

University of Groningen

Unraveling the knots of gaseous Cosmic Web filaments at $z \approx 3$ through H-alpha emission observations

Cantalupo, Sebastiano; Fossati, Matteo; Fumagalli, Michele; Gallego, Sofia; Lilly, Simon J.; Mackenzie, Ruari; Marino, Raffaella Anna; Maseda, Michael; Matthee, Jorryt; Nanayakkara, Themiya

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

2021

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Cantalupo, S., Fossati, M., Fumagalli, M., Gallego, S., Lilly, S. J., Mackenzie, R., Marino, R. A., Maseda, M., Matthee, J., Nanayakkara, T., Pezzulli, G., Steidel, C. C., & de Beer, S. D. C. (2021, Mar 1). Unraveling the knots of gaseous Cosmic Web filaments at $z \approx 3$ through H-alpha emission observations. <https://ui.adsabs.harvard.edu/abs/2021jwst.prop.1835C>

Copyright

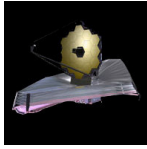
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.



1835 - Unraveling the knots of gaseous Cosmic Web filaments at $z \sim 3$ through H-alpha emission observations

Cycle: 1, Proposal Category: GO

INVESTIGATORS

| <i>Name</i> | <i>Institution</i> | <i>E-Mail</i> |
|--|--|---------------------------------------|
| Prof. Sebastiano Cantalupo (PI) (ESA Member) | Universita di Milano-Bicocca | sebastiano.cantalupo@unimib.it |
| Prof. Charles C. Steidel (CoI) (US Admin CoI) | California Institute of Technology | ccs@astro.caltech.edu |
| Dr. Ruari Mackenzie (CoI) (ESA Member) | ETH Zurich | mruari@phys.ethz.ch |
| Prof. Simon J. Lilly (CoI) (ESA Member) | Eidgenossische Technische Hochschule (ETH) | simon.lilly@phys.ethz.ch |
| Ms. Sofia Gallego (CoI) (ESA Member) | ETH Zurich | sofiag.gallego@gmail.com |
| Dr. Raffaella Anna Marino (CoI) (ESA Member) | Eidgenossische Technische Hochschule (ETH) | marinor@phys.ethz.ch |
| Dr. Jorryt Matthee (CoI) (ESA Member) | ETH Zurich | matthee@strw.leidenuniv.nl |
| Dr. Gabriele Pezzulli (CoI) (ESA Member) | Kapteyn Astronomical Institute | pezzulli@astro.rug.nl |
| Ms. Stephanie Dorothy Catherine de Beer (CoI) (ESA Member) | Universita di Milano-Bicocca | s.debeer@campus.unimib.it |
| Dr. Michael Maseda (CoI) (ESA Member) | Universiteit Leiden | maseda@strw.leidenuniv.nl |
| Dr. Themiya Nanayakkara (CoI) | Swinburne University of Technology | themiyananayakkara@gmail.com |
| Prof. Michele Fumagalli (CoI) (ESA Member) | Universita di Milano-Bicocca | michele.fumagalli@unimib.it |
| Dr. Matteo Fossati (CoI) (ESA Member) | Universita di Milano-Bicocca | matteo.fossati@unimib.it |

OBSERVATIONS

| <i>Folder</i> | <i>Observation</i> | <i>Label</i> | <i>Observing Template</i> | <i>Science Target</i> |
|--------------------|--------------------|--------------|----------------------------------|-----------------------|
| Observation Folder | | | | |
| | 1 | MQN03_Plan1 | NIRSpec MultiObject Spectroscopy | (1) MQN03-PA28 |
| | 2 | MQN01_Plan1 | NIRSpec MultiObject Spectroscopy | (2) MQN01-PA45 |

ABSTRACT

Our cosmological model predicts that most of the matter in the universe is distributed in a network of filaments - the Cosmic Web - in which galaxies form and evolve. Because most of this material is very diffuse, its direct imaging has for long remained elusive, leaving many questions still open, e.g.: what are the morphological and kinematical properties of the Cosmic Web on both small (kpc) and large (Mpc) scales? How do galaxies get their gas from the Cosmic Web? Here, we tackle these questions with an innovative method to detect in emission the gaseous Cosmic Web using bright quasars as “cosmic flashlights”. In particular, we propose to observe in H-alpha emission two fields at $z \sim 3$ which contain the largest Cosmic Web filaments – over 4 cMpc in length - discovered so far in deep MUSE Ly-alpha emission searches around bright quasars. Because Ly-alpha is affected by radiative transfer which change both its spatial and spectral distribution, non-resonant H-alpha observations are fundamental in order to directly constrain both the filament densities and kinematics. The filament projected angular sizes are perfectly suited for NIRSpec-MOS which can trace the filaments over their full length capturing, at the same time, several embedded galaxies. Our H-alpha observations will probe structures within the filaments on scales smaller than a few physical kpc directly constraining both their density and kinematics. By relating these quantities to the kinematics and distance from associated galaxies, our result will be fundamental to informing a new generation of theoretical and numerical models in order to reveal the physics of intergalactic gas accretion and galactic outflows.

OBSERVING DESCRIPTION

The observations for this program consist of NIRSpec Multi-Object-Spectroscopy using the G235H grating and F170LP filter within two different fields, labeled MQN01 and MQN03, centered on two bright quasars at $z \sim 3.2$. These two fields contain the largest contiguous Cosmic Web filaments discovered so far in Ly-alpha emission around bright quasars.

The primary observational goal of this proposal is to detect the H-alpha emission produced by both gas and galaxies within these filaments. The emission is expected to be at a wavelength of about 2.7 microns. The region of interest in both fields extend to about 90” and they can therefore fit in a single MSA quadrant in each field. In particular, the MSA configurations are designed to follow the most interesting filamentary structures using a set of “slitlets” with a length not smaller than 3 MSA. The ideal PA which orients the MSA vertical direction parallel to the direction of the main filaments is within the schedulable range for both fields. Given the extended nature of our target, a range of PAs can be used as well in order to cover the filamentary structures and an optimal configuration can be provided once the PA is assigned. For similar reasons, continuum pre-imaging and Target Acquisition are not needed for our observations. A small nod and sub-pixel dither pattern will be used to mitigate the effect of open shutters, light-leakages and detector defects, as well as to improve PSF sampling. Open shutters in other quadrants and the fix slits will be used to obtain a “master background”.

Observations for each field can be executed in single visits of duration 12.2 hours including overheads, estimated with the JWST ETC and APT in order to reach the required SN level. The observations, which are mostly read-out noise limited, are split in 21 exposures of about 27 minutes each per field in order to avoid excessive cosmic ray hits. In order to reduce data volume and flow, we will use the "NRSIRS2" read-out pattern splitting each integrations in 22 groups. Given the faint and diffuse nature of our targets, saturation and persistence are not an issue for our observations.

Proposal 1835 - Targets - Unraveling the knots of gaseous Cosmic Web filaments at z~3 through H-alpha emission observations

| Fixed Targets | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---------------|------------|---|---|--------------------------|---------------|
| | (1) | MQN03-PA28 | RA: 00 44 33.7558 (11.1406492d) Dec: -26 11 45.50 (-26.19597d) Equinox: J2000 <i>Comments:</i> Description=[] | | |
| (2) | MQN01-PA45 | RA: 00 41 32.5500 (10.3856250d) Dec: -49 36 20.95 (-49.60582d) Equinox: J2000 <i>Comments:</i> Description=[] | | | |

Proposal 1835 - Observation 1 - Unraveling the knots of gaseous Cosmic Web filaments at z~3 through H-alpha emission observations

| Observation | Proposal 1835, Observation 1: MQN03_Plan1 Tue Mar 30 20:02:47 GMT 2021 Diagnostic Status: Warning Observing Template: NIRSpec MultiObject Spectroscopy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------|--|---|-------------------------|-------------------------------|------------------------------|-----------------------------|-----------------------------------|---|------|--------------------|--------------------------|---------------|--|--|-----|------------|---|--|--|--|--|------------------|--|--|--|--|--|--|-----------------------|--|--|--|--|--|--|
| | Diagnosics (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#1) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#2) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#3) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#4) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#5) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#6) has 6 primary slit traces affected by failed open shutters. (MQN03_Plan1 (Obs 1)) Warning (Form): Config c1 (#7) has 6 primary slit traces affected by failed open shutters. (Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fixed Targets | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th colspan="3">Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>MQN03-PA28</td> <td>RA: 00 44 33.7558 (11.1406492d) Dec: -26 11 45.50 (-26.19597d) Equinox: J2000</td> <td></td> <td colspan="3"></td> </tr> <tr> <td colspan="7"><i>Comments:</i></td> </tr> <tr> <td colspan="7"><i>Description=[]</i></td> </tr> </tbody> </table> | | | | | | | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous | | | (1) | MQN03-PA28 | RA: 00 44 33.7558 (11.1406492d) Dec: -26 11 45.50 (-26.19597d) Equinox: J2000 | | | | | <i>Comments:</i> | | | | | | | <i>Description=[]</i> | | | | | | |
| | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (1) | MQN03-PA28 | RA: 00 44 33.7558 (11.1406492d) Dec: -26 11 45.50 (-26.19597d) Equinox: J2000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Comments:</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Description=[]</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Template | TA Method | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | NONE | No | MSA Center | MQN03-PA28 (23 sources) | | jwst-nirspec-g235h | 1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Proposal 1835 - Observation 1 - Unraveling the knots of gaseous Cosmic Web filaments at z~3 through H-alpha emission observations

| # | Exposure Specification | MSA Configuration | Nod Pattern | Pointing | Dispersion Offset (Shutters) | Cross-Dispersion Offset (Shutters) | Total Dithers | Total Integrations | Total Exposure Time |
|----------------------|--|-------------------|-------------------|--|------------------------------|------------------------------------|---------------|--------------------|---------------------|
| Spectral Elements | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | | 1 | 3 | 4858.1 |
| | 2 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | 0.05 | 1 | 3 | 4858.1 |
| | 3 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | -0.05 | 1 | 3 | 4858.1 |
| | 4 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | 0.1 | 1 | 3 | 4858.1 |
| | 5 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | -0.1 | 1 | 3 | 4858.1 |
| | 6 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | 0.15 | 1 | 3 | 4858.1 |
| | 7 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 11.161054 Degrees - 26.18659305555553 4 Degrees | | -0.15 | 1 | 3 | 4858.1 |
| Special Requirements | Aperture PA Range 13 to 43 Degrees (V3 234.50765991 to 264.50765991000003) MSA Planned Aperture PA 28.0 to 28.0 Degrees (V3 249.50765991 to 249.50765991) | | | | | | | | |

Proposal 1835 - Observation 2 - Unraveling the knots of gaseous Cosmic Web filaments at z~3 through H-alpha emission observations

| Observation | Proposal 1835, Observation 2: MQN01_Plan1 Tue Mar 30 20:02:47 GMT 2021 Diagnostic Status: Warning Observing Template: NIRSpec MultiObject Spectroscopy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------|---|---|-------------------------|--------------------------|----------------------|----------------------------|--|-----------|----------------------------|------------------|------------------------|--------------------------|----------------------|----------------------------|------|-----|------------|---|--|--------------------|-----|--|------------------|--|--|--|--|--|--|-----------------------|--|--|--|--|--|
| | Diagnostics | (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#1) has 4 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#2) has 4 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#3) has 4 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#4) has 4 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#5) has 2 master background shutters affected by failed open or closed shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#5) has 2 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#6) has 4 primary slit traces affected by failed open shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#7) has 2 master background shutters affected by failed open or closed shutters. (MQN01_Plan1 (Obs 2)) Warning (Form): Config c1 (#7) has 2 primary slit traces affected by failed open shutters. (Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fixed Targets | | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;">#</th> <th style="width: 20%;">Name</th> <th style="width: 25%;">Target Coordinates</th> <th style="width: 15%;">Targ. Coord. Corrections</th> <th colspan="3" style="width: 30%;">Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(2)</td> <td>MQN01-PA45</td> <td>RA: 00 41 32.5500 (10.3856250d) Dec: -49 36 20.95 (-49.60582d) Equinox: J2000</td> <td></td> <td colspan="3"></td> </tr> <tr> <td colspan="7"><i>Comments:</i></td> </tr> <tr> <td colspan="7"><i>Description=[]</i></td> </tr> </tbody> </table> | | | | | | | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous | | | (2) | MQN01-PA45 | RA: 00 41 32.5500 (10.3856250d) Dec: -49 36 20.95 (-49.60582d) Equinox: J2000 | | | | | <i>Comments:</i> | | | | | | | <i>Description=[]</i> | | | | | |
| | # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (2) | MQN01-PA45 | RA: 00 41 32.5500 (10.3856250d) Dec: -49 36 20.95 (-49.60582d) Equinox: J2000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Comments:</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Description=[]</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Template | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">TA Method</th> <th style="width: 15%;">Obtain Confirmation Images</th> <th style="width: 15%;">Science Aperture</th> <th style="width: 15%;">Primary Candidate List</th> <th style="width: 15%;">Filler Candidate List</th> <th style="width: 15%;">Spectral Overlap Map</th> <th style="width: 15%;">Spectral Overlap Threshold</th> </tr> </thead> <tbody> <tr> <td>NONE</td> <td>No</td> <td>MSA Center</td> <td>MQN01-PA45 (29 sources)</td> <td></td> <td>jwst-nirspec-g235h</td> <td>1.2</td> </tr> </tbody> </table> | | | | | | | TA Method | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold | NONE | No | MSA Center | MQN01-PA45 (29 sources) | | jwst-nirspec-g235h | 1.2 | | | | | | | | | | | | | | |
| TA Method | Obtain Confirmation Images | Science Aperture | Primary Candidate List | Filler Candidate List | Spectral Overlap Map | Spectral Overlap Threshold | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NONE | No | MSA Center | MQN01-PA45 (29 sources) | | jwst-nirspec-g235h | 1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Proposal 1835 - Observation 2 - Unraveling the knots of gaseous Cosmic Web filaments at z~3 through H-alpha emission observations

| | # | Exposure Specification | MSA Configuration | Nod Pattern | Pointing | Dispersion Offset (Shutters) | Cross-Dispersion Offset (Shutters) | Total Dithers | Total Integrations | Total Exposure Time |
|-----------------------------|--|------------------------|-------------------|-------------------|--|------------------------------|------------------------------------|---------------|--------------------|---------------------|
| Spectral Elements | 1 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | | 1 | 3 | 4858.1 |
| | 2 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | 0.05 | 1 | 3 | 4858.1 |
| | 3 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | -0.05 | 1 | 3 | 4858.1 |
| | 4 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | 0.1 | 1 | 3 | 4858.1 |
| | 5 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | -0.1 | 1 | 3 | 4858.1 |
| | 6 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | 0.15 | 1 | 3 | 4858.1 |
| | 7 | 1 (G235H/F170LP) | c1 | 1 Shutter Slitlet | 10.38745320833333 4 Degrees - 49.63508083333335 Degrees | | -0.15 | 1 | 3 | 4858.1 |
| Special Requirements | Aperture PA Range 30 to 60 Degrees (V3 251.50765991 to 281.50765991000003) MSA Planned Aperture PA 45.0 to 45.0 Degrees (V3 266.50765991000003 to 266.50765991000003) | | | | | | | | | |