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COMMISSION J3 **Galaxies at the Epoch of Reionisation**

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COMMISSION J3 WORKING GROUPS

TRIENNIAL REPORT 2022-2024

1. Background

1. Introduction The commission Galaxies at the Epoch of Reionization (C.J3) commission is a commission under Division J, Galaxies and Cosmology. The epoch of reionization as a transition epoch from a Universe filled with relatively cold neutral hydrogen to a universe fully filled with hot ionized gas. The end of the reionization occurred at a redshift z $\sim$ 6, that is about 1 billion years after the Big Bang. However, we still have not definitively established how reionization occurred. The origin could be found in low-mass galaxies that are broadly distributed, or in massive galaxies that are rare and clustered in high-density regions. While still debated, it seems active galactic nuclei (AGN) seem less favoured as the source of the reionization. In summary, it is still a crucial question for the formation and evolution of galaxies and the universe to address the question: What sources caused reionization? Many facilities are used to constrain the characteristics of galaxies at the epoch of reionization. However, the James Webb Space Telescope (JWST) is one of the main facilities that should be able to provide key observable constraints around the end of the epoch of reionization, to constrain the origin of the reionization itself.

2. Developments within the past triennium

New observations might suggest that the end of the reionization that was thought to be close to z$\sim$6 might be a little bit later in Cosmic times (Bosman et al. (2022)). This result for a late end of hydrogen reionization is derived from the presence of excess scatter in the Ly-α forest at z $\sim$ 5.5, together with the existence of sporadic extended opaque Gunn-Peterson troughs. Simulations (e.g. Garaldi et al. (2022)) featuring realistic late reionization histories, are able to match constraints on global IGM properties.

On the galaxies side, JWST collected a sample of galaxies at z $>$ 6, and even a reasonable sample at z $>$ 10 with the detection and spectroscopic confirmation of about 10 galaxies beyond this z>10 impressive limit. During this triennum, we have been witnessing a blooming of such studies† that allows to gather some new information on the physics of the galaxies themselves (e.g. Robertson et al. 2023, Wang et al. 2023, Calabro et al. 2024, Zavala2024).

2.1. *Meeting on the galaxies at the Epoch of Reionization*

- From galaxies to cosmology with deep spectroscopic surveys, 1 June 2022 - 5 June 2022, Marseille, France
- IAU Symposium 373: Resolving the Rise and Fall of Star Formation in Galaxies, 7 July 2022 - 9 July 2022, Busan, Republic of Korea
- Shedding new light on the first billion years of the Universe, 29 June 2023 - 3 July 2023, Marseille, France
- The Cosmic Web: Connecting Galaxies to Cosmology at High and Low Redshift, 28 December 2022 - 11 March 2023, Santa Barbara, California, USA
- 2023 Kavli-IAU Astrochemistry Symposium — Astrochemistry VIII - From the First Galaxies to the Formation of Habitable Worlds, 4 July 2023 - 8 July 2023, Traverse City, MI, USA
- Resolving the Extragalactic Universe with ALMA and JWST, 31 October 2023 - 4 November 2023, Waseda University, Tokyo, Japan
- Understanding the epoch of cosmic reionization at Sexten, March 6, 2023
- Escape of Lyman radiation from galactic labyrinths 18-21 April 2023, OAC, Kolymbari, Crete
- Cosmology in the Alps 2024 18 - 22, march, 2024
- Reionization in the summer ‡: June 26-30 2023 MPIA Heidelberg,

3. Conclusion and future plans

JWST will certainly keep improving our knowledge and understanding of the galaxies at the epoch of reionization in the future. We are expecting to get new breakthrough results, but also more global and statistical analysis to be published. One question that remains and still need to be addressed: will JWST find direct evidence of Lyman Continuum radiation from the EoR era?

However, the next triennum will see new facilities that will add up to the information collected by JWST. For instance, the Square Kilometer Array (SKA¶) will use the fact that Hydrogen gas can be probed by observations of its hyperfine 21-cm spectral line transition. SKA plans to carry out the deepest observations of the diffuse neutral Hydrogen gas to trace the evolution of cosmic structure in the $6 < z < 30$ range. Radio observations of the 21-cm line from primordial hydrogen promise to be one of the best tools to study the early epochs of the Universe: the dark ages, the cosmic dawn and the subsequent epoch of reionization (see, e.g. de Lera Acedo et al. (2022)).The European Extremely Large Telescope (ELT‖) enormous sensitivity and resolution gains will allow to study the physical processes that form and transform galaxies across cosmic time, and its spatially resolved spectroscopic surveys of hundreds of massive galaxies to the most distant galaxies presently. The Roman space telescope†† and th Vera Rubin Observtory‡‡

† https://en.wikipedia.org/wiki/List_of_the_most_distant_astronomical_objects
‡ https://sites.google.com/view/reionisation-in-the-summer/
¶ https://www.skao.int/index.php/en/science-users/science-working-groups/106/epoch-reionization
‖ https://www.eso.org/sci/facilities/eelt/science/index.html
†† https://science.nasa.gov/mission/roman-space-telescope/
‡‡ https://www.lsst.org/science

will also contribute to this strong international effort by proving deep and very wide-field observations reaching out to the epoch of reionization.

Denis Burgarella
President of the Commission

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