The BLOBs: Enigmatic diffuse ionized gas in a cluster of galaxies near cosmic noon

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Introduction

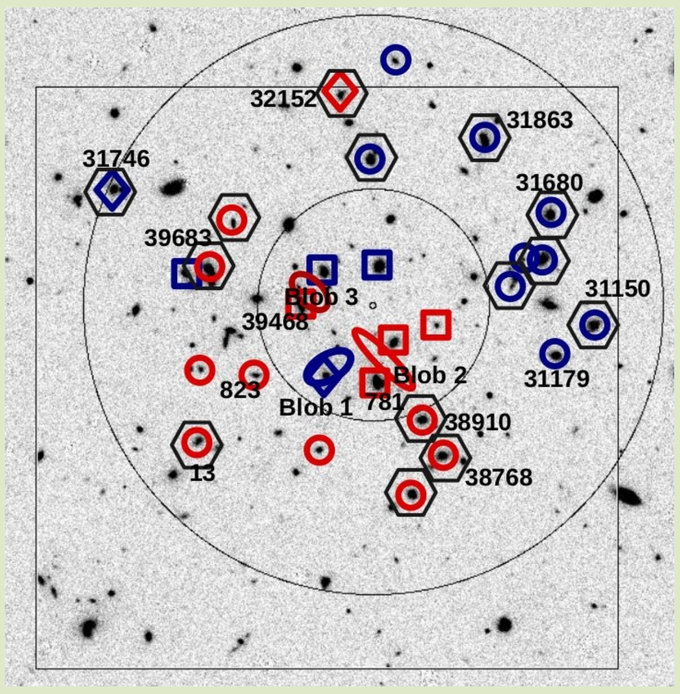
Direct emission studies of the diffuse gas in the circumgalactic and intergalactic medium are not generally feasible for individual galaxies beyond the local Universe, only in some rare cases:

1) around quasars, that produce a significantly elevated ionizing radiation background

or 2) in dense environments, where extended gas can be ionized by shocks triggered by gravitatio-nal interactions.

Diffuse [OII]λλ3726,3729 ionized gas traces warm 10^4K gas. Yuma et al. (2013), using narrow-band imaging, performed a first systematic search for spatially extended [OII] emission, called [OII] blobs. They found [OII] blobs to be mainly associ-ated with active galactic nuclei (AGN) outflows.

We investigate blobs of ionized [OII] emission in a cluster of galaxies at z~1.5.



HST F160W image of the *z~1.5 XMMXCS J2215.9-1738* cluster with area covered by MUSE (large square)

The central area of the z~1.5 XMM2215 cluster

28 galaxies and **3 BLOBs (ellipses)**

21 SF galaxies (circles), 7 passive galaxies (squares), 3 AGN (rhombuses), 14 ALMA detections (hexagons)

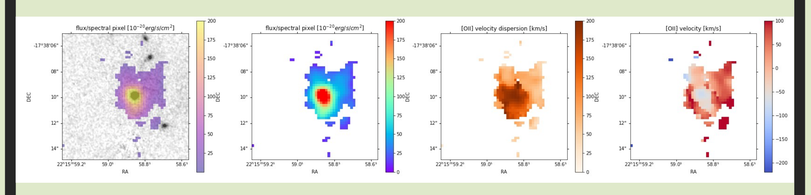
Cluster X-ray center: tiny open circle

14 cluster galaxies with z<1.457, 14 cluster galaxies with z>1.457

Inner part (circle with diameter 0.2Mpc, cf. R_{vir}~1Mpc): six passive galaxies and one AGN

Bimodal velocity distribution: two kinematically distinct structures in the southeast and northwest region

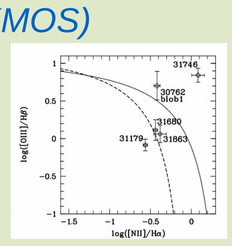
Blob 1: Ionized gas around 30762



Left to right: HST F160W image with [OII] EL map overlaid, spatially resolved [OII] EL map, [OII] velocity dispersion map, [OII] velocity map

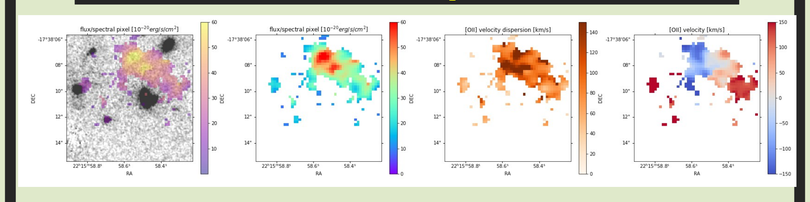
Galaxy 30762 at z~1.453, 74kpc from cluster X-ray center; ionized gas with a surface of 1145 kpc²; contains a point X-ray source, and is a type-2 AGN from BPT diagram (KMOS)

Maier et al. (2025)



The ionized gas of the blob extends beyond visible component of the galaxy 30762 and exhibits two filamentary patterns: north filament: projected receding velocity of ~100km/s, north-west filament: receding velocity of ~175km/s

Blob 2: Ionized gas without stellar component



At z~1.466, 70kpc from cluster X-ray center; extended [OII] ionized gas with a surface of 1270 kpc²

Using Kennicutt-Schmidt relation: gas mass of (1.9±0.5) x $10^{10}M_{sun}$

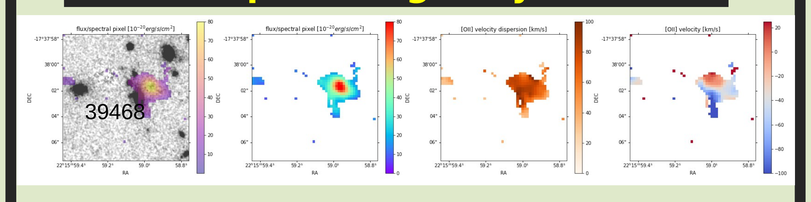
Ratio [OII]λ3729/[OII]λ3726: gas density n_e<10cm^{-3} for part with highest [OII] flux and approaching velocity, and n_e<100-1000cm^{-3} for the rest of the blob

No stellar counterpart, lies between two passive galaxies at similar redshift

Velocity rotation pattern with velocity gradient of ~300km/s

Maier et al. (2025)

Blob 3: Ionized gas close to a passive galaxy



At z~1.459, 62kpc from cluster X-ray center; [OII] ionized gas with a surface of 571 kpc²

Using Kennicutt-Schmidt relation: gas mass of blob of (1.4±0.4) x $10^{10}M_{sun}$

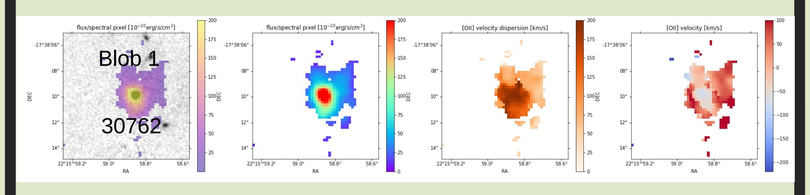
Very faint small stellar counterpart in the center of the blob, diameter 0.3 arcsec, surface of ~20 kpc², about 30 times smaller than surface of Blob 3

Velocity gradient from north to south of ~120km/s

Close to a passive galaxy 39468

Maier et al. (2025)

Blob 1: Future active BCG?

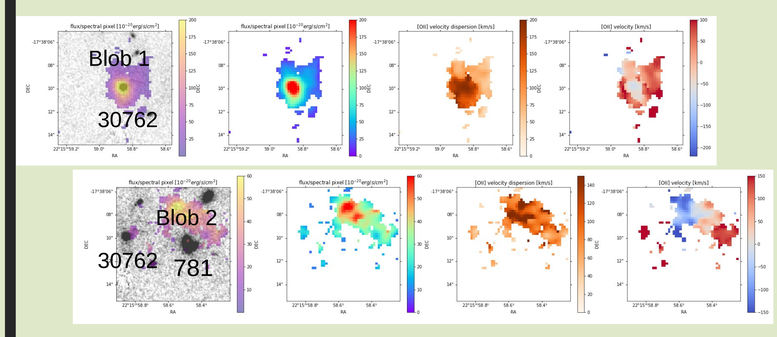


Two filamentary structures likely tracing out-flow of gas with velocities of ~100 and 175km/s

Outflow interpretation: no ALMA molecular detection + high (about solar) gas metallicity derived by Maier et al. (2019) for galaxy 30762

Galaxy 30762: 74kpc from cluster X-ray center, phase-space diagram velocity ~1000 km/s, likely becomes the (active) brightest cluster galaxy (BCG) of cluster XMM2215 in the future

Blob 2: enigmatic; AGN-RPS synergy?

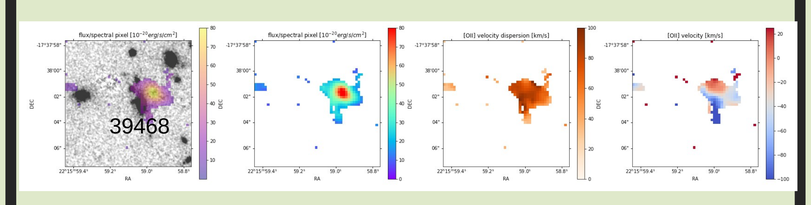


Blob 1 (30762) at z~1.453 and Blob 2 at z~1.466 slightly overlap in projection

AGN 30762 pushed away gas from galaxy 781 in the past traveling through cluster. Outflowing receding gas with proper motion of 300km/s.

Blob 2 produced by AGN-RPS synergy (cf. Maier et al. 2022): 2 x $10^{10}M_{sun}$ gas stripped from galaxy 781 by i) AGN 30762 & ii) RPS (ram pressure stripping) by intracluster medium (ICM) - Short recombination time (~10^4yrs): additional source of gas excitation inside Blob 2: shocks from past and ongoing merger events (c.f. bimodal velocity distribution of the cluster)

Blob 3: stripped gas or shocks?



Ionized gas Blob 3: RPS by cluster ICM acting on 39468 in the past when galaxy entered the inner region of the cluster (39468 became passive galaxy)

Very faint stellar counterpart in the center of the blob: star formation induced in the stripped gas, as observed during RPS of gas at lower redshifts

Ionization due to shocks from past and ongoing merging events (c.f. bimodal velocity distribution of the cluster)

Enigmatic origin of photoionization of Blobs 2 and 3: to be addressed with future improved numerical simulations of massive clusters that form at cosmic noon (z~2-3), including also warm gas.