1991. During this time, he led the development of the APSOH anti-submarine sonar system and established three key R&D labs for the Indian government. His contributions earned him the prestigious Padma Bhushan award, India's third highest civilian honor.

Following his naval career, Paulraj joined Stanford University as a postdoctoral researcher. His research focus shifted to wireless communication, where he made groundbreaking contributions to MIMO technology. MIMO enables data transmission using multiple antennas, significantly increasing network capacity and data rates.

Paulraj's innovation has been recognized with numerous accolades, including the 2024 Royal Acad. Eng. Prince Philip Medal, the 2023 IET Faraday Medal, the 2014 Marconi Prize, and the 2011 IEEE Alexander Graham Bell Medal. He is also a fellow of nine national academies in engineering, sciences, and the arts, and an inductee of the US Patent Office’s National Inventors Hall of Fame.

Currently, Paulraj continues to contribute to technological advancement. He chairs several committees for the Government of India, focusing on the Indian Semiconductor Mission and Core ICT initiatives. His dedication to research and development continues to shape the future of wireless communication.

ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Electrical Engineering - Information Systems Laboratory
- Member, Cardiovascular Institute
- Member, Institute for Computational and Mathematical Engineering (ICME)

ADMINISTRATIVE APPOINTMENTS

- Chairman,Executive Council, Indian Semiconductor Mission, DLI (Govt. of India), (2022- present)
- Advisor, Celesta Capital, (2021- present)

- Advisor, Facebook Inc, (2016-2021)
- CTO, Founder, Rasa Networks, (2014-2016)
- Sr. Advisor,, Broadcom Corp., (2010-2014)
- CTO / Co-Founder, Beceem Comm. Inc, (2004-2010)
- CTO, Founder, Iospan Wireless Inc.,, (1998-2004)
- Professor / Emeritus (Research),, Stanford University, (1993- present)
- Visiting Scientist, Stanford University, (1992-1993)
- Chief Scientist, Central Research Lab, Bharat Electronics, Bangalore, (1988-1991)
- Director, Center for Development of Advance Computing, Bangalore (Govt. of India), (1989-1990)
- Director, Center for Artificial Intelligence and Robotics, DRDO, Govt. of India, (1987-1988)
- Visiting. Scientist, Stanford University, (1983-1985)
- APSOH Project Lead, Naval Physical & Oceanographic Laboratory, Cochin, India, (1977-1983)
- Research Fellow, Loughborough University of Technology, Loughborough, UK, (1974-1975)
- Sonar 170B Project lead, Indian Institute of Technology, New Delhi, (1972-1073)

HONORS AND AWARDS

- Prince Phillip Medal, Royal Academy of Engineering, UK (2024)
- Faraday Medal, Inst, of Engineering and Technology (2023)
- Hall of Fame, Wireless History Foundation (2022)
- Member, American Academy of Arts and Sciences (2020)
- RCC Technical Recognition Award, IEEE (2019)
- China Friendship Award, Govt. of PR China (2018)
- National Inventors Hall of Fame, US Patent and Trademark Office (2018)
- Foreign Fellow, Indian National Science Academy (2016)
- Foreign Fellow, Chinese Academy of Engineering (2015)
- Foreign Fellow, Indian Academy of Sciences, India (2014)
- Marconi Prize and Fellowship, Marconi Society (2014)
- Alexander Graham Bell Medal, IEEE (2011)
- Foreign Fellow, National Academy of Sciences, India (2011)
- Fellow, American Association for Advancement of Sciences (2010)
- Padma Bhushan, President of India (2010)
- Foreign Member, Royal Swedish Academy of Engineering Sciences (2008)
- Fellow, The World Academy of Sciences (2007)
- Member, US National Academy of Engineering (2006)
- Technical Achievement Award, IEEE SP Soc (2003)
- Distinguished Alumnus Award, Indian Institute of Technology, Delhi (1998)
- Fellow, Indian National Academy of Engineering (1997)
- Fellow, IEEE (1990)
- Scientist of the Year Award, Government of India (1985)
- Ati Vishist Seva Medal, Government of India (1983)

- Vishist Seva Medal, Government of India (1974)

BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Board of Directors, Iospan Wireless (1998 - 2004)
- Board of Directors, Quadgen Wireless Inc (2016 - present)
- Board of Directors, Rasa Networks (2014 - 2016)
- Board of Directors, Beceem Comm. Inc (2004 - 2010)

PROFESSIONAL EDUCATION

- BE, Naval College of Engineering, Lonavala, India , Elect. Engg. (1966)
- PhD, Indian Institute of Technology, Delhi, India , Elect. Engg. (1973)

PATENTS

- Arogyaswami Paulraj. "United States See Home Page www.stanford.edu/~apaulraj"

Publications

PUBLICATIONS

- **An approach to physical layer security in MIMO wireless via vector perturbation precoding** *COMMUNICATIONS IN INFORMATION AND SYSTEMS*
  Du, L., Li, L., Paulraj, A. J.
  2020; 20 (2): 117–29
- **Cache-Assisted Broadcast-Relay Wireless Networks: A Delivery-Time Cache-Memory Tradeoff** *IEEE ACCESS*
  Kakar, J., Ahmad, A., Chaaban, A., Sezgin, A., Paulraj, A.
  2019; 7: 76833–58
- **Distributed Online Optimization of Fog Computing for Selfish Devices With Out-of-Date Information** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
  Lyu, X., Ni, W., Tian, H., Liu, R., Wang, X., Giannakis, G. B., Paulraj, A.
  2018; 17 (11): 7704–17
- **Delivery Time Minimization in Cache-Assisted Broadcast-Relay Wireless Networks with Imperfect CSI**
  Kakar, J., Chaaban, A., Sezgin, A., Paulraj, A., IEEE
  IEEE.2018: 880–84
- **Optimal Schedule of Mobile Edge Computing for Internet of Things Using Partial Information** *IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS*
  Lyu, X., Ni, W., Tian, H., Liu, R., Wang, X., Giannakis, G. B., Paulraj, A.
  2017; 35 (11): 2606–15
- **MOTIVATING NETWORK DEPLOYMENT Vehicular Communications** *IEEE VEHICULAR TECHNOLOGY MAGAZINE*
  McGiffen, T., Beiker, S., Paulraj, A.
  2017; 12 (3): 22–33
- **Opportunistic Downlink Interference Alignment for Multi-Cell MIMO Networks** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
  Yang, H. J., Shin, W., Jung, B. C., Suh, C., Paulraj, A.
  2017; 16 (3): 1533-1548
- **Load Balancing in Small Cell Networks Using User Equipment Transfer**
  Nie, G., Tian, H., Zhang, P., Paulraj, A., IEEE
  IEEE.2017
- **User-Centric Precoding Designs for the Non-Regenerative MIMO Two-Way Relay Systems** *IEEE COMMUNICATIONS LETTERS*
  Wang, Z., Li, L., Tian, H., Paulraj, A.

2016; 20 (10): 1935-1938

- **Simultaneous Wireless Information and Power Transfer in Multi-User Interference SISO System**
  Li, L., Wang, H., Wang, Z., Paulraj, A., IEEE
  IEEE.2015
- **Codebook-Based Opportunistic Interference Alignment** *IEEE TRANSACTIONS ON SIGNAL PROCESSING*
  Yang, H. J., Jung, B. C., Shin, W., Paulraj, A.
  2014; 62 (11): 2922-2937
- **Opportunistic Downlink Interference Alignment** *IEEE International Symposium on Information Theory (ISIT)*
  Yang, H. J., Shin, W., Jung, B. C., Suh, C., Paulraj, A.
  IEEE.2014: 1588–1592
- **THE DESIGN OF OPTIMAL RECEIVER FOR OPPORTUNISTIC INTERFERENCE ALIGNMENT** *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*
  Yang, H. J., Jung, B. C., Shin, W., Paulraj, A.
  IEEE.2014
- **Distributed Sum-Rate Optimization for Full-Duplex MIMO System Under Limited Dynamic Range** *IEEE SIGNAL PROCESSING LETTERS*
  Kim, T. M., Yang, H. J., Paulraj, A. J.
  2013; 20 (6): 555-558
- **Cell-Edge Multi-User Relaying with Overhearing** *IEEE COMMUNICATIONS LETTERS*
  Sun, F., Kim, T. M., Paulraj, A. J., De Carvalho, E., Popovski, P.
  2013; 17 (6): 1160-1163
- **Opportunistic Interference Alignment for MIMO Interfering Multiple-Access Channels** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
  Yang, H. J., Shin, W., Jung, B. C., Paulraj, A.
  2013; 12 (5): 2180-2192
- **Low-Complexity MMSE Precoding for Coordinated Multipoint With Per-Antenna Power Constraint** *IEEE SIGNAL PROCESSING LETTERS*
  Kim, T. M., Sun, F., Paulraj, A. J.
  2013; 20 (4): 395-398
- **Achievable Sum-Rate of MU-MIMO Cellular Two-Way Relay Channels: Lattice Code-Aided Linear Precoding** *IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS*
  Yang, H. J., Choi, Y., Lee, N., Paulraj, A.
  2012; 30 (8): 1304-1318
- **On the Application of Character Expansions for MIMO Capacity Analysis** *IEEE TRANSACTIONS ON INFORMATION THEORY*
  Ghaderipoor, A., Tellambura, C., Paulraj, A.
  2012; 58 (5): 2950-2962
- **Achievable and Crystallized Rate Regions of the Interference Channel with Interference as Noise** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
  Charafeddine, M. A., Sezgin, A., Han, Z., Paulraj, A.
  2012; 11 (3): 1100-1111
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  Yang, H. J., Chun, J., Choi, Y., Kim, S., Paulraj, A.
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- **Analytical Multi-User MIMO Channel Modeling: Subspace Alignment Matters** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
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- **A Feasibility Study on Opportunistic Interference Alignment: Limited Feedback and Sum-Rate Enhancement** *46th Asilomar Conference on Signals, Systems and Computers*

Yang, H. J., Shin, W., Jung, B. C., Paulraj, A.
IEEE.2012: 1132–1136

- **Antenna Selection and Power Combining for Transmit Beamforming in MIMO Systems** *IEEE Global Communications Conference (GLOBECOM)*
  Kim, T. M., Ghaderipoor, A., Paulraj, A.
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- **Outage Probability of Amplify-and-Forward Cooperation with Full Duplex Relay** *IEEE Wireless Communications and Networking Conference (WCNC)*
  Kim, T. M., Paulraj, A.
  IEEE.2012
- **Transmit Beamforming for EIRP-limited MIMO Systems based on Golay Sequence** *IEEE Global Communications Conference (GLOBECOM)*
  Kim, T. M., Ghaderipoor, A., Paulraj, A.
  IEEE.2012: 4798–4803
- **Opportunistic Interference Alignment for MIMO IMAC: Effect of User Scaling Over Degrees-of-Freedom** *IEEE International Symposium on Information Theory*
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- **Asymptotic Capacity of the Separated MIMO Two-Way Relay Channel** *IEEE TRANSACTIONS ON INFORMATION THEORY*
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- **Evolution of Indian Wireless Networks** *IETE TECHNICAL REVIEW*
  Paulraj, A.
  2011; 28 (5): 375-380
- **Correlation-based radio localization in an indoor environment** *EURASIP JOURNAL ON WIRELESS COMMUNICATIONS AND NETWORKING*
  Callaghan, T., Czink, N., Mani, F., Paulraj, A., Papanicolaou, G.
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- **MIMO From Theory to Implementation Foreword** *MIMO: FROM THEORY TO IMPLEMENTATION*
  Paulraj, A.
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  2011: XI-+
- **On Gaussian Multiple Access Channels with Interference: Achievable Rates and Upper Bounds**
  Chaaban, A., Sezgin, A., Bandemer, B., Paulraj, A.
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  SPRINGER-VERLAG BERLIN.2011: 87-+
- **Subspace Modeling of Multi-User MIMO Channels** *IEEE 74th Vehicular Technology Conference (VTC)*
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- **MIMO Systems Based on Modulation Diversity** *IEEE TRANSACTIONS ON COMMUNICATIONS*
  Lee, H., Paulraj, A.
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- **Experimental Characterization and Modeling of Outdoor-to-Indoor and Indoor-to-Indoor Distributed Channels** *IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY*
  Oestges, C., Czink, N., Bandemer, B., Castiglione, P., Kaltenberger, F., Paulraj, A. J.
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- **Experimental Investigation on Time Reversal Precoding for Space-Time Focusing in Wireless Communications** *IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT*
  El-Sallabi, H., Kyritsi, P., Paulraj, A., Papanicolaou, G.

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- **Beamforming for Network-Coded MIMO Two-Way Relaying** *44th Asilomar Conference on Signals, Systems and Computers*
  Kim, T. M., Bandemer, B., Paulraj, A.
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- **Secret Key Agreement Based on Radio Propagation Characteristics in Two-Way Relaying Systems** *IEEE Global Telecommunications Conference (GLOBECOM 2010)*
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  Castiglione, P., Oestges, C., Czink, N., Bandemer, B., Kaltenberger, F., Paulraj, A.
  IEEE.2010
- **Robust Collaborative-Relay Beamforming** *IEEE TRANSACTIONS ON SIGNAL PROCESSING*
  Zheng, G., Wong, K., Paulraj, A., Ottersten, B.
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  Sezgin, A., Altay, G., Paulraj, A.
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  Bandemer, B., Oestges, C., Czink, N., Paulraj, A.
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- **2-Sector Interference Channel Communication for Sum Rates and Minimum Rate Maximization** *43rd Annual Conference on Information Sciences and Systems*
  Charafeddine, M., Paulraj, A.
  IEEE.2009: 951–956
- **Maximum Sum Rates via Analysis of 2-User Interference Channel Achievable Rates Region** *43rd Annual Conference on Information Sciences and Systems*
  Charafeddine, M., Paulraj, A.
  IEEE.2009: 170–174
- **Spatial Separation of Multi-User MIMO Channels** *20th IEEE Symposium on Personal, Indoor and Mobile Radio Communications*
  Czink, N., Bandemer, B., Vazquez-Vilar, G., Jalloul, L., Oestges, C., Paulraj, A.
  IEEE.2009: 1059–1063
- **Overhearing-based Interference Cancellation for Relay Networks** *70th IEEE Vehicular Technology Conference*
  Bandemer, B., Li, Q., Lin, X. E., Paulraj, A.
  IEEE.2009: 566–570
- **Crystallized Rates Region of the Interference Channel via Correlated Equilibrium with Interference as Noise** *IEEE International Conference on Communications (ICC 2009)*
  Charafeddine, M., Han, Z., Paulraj, A., Cioffi, J.
  IEEE.2009: 3322–3327
- **On the Asymptotic Optimality of Opportunistic Norm-Based User Selection with Hard SINR Constraint** *EURASIP JOURNAL ON ADVANCES IN SIGNAL PROCESSING*
  Zhang, X., Jorswieck, E. A., Ottersten, B., Paulraj, A.

2009

- **Spatial Separation of Multi-User MIMO Channels** *20th IEEE Symposium on Personal, Indoor and Mobile Radio Communications*
  Czink, N., Bandemer, B., Vazquez-Vilar, G., Jalloul, L., Oestges, C., Paulraj, A.
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- **Overhearing-based Interference Cancellation for Relay Networks** *70th IEEE Vehicular Technology Conference*
  Bandemer, B., Li, Q., Lin, X. E., Paulraj, A.
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- **Crystallized Rates Region of the Interference Channel via Correlated Equilibrium with Interference as Noise** *IEEE International Conference on Communications (ICC 2009)*
  Charafeddine, M., Han, Z., Paulraj, A., Cioffi, J.
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- **On the Asymptotic Optimality of Opportunistic Norm-Based User Selection with Hard SINR Constraint** *EURASIP JOURNAL ON ADVANCES IN SIGNAL PROCESSING*
  Zhang, X., Jorswieck, E. A., Ottersten, B., Paulraj, A.
  2009
- **On the relation of OSTBC and code rate one QSTBC: Average rate, BER, and coding gain** *7th IEEE Workshop on Signal Processing Advances in Wireless Communications*
  Sezgin, A., Jorswieck, E. A., Henkel, O., Pereira, S., Paulraj, A.
  IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC.2008: 4879–91
- **Antenna selection in space-time block coded systems: Performance analysis and low-complexity algorithm** *IEEE Global Telecommunications Conference (GLOBECOM 07)*
  Chen, C., Sezgin, A., Cioffi, J. M., Paulraj, A.
  IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC.2008: 3303–14
- **Multicell optimization for diversity and interference mitigation** *IEEE Global Telecommunications Conference (GLOBECOM 05)*
  Oteri, O., Paulraj, A.
  IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC.2008: 2050–61
- **Statistical opportunistic scheduling with tap correlation information for an OFDMA system in uplink** *IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY*
  Yoon, E., Tujkovic, D., Paulraj, A.
  2008; 57 (3): 1708-1714
- **Guaranteed performance region in fading orthogonal space-time coded broadcast channels** *EURASIP JOURNAL ON WIRELESS COMMUNICATIONS AND NETWORKING*
  Jorswieck, E., Ottersten, B., Sezgin, A., Paulraj, A.
  2008
- **Interference Limited Broadcast: Role of Interferer Geometry** *IEEE International Symposium on Information Theory*
  Pereira, S., Sezgin, A., Paulraj, A., Papanicolaou, G.
  IEEE.2008: 757–761
- **Feedback reduction in uplink MIMO OFDM systems by chunk optimization** *IEEE International Conference on Communications (ICC 2008)*
  Jorswieck, E., Ottersten, B., Sezgin, A., Paulraj, A.
  IEEE.2008: 4348–4352
- **Where to place interferers in a wireless network** *IEEE Information Theory Workshop*
  Sezgin, A., Paulraj, A., Jorswieck, E. A.
  IEEE.2008: 348–352
- **On the Noisy Interference Regime of the MISO Gaussian Interference Channel** *42nd Asilomar Conference on Signals, Systems and Computers*
  Bandemer, B., Sezgin, A., Paulraj, A.
  IEEE.2008: 1098–1102
- **Tile-based MIMO OFDM systems: The Impact of Inaccurate Channel State Information** *42nd Asilomar Conference on Signals, Systems and Computers*

Sezgin, A., Bandemer, B., Paulraj, A., Jorswieck, E. A.
IEEE.2008: 1326–1329

- **Mobility Dependent Feedback Scheme for point-to-point MIMO Systems** *42nd Asilomar Conference on Signals, Systems and Computers*
  Vazquez-Vilar, G., Majjigi, V., Sezgin, A., Paulraj, A.
  IEEE.2008: 1315–1319
- **Feedback reduction in uplink MIMO OFDM systems by chunk optimization** *EURASIP JOURNAL ON ADVANCES IN SIGNAL PROCESSING*
  Jorswieck, E., Sezgin, A., Ottersten, B., Paulraj, A.
  2008
- **Distributed space-time systems** *EURASIP JOURNAL ON ADVANCES IN SIGNAL PROCESSING*
  Mallik, R. K., Paulraj, A. J., Chakraborty, M., Zhang, K. Q., Karagiannidis, G. K.
  2008
- **Space-frequency precoding with space-tap correlation information at the transmitter** *IEEE TRANSACTIONS ON COMMUNICATIONS*
  Yoon, E., Hansen, J., Paulraj, A.
  2007; 55 (9): 1702-1711
- **MIMO wireless linear precoding** *IEEE SIGNAL PROCESSING MAGAZINE*
  Vu, M., Paulraj, A.
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- **On the capacity of MIMO wireless channels with dynamic CSIT** *43rd Annual Allerton Conference on Communication, Control and Computing*
  Vu, M., Paulraj, A.
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- **Linear precoding for high-K-factor channels exploiting channel mean and covariance information** *59th IEEE Vehicular Technology Conference*
  Oteri, O., Yoon, E., Paulraj, A.
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  Oyman, O., Paulraj, A. J.
  IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC.2007: 2282–93
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- **Efficient high-performance decoding for overloaded MIMO antenna systems** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
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  Lee, F. K., Vu, M. H., Paulraj, A. J.
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- **User selection schemes in multiple antenna broadcast channels with guaranteed performance** *8th IEEE Workshop on Signal Processing Advances in Wireless Communications*
  Zhang, X., Jorswieck, E. A., Ottersten, B., Paulraj, A.

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- **Simplified eigenvalues distributions of 2x2 complex noncentral Wishart** *41st Asilomar Conference on Signals, Systems and Computers*
  Charafeddine, M., Paulraj, A.
  IEEE.2007: 1215–1218
- **Guaranteed performance region in fading orthogonal space-time coded broadcast channels** *IEEE International Symposium on Information Theory*
  Jorswieck, E. A., Ottersten, B., Sezgin, A., Paulraj, A.
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- **SOS-based blind channel estimation under space-time block coded transmissions** *8th IEEE Workshop on Signal Processing Advances in Wireless Communications*
  Via, J., Santamaria, I., Sezgin, A., Paulraj, A. J.
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- **Sequential geometric programming for 2x2 interference channel power control** *41st Annual Conference on Information Sciences and Systems (CISS 2007)*
  Charafeddine, M., Paulraj, A.
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  Sezgin, A., Paulraj, A., Vu, M.
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- **On the ergodic sum-rate performance of CDD in multi-user systems** *IEEE Information Theory Workshop*
  Sezgin, A., Charafeddine, M., Paulraj, A.
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  Wong, K., Paulraj, A.
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  Dua, A., Medepalli, K., Paulraj, A. J.
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- **Design and analysis of linear distributed MIMO relaying algorithms** *IEE PROCEEDINGS-COMMUNICATIONS*
  Oyman, O., Paulraj, A. J.
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- **Capacity scaling law's in MIMO relay networks** *IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS*
  Bolcskei, H., Nabar, R. U., Oyman, O., Paulraj, A. J.
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  Heath, R. W., Strohmer, T., Paulraj, A. J.
  IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC.2006: 1217–26
- **Multiple antenna technology in mobile broadband - New challenges for RF designers** *IEEE Radio Frequency Integrated Circuits Symposium (RFIC)*
  Paulraj, A.
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- **MSE based optimization of multiuser MIMO MAC with partial CSI** *40th Asilomar Conference on Signals, Systems and Computers*
  Zhang, X., Jorswieck, E. A., Ottersten, B., Paulraj, A.
  IEEE.2006: 374–378
- **Studies in Downlink Spectral Efficiency of OFDMA networks with MIMO and Opportunistic Scheduling** *IEEE Global Telecommunications Conference (GLOBECOM 06)*
  Oteri, O., Chiurtu, N., Lee, F. K., Charafeddine, M., Paulraj, A.
  IEEE.2006
- **Partially cooperative MIMO channels with scaled identity transmit covariance** *IEEE International Symposium on Information Theory*
  Stauffer, E., Tujkovic, D., Paulraj, A.
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