

## Urvashi Rao Venkata

### **Assistant Scientist (Computational Sciences)**

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### Research Interests

Algorithm research and software development for image reconstruction, signal calibration and image/data analysis, applied to radio interferometers and radio astronomy.

- Application of numerical optimization techniques to inverse problems in image reconstruction.
- Algorithms for the detection and removal of electromagnetic interference.
- Algorithms for calibration of radio-frequency receivers.
- Parallel and high-performance computing, data visualization.

### Education

#### **Ph.D. Physics**

Aug 2004 - May 2010

New Mexico Institute of Mining and Technology, Socorro, NM, USA

*Dissertation:* "Parameterized Deconvolution for Wide-Band Radio Synthesis Imaging"

#### **M.S. Computer Science (Scientific Computing)**

Sep 2002 - Jun 2004

University of California, San Diego, CA, USA

*Thesis:* "A performance model and load balancer for a Parallel Monte-Carlo Cellular Microphysiology Simulator"

#### **M.Sc.(Hons.) Physics & B.E.(Hons.) Computer Science**

Aug 1997 - Jun 2002

Birla Institute of Technology and Science, Pilani, India

### Current Position

- **Assistant Scientist/CS**, National Radio Astronomy Observatory, Socorro, USA [Aug 2010 - present]

*Supervisors :* Jeff Kern, Gareth Hunt

#### **Algorithm Research and Development**

(Numerical formulation, implementation, validation, deployment, documentation and user-support).

- A multi-scale multi-frequency synthesis (MS-MFS) algorithm for wide-band imaging.
- Wide-field wide-band imaging with primary-beam correction, w-projection and mosaicing.
- Wide-band full-polarization image reconstruction
- Automated detection and removal of radio-frequency interference.

#### **CASA Software Development**

- Feature additions, software bug fixes and refactoring in accordance with the CASA release process.
- Imager module : Technical documentation, user-support, technical input to management.

## Journal Publications

- "A multi-scale multi-frequency deconvolution algorithm for synthesis imaging in radio-interferometry", **U.Rau**, T.J.Cornwell, (**submitted to A&A**)
- "Deep Radio Continuum Imaging of the Dwarf Irregular IC 10: Tracing Star Formation and Magnetic Fields", Volker Heesen, **U. Rau**, Michael P. Rupen, Elias Brinks, Deidre Hunter (**submitted to ApJL**)
- "EVLA Observations of Galactic Supernova Remnants: wide-field continuum and spectral-index imaging", Sanjay Bhatnagar, **U. Rau**, David A. Green, and Michael P. Rupen, (**submitted to ApJL**)
- "SparseRI: A Compressed Sensing Framework for Aperture Synthesis Imaging in Radio Astronomy", Wenger, S. Magnor, M. Pihlström, Y. Bhatnagar, **S. Rau, U.**, Publications of the Astronomical Society of the Pacific, Volume 122, issue 897, pp.1367-1374.
- "Advances in Calibration and Imaging Techniques in Radio Interferometry", **U.Rau**, S.Bhatnagar, M.A.Voronkov, T.J.Cornwell, Proceedings of the IEEE, Vol.97, No.8, p-1472, August 2009.

## Conference Proceedings

- "Monte-Carlo Image analysis in Radio Interferometry", **U.Rau**, T.J.Cornwell, Astronomical Data Analysis Software and Systems XIV ASP Conference Series, Vol. 347, p-168 2004
- "Solving for Polarization Leakage in Radio Interferometers Using Unpolarized Sources", Bhatnagar S., **Urvashi R.V.**, Nityananda R., Astronomical Data Analysis Software and Systems XII ASP Conference Series, Vol. 295, p-469 2003.

## Theses

- "Parameterized Deconvolution for Wide-Band Radio Synthesis Imaging", **Urvashi R.V.**, Ph.D. Dissertation, New Mexico Institute of Mining and Technology, Socorro, NM, USA, May 2010.
- "A performance model and load balancer for a Parallel Monte-Carlo Cellular Microphysiology Simulator", **Urvashi R.V.**, M.S. Thesis, University of California, San Diego, June 2004.

## Memos / Technical Reports

- "Imaging Algorithms in CASA", **U.Rau**, CASA documentation, 2010/2011.
- "Casapy Flag tool and casa::Flagger", **U. Rau**, CASA Programmers Note, 23 August 2007
- "Design of casa::TablePlot for Casapy", **U. Rau**, CASA Programmers Note, 18 August 2007
- "Multi Frequency Synthesis Imaging for the EVLA : An initial investigation", **Urvashi R.V.**, T.J.Cornwell, S.T.Myers, EVLA Memo 101, April 2006
- "Monte Carlo Methods for Bayesian Image Reconstruction and Analysis in Radio Astronomy", **Urvashi R.V.**, T.J.Cornwell, EVLA Memo 102, February 2006
- "Automatic RFI identification and flagging", **Urvashi R.V.**, A. Pramesh Rao, NCRA Technical Report No. R00202, October 1 2003

## Selected Talks and Presentations

- "*Pilot Project for an EVLA wide-band Galactic-plane survey : first results*", 26th Annual New Mexico Symposium, 5 November 2010, Socorro, NM, USA.
- "*A few imaging results using wide-band EVLA data*", Wednesday Lunch talk at the NRAO/SOC, 3 November 2010, Socorro, NM, USA.
- "*Wide-field Wide-band image reconstruction with the EVLA*", Univ. of New Mexico Physics Dept. Seminar, 30 September 2010, Albuquerque, NM, USA.
- "*Feasibility of wide-band imaging (using MS-MFS)*", Talk at the Fifth SKA Calibration and Imaging workshop, 23 August 2010, Dwingeloo, The Netherlands.
- "*Wide-Field Wide-Band Imaging in Radio Interferometry*", NCRA Colloquium, 12 July 2010, Pune, India
- "*Parameterized Deconvolution for Wide-Band Radio Synthesis Imaging*", Colloquium / PhD Thesis defense, 17 May 2010, Socorro, NM, USA
- "*Wide-Field Wide-Band Imaging with the EVLA*", Talk at the 215<sup>th</sup> American Astronomical Society (AAS) meeting, 6 January 2010, Washington D.C., USA
- "*Feasibility of Multi-Frequency-Synthesis - for non-standard cases*", Presentation to the NRAO Algorithm Research and Development Group, 16 July 2009, Socorro, USA
- "*Wide-Field Wide-Band Imaging in Radio Interferometry*", Talk at the ATNF Student Symposium, 16 June 2009, Sydney, AU (via audio link from Socorro)
- "*Remote Sensing, Image Making and Radio Telescopes*", Colloquium at the New Mexico Tech Physics Department, 09 Apr 2009, Socorro, USA
- "*Wide-Field Wide-Band Imaging with the EVLA - initial results*", Talk at the Fourth SKA Calibration and Imaging Workshop, 31 March 2009, Socorro, USA
- "*Multi Frequency Synthesis Imaging with Wideband EVLA data*", Lunch Talk at the EVLA Advisory Committee Meeting, 19-20 March 2009, Socorro, USA
- "*Multi-Frequency Synthesis Imaging with Multi-Scale Deconvolution (EVLA, e-MERLIN)*", Talk at the Workshop on Imaging and Calibration Algorithms for EVLA, eMERLIN and ALMA, 02 December 2008, Oxford, UK (via video link from Socorro)
- "*Multi-Frequency Synthesis Imaging with Wide-Band (E)VLA data*", Talk at the 24th Annual New Mexico Symposium, 24 October 2008, Socorro, USA
- "*Multi-Frequency Synthesis Imaging with Multi-Scale Deconvolution*", Invited Talk at the XXIX URSI General Assembly, 15 August 2008, Chicago, USA
- "*Wide-Band Imaging - Algorithms and Errors*", Talk at the Third SKA Calibration and Imaging Workshop, 09 April 2008, Perth, AU
- "*Multi-Frequency Synthesis Imaging with Multi-Scale deconvolution*", Talk at the Second SKA Calibration and Imaging Workshop, 05 December 2006, Cape Town, South Africa
- "*Wide Bandwidth Imaging: Challenges and prospects for the EVLA and beyond*", Talk at the URSI National Radio Science Meeting, 06 January 2006, Boulder, USA

## Prior Work/Research Experience

- **Pre-doctoral Student**, National Radio Astronomy Observatory (NRAO) [Jan 2008 - May 2010]  
**Affiliated Student**, Australia Telescope National Facility (ATNF) [Jun 2006 - May 2010]  
**Research Assistant**, Dept. of Physics, NMIMT [Aug 2004 - May 2010]  
**Graduate Intern**, National Radio Astronomy Observatory [Jul 2004 - Aug 2004]

*Ph.D. Dissertation* : **Parameterized deconvolution for wide-band radio synthesis imaging**

*Advisors* : Timothy J. Cornwell, Frazer N. Owen, Jean A. Eilek

- Performed a formal mathematical analysis of the imaging process in radio interferometry to describe established and recently developed radio synthesis imaging algorithms and the relations between them, in a common mathematical framework.
- Developed MS-MFS, a multi-scale multi-frequency deconvolution algorithm for wide-field wide-band imaging in radio interferometry, designed for data taken using broad-band receivers in which the incident radiation, telescope transfer function and antenna fields-of-view are all frequency dependent.

- **CASA Programmer**, National Radio Astronomy Observatory [Sep 2004 - Jul 2007]  
*Supervisor* : Joseph P. McMullin

- Designed and implemented an interactive plotting tool for the display of radio-interferometry data, ported the AIPS++ flagger module to CASA.

- **Research Assistant** [Sep 2003 - Mar 2004]  
Dept. of Computer Science & Engineering., UC San Diego [Sep 2002 - Mar 2003]

*M.S. Thesis* : **A performance model and load balancer for a parallel Monte-Carlo cellular microphysiology simulator.**

*Advisor* : Scott B. Baden

- Developed a load balancer for a parallel 3D cell-microphysiology simulator. It used an empirically derived performance model to predict spatial and temporal workload distributions within a 3D computational volume, and a dynamic domain-decomposition based on a 3D Hilbert space-filling curve to preserve locality and minimize communication.

- **Graduate Intern**, National Radio Astronomy Observatory, Socorro, NM [Jul 2003 - Sep 2003]

*Project* : **Monte-Carlo Methods for Bayesian Image Reconstruction in Radio Astronomy**

*Advisor* : Timothy J. Cornwell

- Used the Bayesian interpretation of image reconstruction to develop a Markov-Chain Monte-Carlo based algorithm to find the most probable set of 2D Gaussians for a multi-scale representation of an image formed using an interferometer.

- **Undergraduate Intern**, National Centre for Radio Astrophysics, TIFR, Pune [Jan 2002 - Jun 2002]

*Project 1* : **Automatic RFI Identification and Flagging**

*Advisor* : A. Pramesh Rao

- Developed a pattern recognition algorithm to automate the identification and removal of data affected by radio-frequency interference from measurements taken with an imaging interferometer. Implemented as part of the offline data analysis software at the NCRA (2002) and the NRAO (2008).

*Project 2* : **Numerical Solutions of Complex Antenna Gains and Polarization Leakage**

*Advisor* : Rajaram Nityananda

- Studied the mathematical description of the process of full-polarization calibration of a radio interferometer, and implemented and compared numerical solvers based on least-squares methods and eigen decompositions of a correlation matrix.

- **Other projects**

[before Jun 2002]

- Comparative study of Algebraic Deconvolution algorithms, NCRA, Pune, India
- Study of Computed Axial Tomography algorithms, Physics Dept, BITS-Pilani, India
- Study of Wavelet image-representation and decomposition methods, EEE Dept, BITS-Pilani, India
- Developed a Fragile-Watermarking algorithm for Digital Image Security, CS Dept, BITS-Pilani, India

### Teaching Experience

- **Teaching Assistant**

[Apr 2004 - Jun 2004]

Dept. of Computer Science & Engineering, UC San Diego

[Apr 2003 - Jun 2003]

*Course* : **Introduction to High Performance and Parallel Computing**

*Supervisor* : Scott B. Baden

*Responsibilities* : Discussion sessions, office hours, grading of written and programming homework.

### Software Skills

- Programming languages : C, C++, Python
- Environments : Unix/Linux
- Data Analysis Packages : Matlab/Octave, Scipy/Numpy, CASA, ASKAPSOFT
- Libraries : GNU Scientific Library, Numerical Recipes, Bayesys, KeLP, MPI, Python/C API

### Technical Schools Attended

- Ninth Synthesis Imaging Summer School, NRAO, Socorro, June 2004
- Introductory Astrophysics Summer School, Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, India May 2000 - Jun 2000

### Academic Awards and Fellowships

- NRAO Pre-Doctoral Research Fellowship Jan 2008 - Dec 2009
- Award for Overall Best Outgoing Student, Dept of Physics, BITS, Pilani May 2001

### Education and Public Outreach

- Tour guide for the Very Large Array at open-house events in 2005, 2008, 2010.
- Alumni web-lectures as part of the BITS-Embryo project (<http://www.bitsembryo.org>), aimed at introducing undergraduate students at the Birla Institute of Technology and Science, India, to current research and technology trends in various disciplines. (1) "*Remote Sensing At Its Extreme - the interdisciplinary nature of observational radio astronomy*", BITS-Pilani, Nov 2007 and (2) "*Remote Sensing and Image Making*", BITS-Goa, Jan 2009.
- An introductory lecture about the working of a radio interferometer, for a group of 16 high-school students who visited the NRAO, Socorro, NM in April 2009.
- Coordinator, Physics Department, APOGEE 2000. Organized the Physics section of an all-India science and technology festival held annually at BITS-Pilani.
- Astronomy Club Secretary, BITS-Pilani, 1999-2000. Conducted interactive observation sessions and gave informal Astronomy lectures.