

Tzu-Ching Chang

Jet Propulsion Laboratory

4800 Oak Grove Dr, Pasadena, CA 91109

email: tzu-ching.chang@jpl.nasa.gov

phone: 626-298-5446

PROFESSIONAL HISTORY

- 2017 – present Research Scientist
Jet Propulsion Laboratory, USA
- 2015 – 2015 Long-term Visitor
Jet Propulsion Laboratory, USA
- November 2012 CCASTRO Visitor
University of Melbourne, Australia
- 2010 – 2016 Assistant Research Fellow
**Academia Sinica Institute of Astronomy & Astrophysics (ASIAA),
Taiwan**
- 2006 – 2010 Joint CITA-ASIAA Postdoctoral Fellow
**Canadian Institute for Theoretical Astrophysics (CITA), Canada
ASIAA, Taiwan**
Academia Sinica Distinguished Postdoctoral Fellow
- 2003 – 2006 Theoretical Astrophysics Center (TAC) Postdoctoral Fellow
University of California at Berkeley, USA
- 2001 – 2001 Visiting Graduate Research Assistant
IoA, Cambridge University, UK
- 1997 – 2003 Graduate Research Assistant
Columbia University, USA
- 1997 – 2000 Teaching Assistant
Columbia University, USA

EDUCATION

- 2003 — Ph. D., *Astronomy*
Columbia University, USA
Adviser: *David Helfand*
Thesis title: *Cosmic Shear Measurement with the FIRST Radio Survey.*
- 2002 — M. Phil., *Astronomy*
Columbia University, USA
- 2000 — M. A., *Astronomy*
Columbia University, USA
- 1997 — B. S., *Physics*
National Taiwan University, Taiwan

RESEARCH INTERESTS

- Hydrogen 21-cm Cosmology, global signal and fluctuations
- Line intensity mapping with multiple emission lines, e.g., 21-cm, [CII], CO
- Formation, evolution and probes of cosmic structures
- Physics and probes of the Cosmic Dawn and Epoch of Reionization
- Precision measurement of dark energy
- Weak gravitational lensing

PROFESSIONAL ACTIVITIES

- Principle Investigator of GBT-HIM, the 800 MHz multi-beam instrument at the Green Bank Telescope (GBT). Main scientific goal is Baryon Acoustic Oscillation (BAO) measurements at $0.6 < z < 1$ with redshifted 21cm Intensity Mapping. Passed Design Review in October 2016.
- Team member of TIME (PI: J. Bock, Caltech/JPL), a [CII] Intensity Mapping experiment aiming to measure the [CII] large-scale fluctuations at $5 < z < 9$ during the Epoch of Reionization. TIME commissioning on the APA/12-m telescope expected in spring 2018.
- Team member of AIM-CO, the ASIAA CO Intensity Mapping experiment (PI: Y.-H. Chu). Main scientific goal is to map the cosmic structure and the Epoch of Reionization with CO Intensity Mapping, building on the existing Y-T. Lee Array (formally AMiBA).
- Collaborator of HIRAX, a HI Intensity Mapping experiment (PI: J. Sievers). Main scientific goal is BAO measurements at $0.8 < z < 2.5$ with 21cm intensity mapping and radio fast transient searches. Current design consists of 1024 close-packed 6-m dishes at the South Africa SKA site.
- Collaborator, JPL R&TD on “A global approach to the ‘Global Signal’ measurement from the Epoch of Reionization” (PI: M. Seiffert). Develop robust techniques and analysis framework to optimize 21cm global signal extraction, probing the Cosmic Dawn and the Epoch of Reionization.
- Elected *The World Academy of Sciences (TWAS)* Young Affiliate, 2012-2016
- Atacama Large Millimeter/submillimeter Array (ALMA) Review Panel Science Assessor, Cycles 4-6
- Murchison Widefield Array (MWA, Australia) Time Allocation Committee (TAC) member, 2013-2015
- Next Generation VLA Time Domain, Cosmology, Fundamental Physics Science Working Group member
- SKA Cosmology Science Working Group Core member
- SKA Epoch-of-Reionization Science Working Group member
- SKA HI Science Working Group member
- Exascale Radio Astronomy Center for Computing, advisory panel member, 2014

- National Science Foundation panel reviewer (USA)
- NASA Astrophysics Theory Program (ATP) panel reviewer (USA)

SOC member

- IAU Symposium on “Peering Towards Cosmic Dawn”, Dubrovnik, Croatia, September 2017
- “Shedding light on the dark universe with giant telescopes”, Asia/Oceanic region, Xi-An, China, August 2017
- “Opportunities and Challenges in Intensity Mapping” workshop, KIPAC, Stanford University, USA, March 2016
- “Asia-Pacific regional SKA workshop for HI science”, Seoul, South Korea, November 2015
- Conference on “Early Science from Low-frequency Radio Telescopes”, Tempe, Arizona, USA, December 2014
- SKA Science Workshop in East Asia, Nagoya, Japan, June 2013
- East Asia SKA HI Science Workshop, Beijing, China, September 2012
- East Asia SKA Collaboration Workshop, Daejeon, Korea, November 2011

Conference Organizer

- TIARA workshop on “Dawn of New Cosmology”, Taipei, Taiwan, December 2014
- AP-RASC Meeting, Asia-Pacific Radio Science Conference, September 2013, Taipei, Taiwan
- PASCOS meeting, the 19th International Symposium on Particles, Strings and Cosmology, November 2013, Taipei, Taiwan
- Manuscript referee for ApJ, AJ, MNRAS & JCAP
- Colloquium organizer, ASIAA
- Co-organizer, Theoretical Astrophysics Center Seminars, University of California at Berkeley
- Press release for the *Nature* article in the July 22, 2010 issue, NRAO
- 21-cm Intensity Mapping work featured in *Physics Today* and international press, July-August 2010

TEACHING AND MENTORING EXPERIENCES

- Public Lecture on “Cosmology and General Relativity” in the NTU CASE “Explore” lecture series on “100 years of General Relativity”, October 2015
- International Lecturer, The 2nd joint China-New Zealand SKA summer school, Shanghai, July 1-5, 2014
- Co-teaching “Galaxy Formation and Evolution”, a one-semester graduate level class at the Institute of Astrophysics, National Taiwan University, Taipei, Taiwan, Spring 2013, Spring 2014, & Spring 2016
- Guest Lecturer, Cosmology Seminars, Physics Department, National Taiwan University, Spring & Fall 2012, Fall 2013, Fall 2014
- Lecturer, *COSPA* International Cosmology Winter School, January 2012

TEACHING AND MENTORING EXPERIENCES

- Supervising postdoctoral fellows:
 - Dr. Kai-Yang Lin (2014 - 2016)
 - Dr. Yu-Wei Liao (2013 - 2016)
 - Dr. Cheng-Yu Kuo (2013 - 2015, now assistant Prof. at Chung-Shang Univ.)
 - Co-supervising Berkeley-IAA Fellow Dr. Freeke van de Voort (2012 - 2016)
 - Co-supervising Berkeley-IAA Fellow Dr. Phillip Zukin (2012 - 2013)
- Supervising graduate students at the National Taiwan University:
 - Yun-Ting Cheng (2014 - 2015, M.S. in Physics, now at Caltech Physics)
 - Fang-Chun Liu (2012 - 2014, M.S. in Astrophysics)
- Supervising undergraduate students at the National Taiwan University:
 - Chun-Hao To (2014 - 2016, now at Stanford Physics)
 - Chia-Hui Lin (2014 - 2015, now exchange student at Osaka University)
 - Jen-Wei Hsueh (2013 - 2014, undergraduate student, now at UC Davis)
- Co-supervised several graduate and undergraduate students involved in the projects, including Greg Paciga (Univ. of Toronto), Julia Odegova (Univ. of Toronto), Tingting Lu (Univ. of Toronto), Kevin Bandura (Carnegie Mellon University) and University of Toronto undergraduate summer students Hans Nguyen, Josh Albert, Connie Lien, Nidhi Banavar, Mark Kuiack at GMRT, India.
- Lectured and designed astrophysics laboratory works for undergraduate students as a graduate teaching assistant at Columbia University.

REFERENCES

**HELFAND
David J.**

Columbia Astrophysics Laboratory & QUEST University
Columbia University, Pupin Hall, New York, NY 10027, USA
tel : +1 (212) 854 2150 fax : +1 (212) 854 8121
email : djh@astro.columbia.edu

**MA
Chung-Pei**

Department of Astronomy
Dept. of Astronomy, UC Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA
tel : +1 (510) 642 4850 fax: +1 (510) 642 3411
email : cpma@berkeley.edu

**PEN
Ue-Li**

Canadian Institute for Theoretical Astrophysics
60 St George Street, University of Toronto, Toronto, Ontario M5S 3H8, CANADA
tel : +1 (416) 978 6477 fax: +1 (416) 978 3921
email : pen@cita.utoronto.ca

**PETERSON
Jeffrey B.**

Department of Physics
Carnegie Mellon University, Pittsburgh, PA 15213, USA
tel : +1 (412) 268-2785 fax : +1 (412) 681-0648
email : jbp@cmu.edu

Ensemble Photometric Redshifts

N. Padmanabhan, M. White, **T.-C. Chang**, J. D. Cohn, O. Doré, G. Holder
MNRAS, 2017, submitted

Spectral Lines De-confusion in an Intensity Mapping Survey

Y.-T. Cheng, T.-C. Chang, J. J. Bock, C. M. Bradford, A. Cooray
ApJ, 2016, 832, 165, arXiv:1604.07833

A Practical Theorem on Using Interferometry to Measure the Global 21-cm Signal

T. Venumadhav, T.-C. Chang, O. Doré, C. M. Hirata
ApJ, 2016, 826, 116, arXiv:1512.05248

Accurate Polarization Calibration at 800 MHz with the Green Bank Telescope

Y.-W. Liao, T.-C. Chang, C.-Y. Kuo, K. Masui, N. Opperman, U.-L. Pen, J. B. Peterson
ApJ, 2016, 833, 289, arXiv:1610.04365

Combining Galaxy and 21cm Surveys

J. D. Cohn, M. White, **T.-C. Chang**, G. Holder, N. Padmanabhan, O. Doré
MNRAS, 2016, 457, 2068, arXiv:1511.07377

Dense Magnetized Plasma Associated with a Fast Radio Burst

K. Masui, H.-H Lin, J. Sievers, C. J. Anderson, **T.-C. Chang**, X. Chen, A. Ganguly, M. Jarvis, C.-Y. Kuo, Y.-C. Li, Y.-W. Liao, M. McLaughlin, U.-L. Pen, J. B. Peterson, A. Roman, P. T. Timbie, T. Voytek, J. K. Yadav
Nature, 2015, 528, 523

Interpreting the Unresolved Intensity of Cosmologically Redshifted Line Radiation

E. R. Switzer, **T.-C. Chang**, K. W. Masui, U.-L. Pen, T. C. Voytek
ApJ, 2015, 815, 51

Erasing the Milky Way: new cleaning technique for intensity mapping data

L. Wolz, C. Blake, F. B. Abdalla, C.M. Anderson, **T.-C. Chang**, K.W. Masui, P. Timbie, U.-L. Pen, T.C. Voytek, J. Yadav
MNRAS, 2017, 464, 4938, arXiv:1510.06432

First Results From COPSS: The CO Power Spectrum Survey

G. K. Keating, G. C. Bower, D. P. Marrone, D. R. DeBoer, C. Heiles, **T.-C. Chang**, J. E. Carlstrom, C. H. Greer, D. Hawkins, J. W. Lamb, E. Leitch, A. D. Miller, S. Muchovej, D. P. Woody
ApJ, 2015, 814, 140

Exploiting Cross Correlations and Joint Analyses

J. Rhodes, S. Allen, B. A. Benson, **T.-C. Chang**, R. de Putter et al.
Astropartical Physics, 2015, 63, 42

Cosmological Spectral Deconvolution

R. de Putter, G. P. Holder, **T.-C. Chang**, O. Doré
submitted to MNRAS, 2014, arXiv:1403.3727

Determination of $z \sim 0.8$ Neutral Hydrogen Fluctuations using the 21 cm Intensity Mapping Auto-correlation

E.R. Switzer, K. W. Masui, K. Bandura, L.-M. Calin, **T.-C. Chang**, X. Chen, Y.-C. Li, Y.-W. Liao, A. Natarajan, U.-L. Pen, J.B. Peterson, J.R. Shaw, T.C. Voytek
MNRAS Letters, 2013, 434, 46

A Refined Foreground-corrected Limit on the HI Power Spectrum at $z=8.6$ from the GMRT Epoch of Reionization Experiment

G. Paciga, J. Albert, K. Bandura, **T.-C. Chang**, Y. Gupta, C. Hirata, J. Odegova, U.-L. Pen, J.B. Peterson, J. Roy
MNRAS, 2013, 433, 639

Cross-correlations as a Carbon Monoxide Detector

A. Pullen, **T.-C. Chang**, O. Doré, A. Lidz
ApJ, 2013, 768, 15

The Weight of Emptiness: The Gravitational Lensing Signal of Stacked Voids

E. Krause, **T.-C. Chang**, O. Doré, K. Umetsu
ApJL, 2013, 762, 20

The Baryon Acoustic Oscillation Broadband and Broad-beam Array: Design Overview and Sensitivity Forecasts

J. Pober, A. R. Parsons, D. R. DeBoer, P. McDonald, M. McQuinn, J. E. Aguirre, Z. Ali, R. F. Bradley, **T.-C. Chang**, M. F. Morales
AJ, 2013, 145, 65

Measurement of 21 cm brightness fluctuations at $z \sim 0.8$ in cross-correlation

K. W. Masui, E.R. Switzer, N. Banavar, K. Bandura, C. Blake, L.-M. Calin, **T.-C. Chang**, X. Chen, Y.-C. Li, Y.-W. Liao, A. Natarajan, U.-L. Pen, J.B. Peterson, J.R. Shaw, T.C. Voytek
ApJL, 2013, 763, 20

Intensity Mapping with Carbon Monoxide Emission Lines and the Redshifted 21 cm Line

A. Lidz, S. Furlanetto, P. S. Oh, J. Aguirre, **T.-C. Chang**, O. Doré, J. R. Pritchard
ApJ, 2011, 741, 70

The GMRT-EoR Experiment: A new upper limit on the neutral hydrogen power spectrum at $z \sim 8.6$

G. Paciga, T.-C. Chang, Y. Gupta, R. Nityanada, J. Odegova, U.-L. Pen, J. Peterson, J. Roy, K. Sigurdson
MNRAS, 2011, 413, 1174

An intensity map of hydrogen 21-cm emission at redshift $z \sim 0.8$

T.-C. Chang, U.-L. Pen, K. Bandura, J. B. Peterson
Nature, 2010, 466, 463

Enhanced Detectability of Pre-reionization 21 cm Structure

M. Alvarez, U.-L. Pen, **T.-C. Chang**
ApJ Letters, 2010, 723, 17

The GMRT EoR Experiment: Limits on Polarized Sky Brightness at 150 MHz

U.-L. Pen, **T.-C. Chang**, J. B. Peterson, J. Roy, Y. Gupta, C. Hirata, J. Odegova, K. Sigurdson
MNRAS, 2009, 399, 181

First Detection of Cosmic Structure in the 21-cm Intensity Field

U.-L. Pen, L. Staveley-Smith, J. B. Peterson, **T.-C. Chang**
MNRAS Letters., 2009, 394, 6

Baryon Acoustic Oscillation Intensity Mapping of Dark Energy

T.-C. Chang, U.-L. Pen, J. B. Peterson, P. McDonald
Phys. Rev. Lett., 2008, 100, 091303

Mergers and Bubble Growth during Reionization

J. D. Cohn, **T.-C. Chang**
MNRAS, 2007, 374, 72

Weak Lensing by Large-Scale Structure with the FIRST Radio Survey

T.-C. Chang, A. Refregier, & D. J. Helfand
ApJ, 2004, 617, 794

Shape Reconstruction and Weak Lensing Measurement with Interferometers: A Shapelet Approach

T.-C. Chang, A. Refregier
ApJ, 2001, 570, 447

A Search for H I in E+A Galaxies

T.-C. Chang, J. H. van Gorkom, A. I. Zabludoff, D. Zaritsky, J. C. Mihos
AJ, 2001, 121, 1965

Synergy of CO/[CII]/Ly α Line Intensity Mapping with the SKA

T.-C. Chang, Y. Gong, M. Santos, M. Silva, J. Aguirre, O. Doré, J. Pritchard, for the SKA EoR/CD SWG
PoS, Advancing Astrophysics with the Square Kilometer Array, arXiv:1501.04654

Cosmology from the EoR/Cosmic Dawn with the SKA

J. Pritchard, A. Mesinger, B. Metcalf, A. Pourtsidou, M. Santos, F. Abdalla, **T.-C. Chang**, X. Chen, J. Weller, S. Zaroubi
PoS, Advancing Astrophysics with the Square Kilometer Array, arXiv:1501.04654

Foreground Subtraction in Intensity Mapping with the SKA

L. Wolz, F. Abdalla, D. Alonso, C. Blake, P. Bull, **T.-C. Chang**, P. Ferreira, C.-Y. Kuo, M. Santos R. Shaw
PoS, Advancing Astrophysics with the Square Kilometer Array, arXiv:1501.04654

The Cosmic Dawn and Epoch of Reionisation with SKA

L. Koopmans, J. Pritchard, G. Mellema, J. Aguirre, K. Ahn, R. Barkana, I. van Bemmell, G. Bernardi, A. Bonaldi, F. Briggs, A.G. de Bruyn, **T.-C. Chang**, E. Chapman, X. Chen, B. Ciardi, P. Dayal, A. Ferrara, A. Fialkov, et al.
PoS, Advancing Astrophysics with the Square Kilometer Array, arXiv:1505.07568

- 2017
- “*The Nonlinear Universe*”, Smartno, Slovenia, July 16-22
 - “*Advances in Cosmology in light of data*”, Nordita, Stockholm, Sweden, July 10-14
 - “*Second Annual Workshop on Intensity Mapping*”, Johns Hopkins University, Maryland, June 12-14
 - “*Fundamental Physics with the Square Kilometer Array*”, Mauritius, May 1-4
 - Colloquium, “*Line Intensity Mapping*”, Columbia University, New York, USA, March 22
 - “*Cosmology with Neutral Hydrogen*”, UC Berkeley, USA, January 11-13
- 2016
- “*CCA Workshop on 21cm*”, CCA Simons Foundation, New York, USA, December 22
 - “*The 38th International Conference on High Energy Physics*”, Chicago, USA, August (declined)
 - “*CMB Spectral Distortions from Cosmic Baryon Evolution*”, Bengaluru, India, July (declined)
 - “*Cosmology with Next Generation Radio Surveys at ICTP*”, Trieste, Italy, June (declined)
 - “*Astronomical Distance Determination in the Space Age*”, Beijing, China, May
 - “*Annual meeting of the Astronomical Society of India*”, Srinagar, India, May (declined)
 - “*Preparing for SKA Wide-field Science and Engineering*”, Cape Town, South Africa, March (declined)
 - “*Opening a New Window on Cosmological Structure with Intensity Mapping: special session at the 227th AAS Meeting*”, Florida, USA, January
- 2015
- “*Cosmology and First Light*”, Paris, France, December
 - “*SKA in Seoul: HI Science Workshop*”, Seoul, South Korea, November
 - “*Preparing for the 21cm Cosmology Revolution*”, Irvine, USA, October
 - “*Rencontres du Vietnam on Cosmology, 50 years after CMB discovery*”, Quy Nhon, Vietnam, August
 - “*OzSKA, Australia SKA Meeting*”, Melbourne, Australia, April (declined)
 - Colloquium, *ICRAR, University of Western Australia*, Perth, Australia, February
- 2014
- Colloquium, *University of Illinois at Urbana-Champaign*, Champaign, USA, November
 - *The 12th Asia-Pacific IAU Regional Meeting*, Daejeon, Korea, August
 - *Exascale Radio Astronomy*, Monterey, USA, April
 - Colloquium, *University of Cape Town*, Cape town, South Africa, March
 - *The South Africa Conference on “Transformational Science with the SKA and Synergies with ALMA and other contemporary Instruments”*, Stellenbosch, South Africa, February
 - *Hydrogen Cosmology*, URSI-meeting, Boulder, USA, January
- 2013
- *The Metre Wavelength Sky: Celebrating 50 years of Radio Astronomy at TIFR*, Pune, India, December
 - *SKA Science Workshop in East Asia*, Nagoya, Japan, June
 - Colloquium, *Oxford University*, Oxford, UK, May
 - *Radio Astronomy in the LSST Era*, Charlottesville, USA, May
 - Colloquium, *NRAO*, Socorro, USA, May
 - *221st AAS meeting, special session on early science results from HERA instruments*, Long Beach, USA, January
- 2012
- *NRO 30th year Anniversary Symposium: New Trends in Radio Astronomy in the ALMA Era*, Hakone, Japan, December
 - *CosPA meeting*, Taipei, Taiwan, November
 - Colloquium, *Melbourne University*, Melbourne, Australia, November
 - Colloquium, *Sydney University*, Sydney, Australia, November
 - Cosmology Seminar, *Swinburne University*, Melbourne, Australia, October
 - *East Asia SKA HI Science Meeting*, Beijing, China, September
 - *URSI Meeting*, Boulder, USA, January

2011

- *East Asia SKA Meeting*, KASI, Korea, December
- Colloquium, *Yonsei University*, Seoul, Korea, December
- *Seminar, LeCOSPA*, National Taiwan University, Taiwan, November
- *Seminar, IPMU*, Tokyo, Japan, September
- *CO Intensity Mapping Workshop*, Berkeley, USA, August
- *A Quarter Century of DLAs: Celebrating the career of Arthur Wolfe*, Ringberg Castle, Germany, July
- *21cm Cosmology Workshop*, Toronto, Canada, June
- *Understanding Galactic and extragalactic foregrounds: A road to success for cosmological experiments*, Zadar, Croatia, May
- Colloquium, *NRAO*, Charlottesville, USA, May
- *The Subaru HSC Workshop*, Taipei, Taiwan, March
- *The NARO Intensity Mapping Workshop*, Charlottesville, USA, February
- *217th AAS meeting, RSSP special session*, Seattle, USA, January