



Report from the event supported by RadioNet

TITLE *THE EARLY STAGES OF GALAXY CLUSTER FORMATION:
MERGERS, PROTOCLUSTERS, AND STAR FORMATION IN
OVERDENSE ENVIRONMENTS*

DATE: *17-21 JULY 2017*

LOCATION: *GARCHING B. MÜNCHEN, GERMANY*

MEETING WEBPAGE: <https://www.eso.org/sci/meetings/2017/GCF2017.html>

HOST INSTITUTE: *EUROPEAN SOUTHERN OBSERVATORY (ESO)*

**RADIONET
BENEFICIARY / NO:** *ESO/13*

Report:

1. SCIENTIFIC SUMMARY

The event brought together experts from across the electromagnetic spectrum studying the largest objects to form by the current epoch, galaxy clusters. Many other conferences and workshops have also come together to discuss galaxy clusters over roughly the 2nd half of the history of the Universe. What was unique here is that we also included an equal mix of scientists studying the precursors to galaxy clusters, which are called “proto-clusters”, even earlier in the Universe and attempted to define precisely what distinguishes the two. Surprisingly, this may have been the first workshop of its kind, as those purely in the protocluster community have also met frequently in the absence of their lower redshift counterparts.

The evolution of a protocluster into a cluster is a continuous process, and often smaller clusters at high redshift on their way to joining other small clusters to form a massive cluster by the current epoch. As such, the definitions of each will always include a few ambiguous cases, but the interaction of theorists, observers, and instrumentation experts lent itself to a useful discussion. Rather than simply hearing the latest results from one’s own field, many (including the conference organizers) felt they had learned something from the conference.

The RadioNet community will continue to play a prominent role in the study of protoclusters and clusters, as these objects are often discovered and characterized using radio, millimeter, and submillimeter facilities and surveys. At high redshift, ALMA and IRAM have been indispensable for studying the coldest and hottest gas in clusters and protoclusters, while at lower redshift, LOFAR and soon SKA have or will discover and characterize many merging systems.

<https://www.eso.org/sci/meetings/2017/GCF2017.html>

2. AGENDA OF THE EVENT

Monday

- 13:55 – 14:30 Monique Arnaud (invited): opening address
- 14:30 – 14:45 Yannick Bahe: The Hydrangea simulations: clusters with resolved galaxies
- 14:45 – 15:00 Marguerite Pierre: XMM-OWLS insights into cluster assembly at redshift 1 to 2
- 15:00 – 15:15 Nina Hatch: What distant clusters can reveal about galaxy evolution
- 15:15 – 15:30 POSTER SESSION
- 15:30 - 16:00 COFFEE & TEA BREAK
- 16:00 – 16:35 Gabriella de Lucia (invited): The build-up of galaxy clusters in a hierarchical Universe
- 16:35 – 16:50 Emanuele Contini: Semi-Analytic Model Predictions of the Galaxy Population in Proto-Clusters
- 16:50 – 17:05 Eda Gjergo: Simulating Galaxy Clusters with Dust Formation and Evolution

Tuesday

- 09:10 – 09:45 Nina Hatch (invited): Protocluster assembly: observations and theory
- 09:45 – 10:00 Audrey Galametz: A large-scale super-structure at $z \sim 0.65$ in the UKIDSS ultra-deep survey field
- 10:00 – 10:15 Rafael Guzman: A spectroscopically confirmed rich proto-cluster at $z \sim 6.5$
- 10:15 – 10:30 Mari Polletta: Multi-wavelength investigation of Planck high-redshift proto-clusters

- 10:30 – 10:45 Ryley Hill: Resolving with ALMA the nature of an early star-forming large-scale structure from PLANCK
- 10:45 – 11:15 COFFEE & TEA BREAK
- 11:15 – 11:30 Gael Noirod (presented by Audrey Galametz): The Densest Structures at $z=1.4-2.8$ from the CARLA Survey
- 11:30 – 11:45 David Clements: Starbursting Protoclusters from Herschel & Planck
- 11:45 – 12:00 Emmet Golden-Marx: The High- z Clusters Occupied by Bent Radio AGN (COBRA) Survey
- 12:00 - 12:30 Discussion
- 13:40 – 14:15 Marcus Bruggen (invited): Merging Clusters as Fundamental Physics Laboratories
- 14:15 – 14:30 Mariachiara Rossetti: Looking for merging clusters in SZ surveys
- 14:30 – 14:45 Kaustuv Basu: Shocks and cool cores: An ALMA view of cluster formation from outside and inside
- 14:45 – 15:00 Remi Adam: Probing the formation of distant clusters using NIKA SZ observations
- 15:00 – 15:15 Andrea Botteon: Non-thermal phenomena in El Gordo at $z = 0.87$
- 15:15 – 15:45 COFFEE & TEA BREAK
- 15:45 – 16:00 Gabriella DiGennaro: Deep in the (un)known: the Sausage Cluster
- 16:00 – 16:15 Matt Owers: The Cold Front Cluster Project: Probing the Impact of Hierarchical Growth on Cluster Galaxies
- 16:15 – 16:30 Michael Gregg: Observing Ram Pressure Stripping and Morphological Transformation in the Coma Cluster
- 16:30 – 16:45 Anshu Gupta: Survival of the fittest under the influence of ram pressure stripping!
- 16:45 – 17:00 Pascale Jablonka: SEEDisCS: how clusters form and galaxies transform in the cosmic web

Wednesday

- 09:10 – 09:45 Dominique Eckert (invited): The formation, evolution and chemical enrichment of the intracluster medium
- 09:45 – 10:00 Martin Bourne: Simulation of AGN jet feedback in galaxy clusters
- 10:00 – 10:15 Charutha Krishnan: Enhancement of AGN activity in a protocluster at $z = 1.6$
- 10:15 – 10:30 Rebecca Canning: AGN activity in massive cluster at $z > 1$
- 10:30 – 10:45 POSTER SESSION
- 10:45 – 11:15 COFFEE & TEA BREAK
- 11:15 – 11:30 Daniel Wik: Characterizing the First Galaxy Clusters at the Epoch of their Formation with STAR-X
- 11:30 – 11:45 Helmut Dannerbauer: Surprising existence of massive and large molecular gas reservoirs in a distant protocluster
- 11:45 – 12:00 William Forman: Anatomy of a Merger: A Deep Chandra Observation of Abell 115
- 12:00 - 12:30 Discussion
- 13:40 – 14:15 Nick Battaglia (invited): Cluster and Protocluster Mass Estimation and Determination of their Dynamical States
- 14:15 – 14:30 Chris Hayward: How well do submillimeter galaxies trace protoclusters?
- 14:30 – 14:45 Cristina Garcia Vergara: Protoclusters traced by high-redshift massive galaxies
- 14:45 – 15:00 Nobunari Kashikawa: High- z protocluster survey by Subaru/HSC
- 15:00 – 15:15 Hisakazu Uchiyama: Luminous Quasars Do Not Live in the Most Overdense Regions of Galaxies at $z \sim 4$
- 15:15 – 15:45 COFFEE & TEA BREAK
- 15:45 – 16:00 Manuela Magliocchetti: High-redshift star-forming galaxies and proto-clusters: an insight from clustering studies

- 16:00 – 16:15 David Sobral: Large H α surveys of field, filaments and (proto-)clusters at z 0.2–2.2: does the environment matter?
- 16:15 – 16:30 Yusei Koyama: The nature of H α selected galaxies along the huge cosmic web across cosmic time with Subaru
- 16:30 – 16:45 Brian Lemaux: A Large Sample of Proto-clusters and Proto-Groups from the VIMOS Ultra-Deep Survey
- 16:45 – 17:00 Mark Brodwin: Epoch of Merger-Driven Star Formation and AGN in Galaxy Clusters

Thursday

- 09:10 – 09:45 Adam Muzzin (invited): The Evolution of Proto-Cluster Galaxies
- 09:45 – 10:00 Miguel Socolovsky: Excess of rapidly-quenched galaxies in distant galaxy clusters
- 10:00 – 10:15 Alessandra Beifiori: Tracing the evolution of passive galaxies at $1.4 \leq z \leq 1.8$ with KMOS
- 10:15 – 10:30 Pierluigi Cerulo: Galaxy Transformations in the Most Massive high-redshift Clusters
- 10:30 – 10:45 Veronica Strazzullo: Quiescent and star-forming galaxy populations in the core of CIJ1449+0856 at $z = 2$
- 10:45 – 11:15 COFFEE & TEA BREAK
- 11:15 – 11:30 Matteo Fossati: Witnessing the onset of environmental quenching at $z \sim 2$. Results and implications from 3D-HST
- 11:30 – 11:45 Donald Lee-Brown: The Spectroscopic Ages of Passive Galaxies in a $z = 1.62$ Protocluster
- 11:45 – 12:00 Jeffrey Chan: The buildup and structural evolution of the cluster red sequence between redshift 1 to 1.5
- 12:00 - 12:30 Discussion
- 14:00 – 14:15 Masao Hayashi: Evolutionary phase of gas-rich galaxies in a galaxy cluster at $z=1.46$
- 14:15 – 14:30 Allison Noble: An ALMA Study of Gas-Rich Galaxies in z 1.6 Galaxy Clusters
- 14:30 – 14:45 Gregory Rudnick: The molecular gas properties of $z = 1.62$ proto-cluster galaxies
- 14:45 – 15:00 Rosemary Coogan: The molecular gas content of star-forming galaxies in a $z \sim 2$ cluster as seen by JVLA and ALMA
- 15:00 – 15:15 Mehdi Walji: The topology of the Spider's web
- 15:15 – 15:45 COFFEE & TEA BREAK
- 15:45 – 16:00 Elizabeth Cooke: A mature galaxy cluster at $z = 1.58$ around the radio galaxy 7C1753+6311
- 16:00 – 16:15 MinJu Lee: Insights of environmental effect in high- z galaxy evolution from radio and (sub)mm perspectives
- 16:15 – 16:30 Mariko Kubo: Bimodal morphologies of massive galaxies at the core of a protocluster at $z = 3.09$
- 16:30 – 16:45 Chao-Ling Hung: The role of galaxy mergers and molecular gas in the early phase of galaxy cluster assembly
- 16:45 – 17:00 Eelco van Kampen: Dust and gas in distant cluster galaxies with ALMA

Friday

- 09:10 – 09:45 Megan Donahue (invited): Lessons Learned from Multiwavelength Studies of Low Redshift Clusters of Galaxies
- 09:45 – 10:00 Tadayuki Kodama: Enhanced Ly α depletion in the proto-cluster cores at $z = 2.5$
- 10:00 – 10:15 Zheng Cai: MAPPING the Most Massive Overdensity Through Hydrogen (MAMMOTH)
- 10:15 – 10:30 Ken Mawatari: Mapping of HI absorption structure in the SSA22 protocluster at $z=3.1$
- 10:30 – 10:45 Toma Badescu: Discovery of a Protocluster Associated with a Ly α Blob Pair at $z=2.3$
- 10:45 – 11:15 COFFEE & TEA BREAK
- 11:15 – 11:30 Alessandro Rettura: Mass-Richness relation for X-ray and SZE-selected clusters at $z < 0.4$

3. PARTICIPANTS

We had 8 invited speakers, of which 4 were female and 4 were male. Half of them represented European institutions, and the other half was from North America. None of the invited speakers received RadioNet support.

Attendees came from 5 continents (all but Africa & Antarctica), with the percentages:
54% Europe (Germany, Italy, France, UK, Switzerland, Turkey, Spain, The Netherlands)
23% North America (US, Canada)
15% Asia (Japan, South Korea, India, China)
5% South America (Chile, Brazil)
3% Australia

35% of talk submissions were from women, and 35% of talk allocations were awarded to women. The talk selection was done blindly, so we conclude there was no measurable bias in how we graded talk abstracts.

Concerning young researchers & students, we had ~25% students, ~30% postdoctoral researchers, and 45% tenure-track or tenured faculty of the ~100 participants.



4. RADIONET FINANCIAL CONTRIBUTION

We used the support from RadioNet, 2500 €, to subsidize the travel of 7 students and postdocs attending the workshop, in addition to waiving their registration fees using internal ESO funding. This was to maximize participation of junior, underrepresented scientists.