

Madrid, 26/07/2017

report on  
**“Crystal Clear Clusters” workshop**

Dear LACEGAL coordinators,

first of all I would like to thank you - on behalf of the whole Science Organisation Committee and the participants - for the financial support of the workshop “Crystal Clear Clusters” that took place during the week June 25-30, 2017 at UAM’s La Cristalera in Miraflores de la Sierra, Spain. We hereby inform you of the details, progress, and outcomes of the meeting.

The meeting was attended by 35 participants (9 women) from 16 different countries (see Appendix A). Following the spirit of our previous workshops (e.g. [Compact Clusters 2016](#), [Cosmic CARNage 2015](#), [nIFTy Cosmology 2014](#), etc.) it was a hands-on workshop where participants were given access to data derived from a large-volume cosmological simulation (i.e. the [MDPL2 simulation](#)):

- 1) semi-analytical models applied to the dark matter only MDPL2 simulation: Galacticus, SAG, and SAGE;
- 2) full physics hydrodynamical simulations run in selected regions (of size  $R=15$  Mpc/h) of the MDPL2 simulation, i.e. only those regions were populated with gas (and eventually star) particles with dark matter particles outside that region successively collapsed to lower resolution. The codes used for that are GadgetMUSIC, GadgetX, and GIZMO.

During the first day the generation of the data and its location and distribution on a dedicated data server has been presented. At the end of that day there has also been the discussion about the science questions to be addressed with that data and - most importantly - work groups have been formed. Each science project has been assigned a lead person and everyone interested was able to sign up: all efforts and progress has and will be coordinated using a (non-public) wiki hosted by [pbworks](#); here we attach an extract from that wiki that summaries the science projects (see Appendix B).

The remainder of the week was dedicated to actually working on the projects and using the data to generate first plots. Those preliminary results have then been discussed and eventually led to refinements in the provided data. For instance, we discovered that the runs performed by GIZMO were not perfectly aligned with the runs undertaken with the other two codes; we also became aware of a subtle issue with the SAGE semi-analytical model that has now been rectified in a revised version of the respective galaxy catalogues.

After the summary on the last day every project lead has agreed to take the project forward and transform it into a scientific publication over the course of the coming year and until the next workshop (to be held in Edinburgh, hosted by Romeel Dave).



Prof. Alexander Knebe (on behalf of the Science Organising Committee)

**Crystal Clear Clusters: Participants**

<b>participant</b>	<b>affiliation</b>	<b>country</b>
Arthur, Jake	Nottingham	UK
Asquith, Rachel	Nottingham	UK
Brown, Shaun	Nottingham	UK
Canas, Rodrigo	ICRAR	Australia
Cialone, Giammarco	La Sapienza	Italy
Contreras, Sergio	Pontificia Universidad Catolica de Chile	Chile
Cora, Sofia	La Plata	Argentina
Cui, Weiguang	UAM	Spain
Cunnama, Daniel	UWC	South Africa
Dave, Romeel	UWC	South Africa
Durando, Giacomo	UAM	Spain
Elahi, Pascal	ICRAR	Australia
Enke, Harry	AIP	Germany
Gargiulo, Ignacio	La Plata	Argentina
Gottloeber, Stefan	AIP	Germany
Grey, Meghan	Nottingham	UK
Hoffmann, Kai	Beijing	China
Knebe, Alexander	UAM	Spain
Moline, Angeles	Lisbon	Portugal
Mostoghiu, Robert	UAM	Spain
Old, Lyndsay	Toronto	Canada
Pearce, Frazer	Nottingham	UK
Power, Chris	ICRAR	Australia
Rafieferantsoa, Mika	UWC	South Africa
Robson, Dylan	Nottingham	UK
Semczuk, Marcin	Warsaw	Poland
Shao, Jiawei	Shanghai	China
Singh, Priyanka	Raman Research Institute	India
Sorce, Jenny	Strasbourg	France
Stoppacher, Doris	UAM	Spain
Vega, Cristian	La Plata	Argentina
Vega, Jesus	Philadelphia	USA
Wang, Yang	Guadong	China
Welker, Charlotte	ICRAR	Australia
Yepes, Gustavo	UAM	Spain

# Appendix B

## Crystal Clear Clusters: Science Projects

Project	Lead	Participants	Comments	Infrastructure	Status
Sample and Hydro Comparison	F. Pearce, A. Knebe	All	Project overview, presentation of both the full physics and cluster SAM sample. Demonstration that the various catalogues are comparable, R200, galaxies, etc.	Galaxy/Halo Catalogues	
Comparison with SAMs	C. Vega	Gustavo, Doris, Robert, Sergio, Daniel, Frazer, Pascal, Rachel, Stefan, Alexander, Gaspari	Comparison of the SAM regions to the hydros. Start with clusters, then possible field regions (regions devoid of clusters, moderate groups). Satellite stellar/baryon fractions, statistical comparison, SFR.	Galaxy/Halo Catalogues, SAMs, Cross Correlated Catalogues	we need to be more specific with the actual science project(s) as 'Comparison w/ SAMs' is rather generic...
Comparison with observations: Optical + X-ray + SZ	W. Cui	M. De Petris, G. Yepes, Giammarco Cialone, Giacomo Durando, Rodrigo, Jiawei, Romeel, Lyndsay, Priyanka, Angie, Gaspari	Project aims: 1) Present the package for making mock ccd and SZ signals. 2) Target observation surveys, make corresponding mock images for the comparison (x-ray/sz/bcg) (weiguang)  Connects with 1) Dynamical state (lyndsay) 2) ICL properties (Rodrigo) 3) mass bias from different observations.	Mock images (ccd, xray, sz)	Properly prepare the mock images for comparison
Gravitational lensing	J. Vega	G. Yepes, M. De Petris	Strong lensing mass models: deflection field, lensing potential and magnification. Comparison of mass estimates from Lensing and X-ray, SZ	Mock images (lensing)	Consolidation/ collaboration with mock images
Cold Flows	C. Welker	Jake, Pascal, Chris, Meghan, Jenny	Flow of cold gas onto halo environment. Think of gas accretion, angular momentum build-up, alignment to satellites. Several possible papers.	Galaxy/Halo Catalogue, Raw Particle Data, Shocks Catalogue, Disperse, Tracking (orbit)	
Gas Stripping in Satellites	P. Elahi, J. Arthur, D. Cunnamea	Romeel, Meghan, Marcin	Gas stripping of satellite galaxies, environmental effects, possible preprocessing.	Galaxy/Halo Catalogue, Raw Particle Data, Shocks Catalogue, Tracking (orbit)	Consolidation with Preprocessing (associated with protocusters)
Environments	Y. Wang	Jake	Some pre-works based on Cluster19 1. Compare the different definitions of node, filament, sheet and void. Cluster 17, Velociraptor catalogue <b>Main method:</b> identified with density and temperature of gas. BY Jake <b>Method for completeness:</b> a. DisPerSe; BY Charlotte b. Hessian Matrix of density field within 1/2/3 Mpc region; BY Yang 2. Examination of Luminosity, Magnitude, Ellipticity, Star Fraction, Spin and their dependency on local density field.	Galaxy/Halo Catalogue, Environment Classification, Disperse	Collaboration with field halos, cosmic web studies, consolidation.
Field Galaxies vs Clusters	R. Mostoghiu	Doris, Yang, Gustavo, Christian, Stefan, Alexander	Comparison of hydro "fields" regions (devoid of clusters, moderate mass groups) SAMs Comparison of hydro "field" galaxies (devoid of clusters, moderate mass groups) to cluster galaxies	Galaxy/Halo Catalogue, SAMs, Environment Classification, Disperse	
Dynamical State	L. Old	Weiguang, Giammarco, Giacomo, Pascal, Jake, Angie, M. De Petris, Meghan, Gaspari	Analyse the suite of cluster simulations (hydro & SAMs) with a variety dynamical state/substructure tests including i) galaxy distribution (DS, Kappa tests, LOS phase-space), ii) X-ray maps, iii) SZ maps, iv) optical maps and v) theoretical analysis. How do these dynamical state analyses compare? How do the simulations compare? Similar to Cui+2017, but from an observational perspective.	Galaxy/Halo Catalogue, Disperse Tracking (orbits)	Consolidation with mock images study
Alignments of galaxies/subhaloes in filaments and clusters	K. Hoffmann	Yang, Charlotte, Alexander, Angie	Alignments of galaxies/subhaloes in filaments, and in parent clusters, for example, calculate the radial alignment of satellite galaxies toward the BCGs and the radial alignments of satellites with each other. In some observational samples, the intrinsic alignment of cluster galaxies is consistent with zero for blue, red galaxies, bright, faint ones, subsamples of clusters based on redshift, dynamical mass, and dynamical state (e.g., Sifon+2015), do we see this in the simulated cluster sample? (data: DM subhaloes).	Galaxy/Halo Catalogue, Disperse Tracking (orbits)	Collaboration with Environment and cold flows (regarding infrastructure)
Close-pairs of galaxies	D. Cunnamea	Lyndsay, Yang, Pascal, Rodrigo, Jake, Marcin, Weiguang	Close-pairs of galaxies, how many pairs do we see in 3D and then project to 2D. Does the prevalence of close-pairs correlate with dynamical state of the cluster? If I can access data from multiple redshift snapshots, how many of the close-pairs eventually merge? (data: hydro).	Galaxy/Halo Catalogue, Tracking (orbits)	
Preprocessing	P. Elahi, J. Arthur, D. Cunnamea		Are halos effected before they reach cluster centre? In which environments does it occur?	Galaxy/Halo Catalogue, Tracking (orbits)	Collaboration/ Consolidation with gas stripping
Protocusters	P. Elahi, J. Arthur, D. Cunnamea	Romeel		Galaxy/Halo Catalogue, Tracking (orbits)	Collaboration/ Consolidation with gas stripping
Quenching of star formation	S. Cora	Christian, Jake, Pascal, Mika, Rodrigo	look at evolution of SFR	Galaxy/Halo Catalogue, Tracking (orbits), SAMs	
HI content of satellites	Mika	Weiguang		Galaxy/Halo Catalogue, Tracking (orbits)	collaboration/ consolidation with environment/gas stripping
Feedback	A. Molines	Rodrigo, Sergio, Pascal, Doris, Gaspari	Study (and numerical convergence) of feedback in MW mass (and below) haloes	Galaxy/Halo Catalogue, Tracking (orbits), SAMs, pure galaxy catalogues	collaboration with halo occupation
The dispersion of the halo occupation distribution.	S. Contreras	Angie, Christian, Doris	Aim: To measure the dispersion on the satellite contribution of the HOD using semi-analytical models (SAMs) and Hydrodynamic simulations. We aim to understand if the dispersion in this relation is model dependent and if it can be parameterised so it can be implemented on HOD models for the creation of mock galaxy catalogues.	Galaxy/Halo Catalogue, SAMs, cross catalogues	
ICL	R. Canas	Pascal, Romeel, Weiguang, Chris	Measurement and growth	Galaxy Catalogue, Tracking (orbits), Mock optical images	
Gaseous outskirts	C. Power	Rodrigo, Pascal, Charlotte	phase-space structure of cluster outskirts	Galaxy Catalogue, Simulation Data	
Baryon fraction environmental dependence	C. Power	Rodrigo, Angie, Charlotte, Pascal, Jenny	Looking at baryon fractions (and perhaps phase of gas) in different environments		
Black Hole Statistics	R. Dave	*Rodrigo, Priyanka, Weiguang, Gaspari	Galaxy-BH relations, accretion, etc  Papers: start with mbh-sigma, accretion rates duty cycle		
Convergence	C. Power	Frazer, Pascal, Jake, Gustavo, Rodrigo, Mika, Stefan, Alexander, Rodrigo	Convergence study with 8x better resolution (and 64x <sup>2</sup> ), feedback tests as well.		Longer term project, needs simulations currently field region resimulated.
Cosmological Parameters	F. Pearce	Alexander, Robert	take Void0001 and estimate cosmological parameters from that volume		