PhD Name: Maria Giulia Campitiello

PhD Cycle: 36

Tutor: Stefano Ettori

RESEARCH PROJECT: CHEX-MATE: the XMM-Heritage cluster project.

TITLE: The morphological and dynamical state of galaxy clusters in the CHEX-MATE sample.

Clusters of galaxies represent a common ground between astrophysics and cosmology. These two areas of research focus on objects that can experience a very different dynamical state, from being very relaxed to very disturbed due to the action, for instance, of a major merger. Relaxed systems are characterised by a spherically symmetric emission, peaked in the centre, and are very suitable for cosmological studies. The absence of signs of mergers indeed allows to assume hydrostatic equilibrium, which is a crucial condition for the derivation from X-ray images of one of the most important cosmological quantities, i. e. the cluster total mass (see, e.g., Ettori et al. 2013; Pratt et al. 2019). Disturbed systems instead, show clear signs of mergers and substructures and do not satisfy the hydrostatic equilibrium assumption. However, they play an important role in the study of all those microphysical processes related to turbulence, sloshing of the ICM or particle reacceleration.

Starting from this context it appears clear that dynamical classification represents a starting point when dealing with large samples of galaxy clusters, since it allows to identify the most suitable set of systems to consider in specific analysis. However, obtaining an accurate characterisation of the dynamical state is very challenging because multi-wavelength information are required and they are available only for few objects. To overcome this limit it is possible to resort to the morphological analysis of the X-ray emission of galaxy clusters: all those processes that can alter the dynamical state of clusters, like mergers or sloshing, are indeed expected to leave traces in the ICM distribution, and thus in the X-ray images.

In this first year of my PhD, I have carried out a morphological analysis of the 118 clusters that constitute the CHEX-MATE (Cluster HEritage project with XMM-Newton Mass Assembly and Thermodynamics at the endpoint of structure formation) sample. This sample was built with the aim to set the stage for future X-rays observations, by providing both an overview of the statistical properties of the underlying cluster population and an improvement of the analysis techniques developed up to date. The morphological analysis that I have realised reflects these two goals: on the one hand, it aims to provide to the entire community an overview of the dynamical state of the CHEX-MATE clusters, which will be useful for future analysis; on the other hand, it aims to check the techniques developed until now. The dataset at my disposal is composed of 118 XMM-Newton images characterised by a signal to noise ratio S/N ~ 150, a feature that allows a uniform characterisation of the whole sample. As first step, I have carried out the morphological analysis following a typical approach developed in the last decades. This procedure consists in the measure of the so-called *morphological parameters,* which are indicators defined to identify even small deviations from regular and spherically symmetric emission. Among the commonly used parameters, I have focused my attention on the concentration (a measure of the peakedness of the emission), the centroid shift and the power ratios (which are parameters that identify the presence of substructures). Starting from this basis, I have then investigated both the robustness of these parameters, by analysing how their estimation is influenced by the quality of the images considered, and their power in identifying the most relaxed and disturbed clusters. For this latter point, I used as support for the analysis a simulated sample of clusters covering the same mass and redshift range of the observations. Hydrodynamical simulations indeed, allow to obtain a priori knowledge of the dynamical state of the considered systems (e.g., De Luca et al. 2021) and could be used to understand whether the morphological parameters show threshold values above or below which

only relaxed or disturbed systems are detected. At the moment I am considering simulations to calibrate these thresholds and to apply them to the observations, in order to obtain the final and objective classification of the CHEX-MATE sample.

Starting from this classification I will focus my analysis on the most disturbed systems with the aim to realise a detailed characterisation of the properties of their ICM, by means of an analysis of all those features resulting from previous or ongoing mergers events (like edges and discontinuities present in the ICM or radio emission). Thanks to the uniform S/N of the XMM-images of the CHEX-MATE sample, this study will allow me to derive for the first time important statistical information about the occurrence of these features in disturbed systems. As support for this investigation, I will analyse also Chandra images (characterised by higher resolution) and LOFAR observations.

WORKSHOPS, CONFERENCES & MEETINGS:

22 January 2021	CHEX-MATE X-ray workshop. Talk: "*Study of the morphological and dynamical state of the CHEX-MATE galaxy clusters".*
8-10 February 2021	CHEX-MATE Workshop. Talk: "*Study of the morphological and dynamical state of the CHEX-MATE galaxy clusters".*
28 June-2 July 2021	Observing the mm Universe with the NIKA 2 Camera. Talk: *"The dynamical state of galaxy clusters in the CHEX-MATE sample"*
12 - 16 July 2021	The Three Hundred: collaboration meeting. Talk: "*The dynamical state of galaxy clusters in the CHEX-MATE sample"*

PhD SCHOOLS:

22-26 March 2021	LOFAR school 2021

INTERNAL COURSES:

30 Nov - 2 Dec 2020	The Interstellar Medium
19 - 23 April 2021	Gamma-Ray Bursts: from observations to physical properties
5 - 14 May 2021	Writing, talking and presenting Science

ISA LECTURES:

15 September 2021	"The Biochemistry of Nickel: Il Buono, Il Brutto, Il Cattivo" Lecture by Michael J. Maroney, University of Massachusetts,USA
28 September 2021	"How the Brain Controls Pain" Lecture by Mary Heinricher, Oregon Health and Science University, USA

RESEARCH PERIOD ABROAD

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COMPETITIVE TELESCOPE/COMPUTER TIME ALLOCATIONS:

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OTHER RELEVANT ACTIVITIES:

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PUBLICATIONS:

Refereed Paper:	*GASP XXXIV: Unfolding the Thermal Side of Ram Pressure Stripping in the Jellyfish Galaxy JO201*
Authors:	**Campitiello M.G.**, Ignesti A., Gitti M., Brighenti F., Radovich M., Wolter A., Tomičić N., Bellhouse C., Poggianti B. M., Moretti A., Vulcani B., Jaffé Y. L., Paladino R., Müller A., Fritz J., Lourenço A. C. C., Gullieuszik M..
Review:	"THE ASTROPHYSICAL JOURNAL", 2021, 911, pp 1 - 15
Paper in preparation:	*The morphological and dynamical state of the galaxy clusters in the CHEX-MATE sample*
Authors:	**Campitiello M.G.**, Ettori S., Lovisari L., Bartalucci I., Rasia E., Rossetti M. et al.