Waseda University Brussels Office
早稲田大学 ブリュッセルオフィス

WORKSHOP SERIES

Early Universe Revealed by JWST and Future Prospects for Wide Field Surveys with GREX-PLUS

Tuesday 11 & Wedesday 12 February 2025

ULB, European Studies Institute, Av. FD Roosevelt 39 – 1050 Bruxelles,
Room Kant

WASEDA University

Early Universe Revealed by JWST and Future Prospects for Wide Field Surveys with GREX-PLUS.

Exploring the early Universe is one of the major goals of modern astronomy and astrophysics. The James Webb Space Telescope (JWST) is now routinely providing a wealth of innovative observations, including the discovery of bright star-forming galaxies beyond the cosmological redshift of z=10, an unexpectedly large population of active galactic nuclei powered by supermassive blackholes, and quiescent galaxies even within the first 1 Gyr of the cosmic time. Although the JWST has super high sensitivity, its field-of-view is still too narrow to conduct >>1 degree2 imaging surveys that require finding rare, massive, bright galaxies in the early Universe. The European Euclid satellite is now conducting its super wide-field surveys, but it is limited to a wavelength less than 2 micron. NASA's Roman telescope to be launched in 2026 also has the same wavelength limitation. Since the Lyman alpha break comes to >2 micron for galaxies at z>15, when the most exciting event, the first galaxy formation happened. The Japanese space telescope concept, GREX-PLUS (Galaxy Reionization EXplorer and PLanetary Universe Spectrometer) will provide the unique capability of wide-field imaging at a wavelength range of 2 to 8 micron in the mid-2030s.

This 2-day meeting aims to discuss the JWST's groundbreaking results for galaxy formation studies and how to fully unlock the potential of GREX-PLUS wide-field imaging surveys in the mid-2030s.

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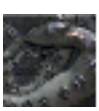
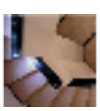



SCHEDULE

TUESDAY FEBRUARY 11th

09:30	Welcome coffee
Workshop opening	
10:00 - 10:10	Issei YAMAMURA (ISAS/JAXA) Opening remark
10:10 - 10:50	Akio INOUE (Waseda University) "An introduction to GREX-PLUS and its WFC survey"
10:50 - 11:20	Coffee Break
Session 1: Extreme high-z (z>10)	
11:20 - 11:50	Pascal OESCH (University of Geneva) "The First Chapters of Galaxy Build-up Revealed by Wide Area Surveys"
11:50 - 12:20	Andrea FERRARA (Scuola Normale Superiore) "The Beautiful Confusion. Super-early Galaxies seen by JWST"
12:20 - 14:00	Lunch
Session 2: High-z galaxies	
14:00 - 14:30	Laura PENTERICCI (INAF, Osservatorio Astronomico di Roma) "Studying the Epoch of Reionization with Current and Future Facilities"
14:30 - 15:00	Erik ZACKRISSON (Uppsala University) "Lensed stars and Population III Tidal Disruption Events with GREX-PLUS"
15:00 - 15:30	Coffee Break
15:30 - 16:00	Sirio BELLI (University of Bologna) "Quiescent Galaxies in the Early Universe"
16:00 - 16:30	Yuma SUGAHARA (Waseda University) "Complex Galaxy Properties of Merging Systems in the Epoch of Reionization"

19:00	Wokshop Dinner

SCHEDULE

WEDNESDAY FEBRUARY 12th	
09:30	Welcome coffee
Session 3: High-z AGNs and other surveys	
10:00 - 10:30	Jorryt MATTHEE (Institute of Science and Technology Austria) "Unveiling the First Supermassive Black Holes: Insights from JWST and Future Prospects with GREX-PLUS"
10:30 - 11:00	Sune TOFT (University of Copenhagen) "Euclid deep survey"
11:00 - 11:30	Eiichi EGAMI (University of Arizona) "Plan for the US Contribution to GREX-PLUS"
11:30 - 11:45	Takao NAKAGAWA (ISAS/JAXA) Closing Remark
11:45 - 14:00	Lunch
(Close discussion)	
14:00 - 16:00	Exchanges & Discussion

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Seminar Organizer

Akio INOUE (Waseda University)

Bio

Doctor of Science in 2003 from Kyoto University, Japan. 2004, JSPS Fellow Research Abroad at the Labratoire d'Astrophysique de Marseille, France. 2005-2018, Lecturer and Associate Professor at Osaka Sangyo University, Japan. 2014, Visiting associate researcher, University California Observatories, Santa Cruz, U.S.A. 2019-current, Professor at Waseda University, Japan.
Served on various committees, including Chair of Time Allocation Committee of the Subaru Telescope, Chair of the Hayakawa Fund Committee of the Astronomical Society of Japan, etc.
Research interests include observations of galaxies in the early universe with the Subaru Telescope, the Atacama Large Millimeter/submillimeter Array, and the James Webb Space Telescope, physics of the interstellar, circumgalactic, and intergalactic media such as nebular emission, dust grains, Lyman alpha forest, and damped Lyman alpha systems.

Title

"An introduction to GREX-PLUS and its WFC survey"

Abstract

GREX-PLUS (Galaxy Reionization EXplorer and PLanetary Universe Spectometer) is one of the two final candidates for the ISAS/JAXA's Strategic L-class mission in the 2030s. This is a cyogenic (<50K), 1.0-m space telescope for observing the infrared universe. It will carry the Wide-Field Camera (WFC) and an optional High Resolution Spectrometer (HRS).The WFC has a super-wide field of view of 0.5 square degrees and covers the wavelength range from 2 to 8 microns.
The primary goal of the GREX-PLUS mission is to search for the first, massive and bright galaxies in the universe by performing super-widefield imaging surveys of 10, 100 and 1,000 square degrees at wavelengths longer than 2 microns.
These surveys will constrain the brightest end of the galaxy luminosity function for the first time in the universe earlier than 300 million years after the Big Bang.
The super-widefield imaging data are extremely versatile for a wide range of scientific topics, including the first quasars, the first supernovae, the cosmic infrared background, the mass assembly history of galaxies, dusty massive galaxies and active galactic nuclei, brown dwarf stars in the Milky Way, icy bodies in the solar system, and so on.
In this talk, I will give an overview of the GREX-PLUS mission and its great scientific impacts.

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Pascal OESCH (University of Geneva)

Bio Pascal Oesch is an Associate Professor at the University of Geneva and at the Cosmic DAWN Center at the University of Copenhagen. He leads an observational research group "Galaxy Build-up at Cosmic Dawn" which focuses on understanding the build-up and assembly of the very first generations of galaxies based on panchromatic observations including data from the James Webb Space Telescope. He received his PhD in 2010 from ETH Zurich, before moving as a Hubble fellow to the University of California, Santa Cruz. After a YCAA fellowship at Yale, he moved back to Europe in 2016 as an SNSF Professor at the University of Geneva, where he is now a permanent faculty member.

Title "The First Chapters of Galaxy Build-up Revealed by Wide Area Surveys"

Abstract Over the last few years, we have made enormous progress in our exploration of galaxies across comic history. Especially the NIR capability of JWST has completely transformed our view and understanding of the early Universe. Surprisingly, JWST revealed that bright galaxies were much more common at z>10 than was previously thought with standard models of galaxy formation. However, JWST data extends over less than 1 square degree, thus missing the rarest, most interesting sources. Very wide area surveys - such as the ones with ESA/Euclid - therefore offer an exciting opportunity to find a large number of bright galaxies in the first billion years of cosmic time, promising crucial new insights into early galaxy assembly. However, Euclid lacks the crucial longer-wavelength capability to safely identify sources at z>10 as well as measure their stellar masses through rest-frame optical imaging. This is exactly where GREX-PLUS can make an enormous impact. Here, I will summarize our current view of galaxy build-up at cosmic dawn and I will highlight the exciting possibilities that the combination of GREX-PLUS and other facilities would enable for the exploration and mass complete stufy of galaxies at cosmic dawn.

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Andrea FERRARA (Scuola Normale Superiore)

Bio

Andrea Ferrara's main scientific activity is in the field of Physical Cosmology and Astrophysics. He is interested in the formation and evolution of the first stars/galaxies, and the role they played for cosmic reionization and large-scale structure formation. These studies are at the forefront of the current research in Cosmology. His work on Population III stars, high-redshift galaxies, feedback processes, cosmic reionization and dark matter has set a benchmark in astrophysical research, influencing observational strategies in modern cosmology. With 580 published papers which have received 35000 citations, a Hirsch H-index=102, Prof. Ferrara is one of the top Italian scientists. He has given over 200 invited talks at major international conferences, served on editorial boards for leading astrophysics journals, and contributed as an evaluator for multiple national and international research councils. His mentorship has guided more than 70 graduate and postdoctoral researchers, many of whom have received prestigious awards and positions. At SNS Prof. Ferrara directs the Cosmology Group, which includes about 30 international members. The group is a leading force in the study of the early Universe via theoretical models, supercomputing simulations, and data visualization.

Title

"The Beautiful Confusion. Super-early Galaxies seen by JWST"

Abstract

One of the major surprises provided by the first years of early Universe observations by JWST has been the detection of a stunning overabundance of luminous, and likely massive, galaxies at redshift z>10. As the first spectroscopic confirmations are accumulating, it is crucial and timely to investigate these important and yet unknown aspects of early galaxy formation and evolution. At a time at which ALMA has laid the foundations of our understanding, Webb seems to hint at a possibly conflicting scenario. These (apparent?) contradictions need to be solved in the framework of studies that combine theory, cosmological simulations and the most advanced IR/sub-mm observations. I will analyze the possible new scenarios and propose some preliminary answers to the above questions.

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Laura PENTERICCI (INAF, Osservatorio Astronomico di Roma)

Bio Laura Pentericci's main scientific activity is in the field of observational Extragalactic Astrophysics. She is interested in studying galaxies during the epoch of reionization, to understand how they formed and evolved at such early epochs, and to use them as probes of the change in the Intergalactic medium that took place during this epoch. To this aim she is particularly focused on the search and study of the so-called Lyman alpha emitters, which are amongst the most important probes of the very distant universe. Laura Pentericci has conducted studies mainly using state of the art spectroscopic facilities and has led large public observational surveys. She is also deeply involved in the development of future spectroscopic facilities such as MOONS for the VLT and MOSAIC for ELT. She has published more than 450 papers which have received almost 30000 citations and have h-index=89. She is one of the editors of Astronomy & Astrophysics for the extragalactic section.

Title "Studying the epoch of reionization with current and future facilities"

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Erik ZACKRISSON (Uppsala University)

Bio Erik Zackrisson is a professor of astrophysics at Uppsala University in Sweden. His research focuses on the first generations of stars, galaxies and black holes that formed in the early Universe. In recent years, most of his work has revolved around observations of gravitationally lensed objects at high redshifts with James Webb Space Telescope. Zackrisson is also part of research and instruments teams connected to the next-generation telescopes The Square Kilometre Array Observatory and the Extremely Large Telescope. On the side, he is also involved in searches for extra-terrestrial intelligence, and is the leader of Project Hephaistos, the largest search to date for Dyson spheres within the Milky Way galaxy.

Title "Lensed stars and Population III tidal disruption events with GREX-PLUST"

Abstract In this talk, I will explore the prospects of two new potential science cases for GREX-PLUS: Gravitationally lensed stars at redshifts z>3 and tidal disruption events produced when metal-free, high-mass (Population III) stars are ripped to shreds by supermassive black holes at z~10..

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Sirio BELLI (University of Bologna)

Bio Sirio Belli is Associate Professor at the University of Bologna, and his research focuses on the formation of massive galaxies and the quenching of their star formation. He uses ground- and space-based observations of quiescent galaxies at high redshift to measure their physical properties including star formation histories, stellar populations, multi-phase gas, and AGN-driven outflows. He is the PI of the Blue Jay survey, a Cycle-1 JWST program that obtained deep NIRSpec spectra for a representative sample of galaxies at z~2.

Title "Quiescent Galaxies in the Early Universe"

Abstract JWST has discovered a rare population of massive quiescent galaxies at z~4-5 that may challenge our understanding of cosmology and/or galaxy formation. How and when did these galaxies form? What is the role of the environment in driving their evolution? And what processes are responsible for shutting down their star formation at such early epochs? To answer these questions, large samples are required. Current wide-field facilities, however, are unable to detect these galaxies because the Balmer break at $z > 4$ shifts beyond 2 micron. Thus, GREX-PLUS will be uniquely capable of studying this crucial galaxy population, characterize their properties and number densities, and provide targets for spectroscopic follow-ups with JWST and ground-based extremely large telescopes.

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Yuma SUGAHARA (Waseda University)

Bio

Yuma Sugahara is an assistant professor (non-tenure-track) at Faculty of Science and Engineering, Waseda University.
After he completed his Ph.D. in the University of Tokyo in 2020, he moved to National Astronomical Observatory of Japan and Waseda University as a project researcher.
His research field is the observational extragalactic astronomy. He is working on the star-forming activity and the interstellar media of high-redshift galaxies to investigate how galaxies were formed and they evolved into what they are today. He uses spectroscopic data of distant galaxies taken by cutting-edge observatories, including JWST and ALMA, and analyze emission and absorption lines appearing in galaxy spectra, which trace the stellar and gaseous activities in the galaxy evolution.

Title

"Complex Galaxy Properties of Merging Systems in the Epoch of Reionization"

Abstract

Major mergers are theoretically predicted to occur more frequently at high redshift by ∝(1 + z)^{2-3}, which would lead to the bursty star-formation history and increase an importance of merging build-up processes at higher redshift. JWST, providing us with a very high angular resolution, enables spatially resolved analyses of galaxies in the epoch of reionization. Nowadays, new observational results are being published one after another, revealing the complex nature of merging galaxies. In this talk, we would like to present JWST NIRCam and NIRSpec IFU observations of high-redshift galaxies. As part of the Reionization and the ISM/Stellar Orgins with JWST and ALMA (RIOJA) project, we targeted twelve galaxies at z = 6-9 that are bright in the ALMA [OIII] 88 um emission line. One of them, B14-65666 («Big Three Dragons»), is a bright Lyman-break galaxy system (MUV=−22.5 mag) at z=7.15. The NIRCam imaging reveals the complex morphology of two galaxy components, the nuclear dusty starbursts induced by major mergers, and the disparate gaseous and dust properties in the two galaxies. The NIRSpec IFU observations in the GA-NIFS program has confirmed this picture and found broad components in emission lines tracing outflows or tidal interactions. As these complex properties are also seen in other galaxies, these results suggest that high-redshift galaxies frequently experiences complex buildup processes.

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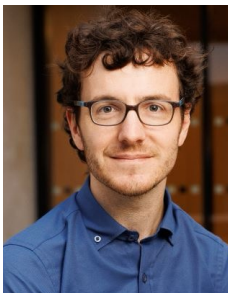

Jorryt MATTHEE (Institute of Science and Technology Austria)

Bio Dr. Jorryt Matthee is an Assistant Professor at the Institute of Science and Technology Austria (ISTA), where he is the first astronomer appointed at this young interdisciplinary institute. He leads a research group in extragalactic astrophysics, supported by an ERC Starting Grant and the MERAC Foundation. His primary research focuses on the formation of the first stars and supermassive black holes in early galaxies, as well as the physical processes that shape their evolution across a wide range of dynamical scales. He primarily uses emission-line spectroscopy with large telescopes in Chile and space-based observatories to study these processes.

Title "Unveiling the First Supermassive Black Holes: Insights from JWST and Future Prospects with GREX-PLUS"

Abstract Supermassive black holes (SMBHs) play an essential role in models of galaxy formation, yet their formation and growth are poorly understood, particularly due to the lack of strong constraints at the early times when rapid SMBH formation occurs. In my talk, I will present results based on observations of distant active galactic nuclei (AGN) with the James Webb Space Telescope (JWST), focussing on: 1) the nature of broad H□ line-selected AGN (the so-called Little Red Dots) that JWST has uncovered in the first few Gyr, and 2) the environments of luminous quasars which can now be characterized with sensitive slitless spectroscopy. I will synthesize what these observations are revealing us in the context of galaxy - SMBH co-evolution, SMBH formation and their role in cosmic reionization. Finally, I will highlight the key limitations of JWST in probing the first AGNs and explore how GREX-PLUS can help bridge these gaps.

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Sune TOFT (University of Copenhagen)

Bio Sune Toft is a professor of extragalactic astrophysics and Cosmology at the Niels Bohr Institute, University of Copenhagen. Since 2018 he has been the director of the Cosmic Dawn Center (DAWN), a center of excellence located at the University of Copenhagen and the National Space Institute at the Danish Technical University. The center, which includes more than 60 scientists, is focused on understanding the formation of the first stars, black holes and galaxies in the Universe, through observations with the prime telescopes and through theory and cosmological simulations. DAWN leads a number of large observational programs, including the Cosmic Dawn Survey, a multiwavelength survey of the Euclid Deep Fields

Title "Euclids Deep Survey"

Abstract Euclid is an ESA cosmology mission that launched in 2023. Over six years it will perform the Euclid wide survey of 14.000 square degrees of the extragalactic sky to accurately map the positions and distances of billions of galaxies out to z=2, with the aim of constraining the properties of dark matter and dark energy.
Additionally the Euclid Deep Survey will observe 60 square degrees to 40 times the nominal depth, reaching limiting magnitudes of 28.5 in a wide optical filter and 26.5 in three near infrared filter (YJH).
The Cosmic Dawn Survey complements Euclids observations with matching depth observations in the optical (u band from CFHT, griz from Subary/HSC) and in the mid infrared from (3.6 and 4.5 microns from Spitzer/IRAC). The resulting catalog enables a range of unique science in the high redshift Universe, probing large statistical samples of the brightest and most massive galaxies and AGN in the EoR, which are too rare to be detected even in the largest JWST surveys.

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Eiichi EGAMI (University of Arizona)

Bio Eiichi Egami is a research professor at Steward Observatory, the University of Arizona. He was involved in a series of infrared space missions in the past (e.g., ISO, Spitzer, Herschel), and is currently a member of the JWST/NIRCam instrument and science teams. He is also a member of the extragalactic science working group for PRIMA, and leads the US GREX-PLUS team

Title "Plan for the US Contribution to GREX-PLUS"

Abstract Steward Observatory, the University of Arizona (UA-Steward), has partnered with Smithsonian Astrophysical Observatory (SAO) to support the GREX-PLUS mission in the US. Building on its long history of providing infrared instruments to major NASA missions (e.g., NICMOS on HST, MIPS on Spitzer, and NIRCam on JWST), the UA-Steward team intends to lead the construction of the Wide Field Camera (WFC) for GREX-PLUS in collaboration with the SAO IR group, which built IRAC on Spitzer. So far, the UA-Steward and SAO teams provided feedback for the conceptual design of WFC and jointly submitted a letter of intent to ISAS/JAXA in support of the GREX-PLUS mission proposal. The participation of the US team, however, is contingent upon the availability of funding from NASA, which is yet to be secured.

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