Curriculum Vitae

Hao-Yi (Heidi) Wu

The Ohio State University
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Current Position

The Ohio State University 2017-present
Postdoctoral Scholar
Center for Cosmology and AstroParticle Physics
Supervisor: David Weinberg and Chris Hirata

Past Positions

California Institute of Technology 2014-2017
Postdoctoral Scholar, Department of Physics
Supervisor: Olivier Doré

The University of Michigan 2011-2014
Research Fellow, Department of Physics
Supervisor: Dragan Huterer

Education

Stanford University 2005-2011
Ph.D. Physics, awarded September 2011
Advisor: Risa Wechsler
Thesis: "Precision Cosmology from Galaxy Cluster Surveys"

National Taiwan University 2001-2005
B.S. Physics, awarded June 2005

Awards

Gabilan Stanford Graduate Fellowship, Stanford University 2008-2010

McMicking Stanford Graduate Fellowship, Stanford University 2008

Dean's Award, National Taiwan University 2005

Presidential Awards, National Taiwan University 2002-2004

Research

Research Interests

- Theoretical and computational cosmology and extragalactic astrophysics
- Cosmic far-infrared background and submillimeter galaxies as probes of star formation
- Galaxy clusters as laboratories of cosmology and astrophysics
- Large-scale structure as probes of dark energy

Major Research Results

- Physically and empirically interpreted **cosmic far-infrared background** and **submillimeter galaxies** observed by Planck and Herschel, constrained cosmic star-formation history, and optimized future survey strategies (4 publications, 2 manuscripts to be submitted)
- Developed **Rhapsody-G hydrodynamic simulations of galaxy clusters**, quantified multi-wavelength observable–mass relations, and improved the accuracy of cluster mass calibration (3 publications, 1 manuscript to be submitted)
- Developed **Rhapsody N-body simulations of galaxy clusters**, achieved simultaneous high resolution and large statistics, and quantified the dark matter halo and subhalo properties in a new mass regime (4 publications)
- Optimized multi-wavelength **surveys of galaxy clusters**, identified important sources of systematic errors, and optimized the strategies to mitigate systematics (5 publications)

Proposal Award

Hubble Space Telescope Cycle 19 June 2011
"Massive Galaxy Clusters at High Redshift: A Challenge to CDM or to Cluster Mass Calibration?"
PI: R. Wechsler, Co-PI: **H.-Y. Wu** and O. Hahn
(Funding for supporting Prof. Wechsler's student for a year)

Publications

Astrophysics Data System Link

[21] O. Hahn, D. Martizzi, **H.-Y. Wu**, A. E. Evrard, R. Teyssier, and R. H. Wechsler. Rhapsody-G simulations - I. The cool cores, hot gas and stellar content of massive galaxy clusters. *Monthly Notices of the Royal Astronomical Society*, 470:166–186, August 2017.

[20] **H.-Y. Wu** and D. Huterer. Sample variance in the local measurements of the Hubble constant. *arXiv:1706.09723*, June 2017.

[19] **H.-Y. Wu** and O. Doré. Optimizing future experiments of cosmic far-infrared background: a principal component approach. *Monthly Notices of the Royal Astronomical Society*, 467:4150–4160, June 2017.

[18] **H.-Y. Wu** and O. Doré. A minimal empirical model for the cosmic far-infrared background anisotropies. *Monthly Notices of the Royal Astronomical Society*, 466:4651–4658, April 2017.

[17] M. Bethermin, **H.-Y. Wu**, G. Lagache, I. Davidzon, N. Ponthieu, M. Cousin, L. Wang, O. Dore, E. Daddi, and A. Lapi. The impact of clustering and angular resolution on far-infrared and millimeter continuum observations. *arXiv:1703.08795*, March 2017.

[16] **H.-Y. Wu**, O. Doré, and R. Teyssier. Interpreting the cosmic far-infrared background anisotropies using a gas regulator model. *arXiv:1607.02546*, July 2016.

[15] D. Martizzi, O. Hahn, **H.-Y. Wu**, A. E. Evrard, R. Teyssier, and R. H. Wechsler. RHAPSODY-G simulations - II. Baryonic growth and metal enrichment in massive galaxy clusters. *Monthly Notices of the Royal Astronomical Society*, 459:4408–4427, July 2016.

[14] **H.-Y. Wu**, A. E. Evrard, O. Hahn, D. Martizzi, R. Teyssier, and R. H. Wechsler. RHAPSODY-G simulations: galaxy clusters as baryonic closed boxes and the covariance between hot gas and galaxies. *Monthly Notices of the Royal Astronomical Society*, 452:1982–1991, September 2015.

[13] D. Huterer, D. Kirkby, R. Bean, A. Connolly, K. Dawson, S. Dodelson, A. Evrard, B. Jain, M. Jarvis, E. Linder, R. Mandelbaum, M. May, A. Raccanelli, B. Reid, E. Rozo, F. Schmidt, N. Sehgal, A. Slosar, A. van Engelen, **H.-Y. Wu**, and G. Zhao. Growth of cosmic structure: Probing dark energy beyond expansion. *Astroparticle Physics*, 63:23–41, March 2015.

[12] **H.-Y. Wu**, O. Hahn, A. E. Evrard, R. H. Wechsler, and K. Dolag. Virial scaling of galaxies in clusters: bright to faint is cool to hot. *Monthly Notices of the Royal Astronomical Society*, 436:460–469, November 2013.

[11] **H.-Y. Wu** and D. Huterer. The impact of systematic uncertainties in N-body simulations on the precision cosmology from galaxy clustering: a halo model approach. *Monthly Notices of the Royal Astronomical Society*, 434:2556–2571, September 2013.

[10] **H.-Y. Wu**, O. Hahn, R. H. Wechsler, P. S. Behroozi, and Y.-Y. Mao. Rhapsody. II. Subhalo Properties and the Impact of Tidal Stripping From a Statistical Sample of Cluster-size Halos. *Astrophysical Journal*, 767:23, April 2013.

[9] Y.-Y. Mao, L. E. Strigari, R. H. Wechsler, **H.-Y. Wu**, and O. Hahn. Halo-to-halo Similarity and Scatter in the Velocity Distribution of Dark Matter. *Astrophysical Journal*, 764:35, February 2013.

[8] **H.-Y. Wu**, O. Hahn, R. H. Wechsler, Y.-Y. Mao, and P. S. Behroozi. Rhapsody. I. Structural Properties and Formation History from a Statistical Sample of Re-simulated Cluster-size Halos. *Astrophysical Journal*, 763:70, February 2013.

[7] P. S. Behroozi, R. H. Wechsler, **H.-Y. Wu**, M. T. Busha, A. A. Klypin, and J. R. Primack. Gravitationally Consistent Halo Catalogs and Merger Trees for Precision Cosmology. *Astrophysical Journal*, 763:18, January 2013.

[6] P. S. Behroozi, R. H. Wechsler, and **H.-Y. Wu**. The ROCKSTAR Phase-space Temporal Halo Finder and the Velocity Offsets of Cluster Cores. *Astrophysical Journal*, 762:109, January 2013.

[5] E. Rozo, E. Rykoff, B. Koester, B. Nord, **H.-Y. Wu**, A. Evrard, and R. Wechsler. Extrinsic Sources of Scatter in the Richness-mass Relation of Galaxy Clusters. *Astrophysical Journal*, 740:53, October 2011.

[4] E. Rozo, **H.-Y. Wu**, and F. Schmidt. Stacked Weak Lensing Mass Calibration: Estimators, Systematics, and Impact on Cosmological Parameter Constraints. *Astrophysical Journal*, 735:118, July 2011.

[3] **H.-Y. Wu**, A. R. Zentner, and R. H. Wechsler. The Impact of Theoretical Uncertainties in the Halo Mass Function and Halo Bias on Precision Cosmology. *Astrophysical Journal*, 713:856–864, April 2010.

[2] **H.-Y. Wu**, E. Rozo, and R. H. Wechsler. Annealing a Follow-up Program: Improvement of the Dark Energy Figure of Merit for Optical Galaxy Cluster Surveys. *Astrophysical Journal*, 713:1207–1218, April 2010.

[1] **H.-Y. Wu**, E. Rozo, and R. H. Wechsler. The Effects of Halo Assembly Bias on Self-Calibration in Galaxy Cluster Surveys. *Astrophysical Journal*, 688:729–741, December 2008.

Presentations

Public Outreach Presentation

Saturday Morning Physics, University of Michigan Dec. 2012
"Cosmic Rhapsody: From the Echo of Big Bang to the Orchestration of the Universe"
(an hour-long popular science talk and demonstrations to an audience of ∼300 of the Ann Arbor Community, also broadcasted on Community Television Network and available on YouTube)

Seminar Presentations

"What does cosmic far-infrared background tell us about cosmic star-formation history?" May 2017
Cosmology Seminar, Ohio State University

"Cosmic Variance of the Hubble Constant" May 2017
Postdoc Lunch Seminar Series, Caltech

"What does cosmic far-infrared background tell us about cosmic star-formation history?" Feb. 2017
Astronomy Seminar, University of Illinois

"Cosmic far-infrared background and cosmic star-formation history" Feb. 2017
Chalk Talk, University of Chicago

"What does cosmic far-infrared background tell us about cosmic star-formation history?" Feb. 2017
Cosmology Seminar, University of Michigan

"What does cosmic far-infrared background tell us about cosmic star-formation history?" Feb. 2017
Tea Talk, Caltech

"What does cosmic far-infrared background tell us about cosmic star-formation history?" Dec. 2016
Observational Cosmology Seminar, Caltech

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" Feb. 2016
Postdoc Lunch Seminar Series, Caltech

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" Jan. 2016
KIPAC Tea Talk, Stanford University

"Cosmology from gas and stars of galaxy clusters: results from Rhapsody-G hydrodynamic simulations" June 2015
Astrophysics Luncheon Seminar, Jet Propulsion Laboratory

"Cosmology from gas and stars of galaxy clusters: results from Rhapsody-G hydrodynamical simulations" Oct. 2014
Observational Cosmology Seminar, Caltech

"Probing Dark Energy Using the Growth of Structure: the Role of Simulations" Apr. 2014
Cosmology Seminar, Case Western Reserve University

"Probing Growth of Structure Using Galaxy Dynamics: A Converging Picture of Velocity Bias" Aug. 2013
Cosmology Seminar, University of Pennsylvania

"Virial Scaling of Galaxies in Clusters: Bright to Faint is Cool to Hot" July 2013
Astronomy Seminar, ETH Zurich

"Precision Cosmology from Galaxy Clusters and Large-scale Structure: The Role of N-body Simulations" July 2013
Cosmology Seminar, University Observatory Munich

"Precision Cosmology from Galaxy Clusters and Large-scale Structure: The Role of N-body Simulations" May 2013
Astrophysics Colloquium, IAA Academia Sinica, Taipei

"N-body Simulations of Galaxy Clusters: Is Overmerging Still an Issue?" Dec. 2011
Cosmology Seminar, CCAPP, Ohio State University

"Precision Cosmology From Galaxy Cluster Surveys: Understanding the Observable-Mass Distribution" Feb. 2011
FLASH Seminar, UC Santa Cruz

"Precision Cosmology From Galaxy Cluster Surveys: Understanding the Observable-Mass Distribution" Jan. 2011
Cosmology Seminar, Yale University

"Precision Cosmology From Galaxy Cluster Surveys: Understanding the Observable-Mass Distribution" Jan. 2011
Cosmology Seminar, University of Michigan

"Precision Cosmology From Galaxy Cluster Surveys: Observational and Theoretical Challenges" Oct. 2010
KICP Friday Seminar, University of Chicago

"Precision Cosmology From Galaxy Cluster Surveys: Observational and Theoretical Challenges" Oct. 2010
Cosmology Group Seminar, UC Davis

"Precision Cosmology From Galaxy Cluster Surveys: Observational and Theoretical Challenges" Sept. 2010
Cosmology Seminar, BCCP, UC Berkeley

Conference Presentations

"Sample variance in the local measurements of H_0" Aug. 2017
TeVPA 2017, Columbus, Ohio
(international conference, ∼300 participants)

"Sample variance in the local measurements of H_0" July 2017
Advances in theoretical cosmology in light of data, Nordita, Stockholm

"Where does cosmic far-infrared background come from? Interpreting Jan. 2017
the Planck and Herschel results using physical and empirical models"
229^{th} Meeting of the American Astronomical Society

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" Aug. 2016
COSMO-16, Ann Arbor, Michigan
(International conference, ∼300 participants)

"Rhapsody-G simulations of galaxy clusters: June 2016
the impact of AGN feedback on cool cores and X-ray scaling relations"
Computing the Universe: At the Intersection of Computer Science and Cosmology
Banff International Research Station, Oaxaca, Mexico
(Invited participation, ∼35 participants)

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" Mar. 2016
SnowPAC 2016: The Galaxy-Halo Connection, Utah
(International conference, ∼150 participants)

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" Jan. 2016
Statistical sampling and non-sampling methods in Cosmology
Berkeley Center for Cosmological Physics
(International workshop, ∼50 participants)

"What can we learn about star formation rate from resolved vs. Aug. 2015
unresolved dusty star-forming galaxies?"
Santa Cruz Galaxy Workshop
(Nationwide workshop, ∼100 participants)

"Cluster mass cross-calibration: the covariance between Mar. 2015
hot gas and galaxies in clusters"
SnowCLUSTER 2015, Utah
(International conference, ∼200 participants)

"Rhapsody-G: Covariance between gas and stars in galaxy clusters" Jan. 2015
Computing the Universe Symposium and Workshop, Berkeley
(Nationwide workshop, ∼100 participants)

"Probing growth of cosmic structure using galaxy dynamics: a converging Aug. 2014
picture of velocity bias"
COSMO-14, Chicago
(International conference, ∼300 participants)

"Quantifying the baryon mass fraction of galaxy clusters" June 2014
Future Directions in Galaxy Cluster Surveys, Paris
(International conference, ∼150 participants)

"Quantifying the baryon mass fraction of galaxy clusters" June 2014
Zeldovich 100, Space Research Institute, Moscow
(International symposium, ∼200 participants)

"Galaxies are not necessarily test particles:
characterizing galaxy velocity bias" Oct. 2013
APS Ohio-Region Section Meeting, Cincinnati

"Galaxies are not necessarily test particles" Sept. 2013
Cosmology After Planck Workshop, University of Michigan
(Nationwide workshop, ∼50 participants)

"Rhapsody: Halo profiles and subhalo properties from a statistical sample of re-simulated cluster-size halos" Mar. 2013
SnowCLUSTER 2013, Utah
(International conference, ∼200 participants)

"Rhapsody: Halo profiles and subhalo properties from a statistical sample of re-simulated cluster-size halos" Mar. 2013
The Mass Profiles of Galaxy Clusters, Madonna di Campiglio, Italy
(International conference, ∼200 participants)

"Precision Cosmology with Galaxy Clustering: Impact of Theoretical Uncertainties" Nov. 2012
Galaxy Cluster Seminar, University of Michigan

"The Impact of Theoretical Systematics on Cosmological Parameter Constraints from Galaxy Clustering" Aug. 2012
Workshop on Cosmic Acceleration, Carnegie Mellon University
(Nationwide conference, ∼80 participants)

"Rhapsody Cluster Re-simulation Project: How does formation history affect (or not affect) the properties of clusters?" July 2012
Galaxy Cluster Seminar, University of Michigan

"Theoretical Uncertainties in the Modeling of Galaxy Clustering" Mar. 2012
Galaxy Cluster Seminar, University of Michigan

"N-body Simulations of Galaxy Clusters: Why Do We Need Orphan Galaxies?" May 2011
KIPAC Tea Talk, Stanford University

"Cluster Observable-Mass Distribution and Halo Assembly History" Jan. 2011
Essential Cosmology for the next Generation, Puerto Vallarta, Mexico
(International conference, ∼150 participants)

"Spectroscopic Follow-ups and Improvement of Dark Energy FoM from Cluster Counts" — Oct. 2010
The Dark Energy Survey Collaboration Meeting, Fermilab
(International conference, ∼200 participants)

"Measuring Halo Bias in Galaxy Cluster Surveys: What Will We Learn About Halo Assembly and Cosmology?" — Aug. 2010
Santa Cruz Galaxy Formation Workshop
(International conference, ∼100 participants)

"Precision Cosmology from Future Galaxy Cluster Surveys" — Jan. 2010
Galaxy Clusters as Cosmic Laboratories, MIT
(International workshop, ∼100 participants)

"Precision Cosmology from Future Galaxy Cluster Surveys" — Nov. 2009
Galaxy Clusters in the Early Universe, ESO Workshop in Chile
(International conference, ∼200 participants)

"Annealing Follow-up Programs for Optical Galaxy Cluster Surveys" — July 2009
Santa Fe Cosmology Summer Workshop
(International conference, ∼150 participants)

"Dark Energy Figure of Merit for DES Clusters" — Mar. 2009
DES Cluster Working Group Workshop, Stanford University

"Dark Energy Studies with Galaxy Clusters: The Efficacy of Self-Calibration and Follow-up Observations" — Jan. 2009
KIPAC Tea Talk, Stanford University

"Projection of Dark Energy Figure of Merit for DES Clusters: Effects of Nuisance Parameters" — Nov. 2008
The Dark Energy Survey Collaboration Meeting, Ohio State University
(International conference, ∼200 participants)

"Self-Calibration: Systematics and Efficacy" — Apr. 2008
Cosmology in Northern California, Stanford University

"Self-Calibration and Assembly Bias in Galaxy Cluster Surveys" — Sept. 2007
KIPAC Tea Talk, Stanford University

"Self-Calibration and Assembly Bias in Galaxy Cluster Surveys" — Aug. 2007
Santa Cruz Galaxy Formation Workshop
(International conference, ∼100 participants)

Poster Presentations

"An empirical model for cosmic far-infrared background anisotropies and submillimeter number counts" — July 2017
SMG20 – Twenty years of Submillimetre Galaxies, Durham, UK

"Galaxy-halo connection for dusty star-forming galaxies" — May 2017
Quantifying and Understanding the GalaxyHalo Connection, KITP

"A Physical Model for the Anisotropies of Cosmic Far-infrared Background" — July 2016
Signals from the Deep Past, Malta

"What can we learn about galaxy evolution from cosmic infrared background (CIB)?" — May 2015
Gas, dust, and star formation from the local to the far Universe, Crete

"Virial Scaling of Galaxies in Clusters: Bright to Faint is Cool to Hot" — July 2013
Tracing Cosmic Evolution with Clusters of Galaxies, Sesto, Italy

"Impact of systematic uncertainties in N-body simulations on the precision cosmology from galaxy clustering" — Mar. 2013
The Mass Profiles of Galaxy Clusters, Madonna di Campiglio, Italy

"Toward A Complete Satellite Galaxy Population in Dark Matter Simulations" — Sept. 2011
Cosmology with X-ray and Sunyaev-Zeldovich Effect Observations of Galaxy Clusters, Huntsville

"Dark Energy Constraints from Optical Galaxy Clusters: the Impact of Observational and Theoretical Uncertainties" — June 2010
From Massive Galaxy Formation to Dark Energy, IPMU, Japan

"Dark Energy Studies with Galaxy Clusters: The Efficacy of Self-Calibration and Follow-up Observations" — Dec. 2008
The 24th Texas Symposium on Relativistic Astrophysics, Vancouver

"Dark Energy Studies with Galaxy Clusters: The Systematics and Efficacy of Self-Calibration" — July 2008
Santa Fe Cosmology Summer Workshop

Outreach

Outreach Activities

March For Science, Pasadena — Apr. 2017
(discussing and demonstrating solar eclipse)

Physics Challenge Week, Polytechnic School, Pasadena — Jan. 2017
(Lecture and demonstration for 9th graders)

Lecture Volunteer, Stargazing & Lecture Series, Caltech — Jan. 2017

Science Literacy Night, Norma Coombs Elementary School, Pasadena — Feb. 2016
(science demonstrations for K-5th grade students and their families)

Skype conference with a class of 1st graders in Knollwood Elementary — Nov. 2015
Salisbury, NC
(discussing the Sun, the Moon, and the Earth)

Caltech Explorers Club — Feb. 2015
(developing and demonstrating the course Our Galaxy the Milky Way at
the Polytechnic School in Pasadena)

Solar eclipse viewing, McKinley School in Pasadena — Oct. 2014
(demonstrating and explaining concepts in the school-wide event)

Michigan Physics Olympiad, University of Michigan — May 2014
(annual one-day event of scientific experiments for area high schools)

Presentation "Preparing for a Talk About Your Research" — Feb. 2013
(sharing my experience of public speech in Professor Judy Dyers
Oral Presentation class, English Language Institute of University of Michigan)

The Science Bus, The East Palo Alto Charter School — Fall 2008
(weekly science demonstrations for 4th and 5th graders in a low-income part
of the San Francisco Bay Area)

SLAC Kids Day — Aug. 2008
(astrophysics demonstrations for the children of SLAC employees)

Menlo School Visit, SLAC — May 2008
(astrophysics demonstrations for 9th graders visiting SLAC)

Services

Volunteering and Organizing Activities

Research Statement Workshop, Caltech Postdoctoral Association	Nov. 2015
Michigan Center of Theoretical Physics Workshop	Sept. 2013
Stanford Physics Open House	Apr. 2008
The SLAC Public Lecture Series	Oct. 2007
The First International GLAST Symposium, Stanford University	Feb. 2007

Journal Review Activities

Astroparticle Physics

Astrophysical Journal

Monthly Notices of the Royal Astronomical Society

Teaching and Mentoring Experiences

Co-supervisions of Students

Mike Mills (N-body simulation, UM undergrad with Evrard)	2012-2013
Alan Coleman (data visualization, UM undergrad with Evrard)	Winter 2012
Vishaal Kalwani (data visualization, UM undergrad with Evrard)	2011-2012
Blythe Moreland (N-body simulation, UM undergrad with Wechsler)	Summer 2011
Adam Bouland (Fisher matrix, Yale undergrad with Wechsler)	Summer 2009

Teaching Assistantships in Stanford

Physics 161: Introduction to Extragalactic Astrophysics and Cosmology (physics majors)	2009, 2010, 2011
Physics 362: Advanced Extragalactic Astrophysics and Cosmology (graduate students in astrophysics)	2008, 2010
Physics 21: Mechanics (biology and pre-medical majors)	2006
Physics 43: Electricity and Magnetism (engineering majors)	2006
Physics120: Intermediate Electricity and Magnetism (physics majors)	2006

Communication and Pedagogical Training

Language and Orientation Tutoring Program, Stanford University (semester-long tutoring on writing and oral presentation)	Summer 2010, 2011
Communication Strategies in Professional Life English for Foreign Students, Stanford University	Spring 2010
Voice and Articulation Intensive for Nonnative English Speakers Center for Teaching and Learning, Stanford University	Winter 2010
I-RITE/I-SPEAK (intensive presentation training) Center for Teaching and Learning, Stanford University	Sept. 2008
English in Action (English conversation and cultural exchange) The Bechtel International Center, Stanford University	2007-2011
Speaking and Teaching in English English for Foreign Students, Stanford University	Summer 2006
Teaching of Physics Seminar Physics Department, Stanford University	Winter 2006

References

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