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CLASH-VLT: the FF cluster MACS J0416.1-2403 : J/ApJS/224/33

CLASH-VLT: dissecting the frontier fields galaxy cluster MACS J0416.1-2403 with ~800 spectra of member galaxies. (2016)

[Go to the original article \(10.3847/0067-0049/224/2/33\)](https://doi.org/10.3847/0067-0049/224/2/33)

Keywords : galaxies: clusters: general; galaxies: clusters: individual: MACS J0416.1-2403; galaxies: distances and redshifts; galaxies: kinematics and dynamics

Abstract: We present VIMOS-Very Large Telescope (VLT) spectroscopy of the Frontier Fields (FF) cluster MACS J0416.1-2403 ($z=0.397$). Taken as part of the CLASH-VLT survey, the large spectroscopic campaign provided more than 4000 reliable redshifts over $\sim 600 \text{ arcmin}^2$, including ~ 800 cluster member galaxies. The unprecedented sample of cluster members at this redshift allows us to perform a highly detailed dynamical and structural analysis of the cluster out to $\sim 2.2r_{200}$ ($\sim 4 \text{ Mpc}$). Our analysis of substructures reveals a complex system composed of a main massive cluster ($M_{200} \sim 0.9 \times 10^{15} M_{\odot}$ and $\sigma_{v,r200} \sim 1000 \text{ km/s}$) presenting two major features: (i) a bimodal velocity distribution, showing two central peaks separated by $\Delta V_{\text{r}} \sim 1100 \text{ km/s}$ with comparable galaxy content and velocity dispersion, and (ii) a projected elongation of the main substructures along the NE-SW direction, with a prominent sub-clump $\sim 600 \text{ kpc}$ SW of the center and an isolated BCG approximately halfway between the center and the SW clump. We also detect a low-mass structure at $z \sim 0.390$, $\sim 10'$ south of the cluster center, projected at $\sim 3 \text{ Mpc}$, with a relative line-of-sight velocity of $\Delta V_{\text{r}} \sim 1700 \text{ km/s}$. The cluster mass profile that we obtain through our dynamical analysis deviates significantly from the "universal" NFW, being best fit by a Softened Isothermal Sphere model instead. The mass profile measured from the galaxy dynamics is found to be in relatively good agreement with those obtained from strong and weak lensing, as well as with that from the X-rays, despite the clearly unrelaxed nature of the cluster. Our results reveal an overall complex dynamical state of this massive cluster and support the hypothesis that the two main subclusters are being observed in a pre-collisional phase, in agreement with recent findings from radio and deep X-ray data. In this article, we also release the entire redshift catalog of 4386 sources in the field of this cluster, which includes 60 identified Chandra X-ray sources and 105 JVLA radio sources.

The cluster MACS J0416.1-2403 was observed between 2012 December and 2014 November as part of the ESO Large Programme 186.A-0798 "Dark Matter Mass Distributions of Hubble Treasury Clusters and the Foundations of Λ CDM Structure Formation Models" (P.I.: Piero Rosati) using VIMOS at the ESO VLT.

A total of 21 masks were observed (15 LR-Blue (low-resolution) masks and 6 MR (medium-resolution) masks). The LR-Blue masks cover the spectral range $3700\text{--}6700 \text{ \AA}$ with a resolution of $R=180$, while the MR masks cover the range $4800\text{--}10000 \text{ \AA}$ with a resolution of $R=580$. The massive cluster has been observed with the Hubble Space Telescope (HST) as part of the Multi-Cycle Treasury program Cluster Lensing And Supernova survey with Hubble (CLASH; P.I.: M. Postman; Postman et al. 2012, [J/ApJS/199/25](https://doi.org/10.1086/668811)). The HST survey is nicely complemented by Subaru wide-field imaging.

- [J/A+A/590/A31](#) : ASTRODEEP Frontier Fields Catalogues (Merlin+, 2016)
- [J/A+A/579/A4](#) : MCS J1206.2-0847 galaxies spectral classif. (Girardi+, 2015)
- [J/ApJ/801/44](#) : HST lensing analysis of the CLASH sample (Zitrin+, 2015)
- [J/MNRAS/443/1549](#) : MACSJ0416.1-2403 strong-lensing analysis (Jauzac+, 2014)
- [J/ApJS/211/21](#) : Spectroscopic redshifts of galaxies in MACS (Ebeling+, 2014)
- [J/ApJ/776/91](#) : Spectrosc. redshifts of galaxies in 2 clusters (Lemze+, 2013)
- [J/ApJ/762/L30](#) : CLASH
- [J/ApJS/199/25](#) : CLASH sources for MACS1149.6+2223 (Postman+, 2012)
- [J/A+A/517/A65](#) : Velocities of A2294 galaxies (Girardi+, 2010)
- [J/A+A/512/A12](#) : VLT/VIMOS spectroscopy in GOODS-South field (Balestra+, 2010)
- [J/A+A/491/379](#) : Velocities of galaxies in Abell 520 (Girardi+, 2008)
- [J/AJ/132/1275](#) : CIRS (Cluster Infall Regions in the SDSS). I. (Rines+, 2006)
- [J/ApJ/621/53](#) : Multiple arc systems in A1689 (Broadhurst+, 2005)
- [J/AJ/126/2152](#) : Cluster And Infall Region Nearby Survey. I (Rines+, 2003)
- [J/A+A/399/813](#) : Multiple merging events in Abell 521 (Ferrari, 2003)
- <http://sites.google.com/site/vltclashpublic/> : CLASH-VLT home page
- <http://www.stsci.edu/hst/campaigns/frontier-fields/Lensing-Models> :

Archives are available through FTP in standardized format described in the ReadMe.
VizieR tables are built from archives with additional transformations.

J/ApJS/224/33 CLASH-VLT: the FF cluster MACS J0416.1-2403 (Balestra+, 2016)

The following files can be converted to FITS (extension .fit or fit.gz)

table[289].dat

Query from: <http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/ApJS/224/33>

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ReadMe	05-May-2017 10:11	-r--r--r--	8.9K	
table2.dat	19-Aug-2016 15:26	-rw-r-- r--	287 K	- text - txt.gz - fits - fits.gz - html
table8.dat	18-Jul-2016 14:56	-r--r--r--	4.2K	- text - txt.gz - fits - fits.gz - html
table9.dat	18-Jul-2016 15:23	-r--r--r--	6.7K	- text - txt.gz - fits - fits.gz - html