

## **Towards Characterization of the First Stars and Galaxies (and Beyond) with Low-Frequency Radio Observations**

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One of the most fundamental questions in astronomy is how the Universe evolved to become the highly structured system of stars and galaxies that we see today. The answer to this question can be largely uncovered in the relatively unexplored periods in the history of the Universe known as the Epoch of Reionization (EoR), where radiation from the first generation of stars and galaxies ionized the neutral hydrogen gas in the intergalactic medium, and its preceding Cosmic Dawn (CD), during which the first stars were formed. The reionization process created “bubbles” of ionized regions around radiating sources that perturbed the matter density distribution and influenced the subsequent formation of stars and galaxies. Exactly how and when reionization occurred are currently up for debate. However, by studying these transformative periods we hope to unravel the underlying astrophysics that governs the formation and evolution of the first stars and galaxies. The most promising probe of the CD/EOR is 21 cm intensity mapping, which aims to create a tomographic map of the neutral hydrogen gas over the epochs by mapping the redshifted 21 cm emission lines of neutral hydrogen with radio interferometers operating at frequencies below 200 MHz. In this talk, I will give an overview on the fundamental of the technique, challenge, and current progress. A significant portion of the talk will be dedicated to discussing statistical detection of the EoR with one-point statistics of 21 cm intensity fluctuations. Other related experiments that utilize low frequency radio observations that might be of interest to the Thai astronomy community will be discussed if time allows.

# Piyanat Kittiwisit

## Curriculum Vitae

✉ [piyanat.kittiwisit@gmail.com](mailto:piyanat.kittiwisit@gmail.com)  
📄 <https://piyanatk.github.io>

### Research Interest

Reionization and Cosmic Dawn, radio astronomy, astrostatistics, big data analysis and machine learning.

### Professional Experience

Beginning **Postdoctoral Fellow**

Sep. 2019 China–South Africa Joint Postdoctoral Fellowship on Cosmology and Radio Astronomy  
University of KwaZulu-Natal, Durban, South Africa  
Shanghai Astronomical Observatory, Shanghai, China  
Shanghai Jiao Tong University, Shanghai, China

2015–2019 **Teaching Assistant**

School of Earth and Space Exploration, Arizona State University

2011–2015 **Research Assistant**

School of Earth and Space Exploration, Arizona State University

2009–2010 **Research Assistant**

Department of Physics, Cornell University, Ithaca, NY

### Education

2019 **Ph.D., Astrophysics**, Arizona State University Tempe, AZ

Advisor: Judd Bowman

Thesis: Towards Characterization of the Epoch of Reionization with Redshifted 21 cm One-point Statistics

2009 **B.A., Physics**, Cornell University, Ithaca, NY

### Publications

#### Selected Articles

These publications I led or made significant contributions to.

- [13] **P. Kittiwisit**, J. D. Bowman, A. P. Beardsley, D. C. Jacobs, S. G. Murray, *Foreground Avoidance in 21 cm One-point Statistics*, in preparation.

- [12] **P. Kittiwisit**, J. D. Bowman, D. C. Jacobs, N. Thyagarajan, A. P. Beardsley, *Sensitivity of the Hydrogen Epoch of Reionization Array and its Build-out Stages to One-point Statistics from Redshifted 21 cm Observations*, 2018, MNRAS, 474, 4487-4499.

### Collaboration Articles

These publications I earned my co-authorship through contributions to the wider MWA, HERA, and CDF collaborations.

- [11] J. Kerrigan, (34 more authors), **P. Kittiwisit**, (28 more authors), *Optimizing Sparse RFI Prediction using Deep Learning*, arXiv:1902.08244
- [10] W. Li, (27 more authors), **P. Kittiwisit**, (27 more authors), *Comparing Redundant and Sky Model Based Interferometric Calibration: A First Look with Phase II of the MWA*, 2018, ApJ, 863, 170.
- [9] A. D. Kapinska, (37 more authors), **P. Kittiwisit**, (31 more authors), *Spectral Energy Distribution and Radio Halo of NGC 253 at Low Radio Frequencies*, 2017, ApJ, 838, 68.
- [8] S. Paul, (21 more authors), **P. Kittiwisit**, (31 more authors), *Delay Spectrum with Phase-Tracking Arrays: Extracting the HI power spectrum from the Epoch of Reionization*, 2016, ApJ, 833, 213.
- [7] A. R. Offringa, (15 more authors), **P. Kittiwisit**, (21 more authors), *Parametrizing Epoch of Reionization foregrounds: a deep survey of low-frequency point-source spectra with the Murchison Widefield Array*, 2016, MNRAS, 458, 1057-1070
- [6] J. C. Pober, (30 more authors), **P. Kittiwisit**, (37 more authors), *The Importance of Wide-field Foreground Removal for 21 cm Cosmology: A Demonstration with Early MWA Epoch of Reionization Observations*, 2016, ApJ, 819, 8.
- [5] J. S. Dillon, (17 more authors), **P. Kittiwisit**, (36 more authors), *Empirical covariance modeling for 21 cm power spectrum estimation: A method demonstration and new limits from early Murchison Widefield Array 128-tile data*, 2015, Phys. Rev. D, 91, 123011.
- [4] A. R. Offringa, (28 more authors), **P. Kittiwisit**, (35 more authors), *The Low-Frequency Environment of the Murchison Widefield Array: Radio-Frequency Interference Analysis and Mitigation*, 2015, PASA, 32, e008.
- [3] N. Thyagarajan, (23 more authors), **P. Kittiwisit**, (39 more authors), *Foregrounds in Wide-field Redshifted 21 cm Power Spectra*, 2015, ApJ, 804, 14.
- [2] N. Thyagarajan, (21 more authors), **P. Kittiwisit**, (32 more authors), *Confirmation of Wide-field Signatures in Redshifted 21 cm Power Spectra*, 2015, ApJL, 807, L28.

- [1] (CDF Collaboration), T. Aaltonen, (235 more authors), **P. Kittiwisit**, (55 more authors), *Search for New Physics in High  $pT$  Like-Sign Dilepton Events at CDF II*, 2011, Phys. Rev. Lett., 107, 181801.

## Professional Service and Memberships

- 2018–Present Scientific Reviewer, Monthly Notices of the Royal Astronomical Society, Oxford University Press.
- 2018–Present Graduate student member, American Astronomical Society.
- 2014–Present Collaboration member, Hydrogen Epoch of Reionization Array (HERA).
- 2011–Present Collaboration member, Murchison Widefield Array (MWA).
- 2010 Collaboration member, The Collider Detector at Fermilab (CDF).

## Talks

- [4] **Measuring Higher-order 21 cm One-point Statistics from the Epoch of Reionization**, American Astronomical Society Meeting 223, Seattle, WA, January, 2019
- [3] **Measuring 21 cm One-point Statistics with HERA**, Radio Astronomy Lab Seminar, University of California, Berkeley, CA, July 7, 2017
- [2] **Instrumental Effects on One-point Statistics from Redshifted 21 cm Observations**, American Physical Society Four Corners Meeting, Arizona State University, Tempe, AZ, October 17, 2015
- [1] **Simulation of Redshifted 21 cm Observation of the Epoch of Reionization and Its Statistical Interpretation**, Physics Seminar, Suranaree University of Technology, Nakhon Ratchasima, Thailand, January 8, 2015

## Contributed Abstracts

Busch, M. P., Bowman, J. D., **Kittiwisit, P.**, Jacobs, D. C., 2016. *Foreground Characterization for the Murchison Widefield Array Using the Jansky Very Large Array*, American Astronomical Society, 227, p.140.07.

## Teaching and Mentoring Experiences

- 2015–2019 Teaching Assistant, School of Earth and Space Exploration, Arizona State University
- In-person Introductory to Astronomy Lecture
  - In-person Introductory Astronomy Laboratory
  - Online Introductory Astronomy (lead TA and course development)

- 2015–2016 Mentored an ASU undergraduate student, Kali Johnson, in a pitching competition organized by the School of Earth and Space Exploration. Kali won the second prize.
- 2015–2016 Mentored an ASU undergraduate student, Michael Busch, who performed analysis of data from the VLA 2014B observation for his honored undergraduate thesis.
- 2006–2007 Physics tutor for athletic students, Cornell University. I held weekly private tutoring session for the university athletic students per request.

## ■ Honors and Awards

- 2019 ASU Graduate and Professional Student Association, Individual Travel Grant, \$900
- 2001–2016 **DPST Fellowship**  
This competitive scholarship from the Development and Promotion of Science and Technology Talents Project (DPST) of Thailand had provided funding supports for my study over the years.

## ■ Observing Time Awards

**Piyanat Kittiwisit**, Judd D. Bowman. Daniel C. Jacobs, *Spectral Observations of Foreground Sources in the North Sidelobe of the Murchison Widefield Array with the Upgraded P-band Receiver*, Very Large Array, 2014B, 10 hours

## ■ Community Outreach Service

- 2011–2019 ASU Earth and Space Open House  
Exhibitor at monthly public outreach event organized by the School of Earth and Space Exploration
- April 2017 Astronomy Day at the Arizona Scienc Center  
Present a radio astronomy exhibit.
- June 2015 The 12th Science and Technology Conference for Youths, Thailand  
Judge for high-school science project awards
- 2012–2013 Grad Council, School of Earth and Space Exploration  
Member of a governing graduate student body whose purpose is to organize professional development workshops and the graduate student recruitment event, and to serve as a bridge between the faculties and fellow graduate students.
- 2012–2013 ASU Astronomy Computational Tools Seminar  
Organize and teach in a graduate-taught seminar whose purpose is to introduce tools that are useful in astronomy computing to fellow graduate students.

2011-2012 ASU Astronomy Coffee  
Organize a weekly seminar where graduate students and postdocs gather to discuss significant astronomy papers.

Periodically Software contribution to CASA, FHD, Astropy and various other python packages.

## ■ Training and Workshops

Jan 2019 AAS Astronomy Ambassadors

Summer 2012 13th Synthesis Imaging Summer School, New Mexico Institute for Mining and Technology and Nation Radio Astronomy Observatory, Socorro, NM.

## ■ Computing Skills

Languages Python, C/C++, Matlab, IDL

Platform High-Performance Computing Cluster (SLURM), Linux, Window, Mac

Software CASA, FHD, MAPS, PRISim, HEALPix, Astropy, DASK, Pandas, XArray