

## Internal NIKA referee report

**Paper:** “Sub-structure and merger detection in resolved Sunyaev-Zel’dovich images of distant clusters”

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### General main comments

This paper describes the application of substructure enhancement filters to NIKA Compton parameter maps of distant clusters in order to reveal substructures and/or pressure discontinuities in the intracluster medium (ICM). The authors start by a detailed description of the methodology and its application to hydrodynamical simulations. The latter are used to identify features in the filtered maps that would trace the presence of substructures or pressure discontinuities related to merging events. They also consider systematic effects in the filtered maps coming from the data processing filtering, the non-gaussianity of the noise, and the presence of foreground emission. Finally, they perform the analysis of the NIKA cluster sample, which consists of 6 clusters in total.

I find the paper particularly interesting and innovative. The analysis presented in the paper is a first step towards identifying the dynamical state of clusters prior to cosmological analyses. As indicated by the authors this kind of analysis is particularly well adapted for the future NIKA2 SZ observations and it will most probably be part of the NIKA2 Large program pipeline. However, I think the paper needs some major modifications:

- 1) The discussion of the NIKA data prior to the description of the simulations will simplify the reading of the paper. In the actual version the simulation discussion relies often on the NIKA data section.
- 2) To better understand the discussion it would be interesting to have a figure showing the tSZ maps, the GGM and DoG filtered maps for the NIKA data. In the current version, the reader needs to go back and forward from figure 6 to figure 7. I also believe that including a grid in the figures will help identifying the position of the discussed features.
- 3) I do not understand why there is a specification discussion of the three clusters for which there is no significant detection of substructures and/or pressure discontinuities. This is probably related to the organization problem mentioned in 1). It would be clearer if the NIKA sample is described in details in a first section and then the results are discussed after the simulation results.
- 4) The results on the simulations, section 3, are mainly qualitative. I understand why this is the case and I am not asking for detailed quantitative results. However, few things could be done to clarify them as they are used to interpret the results in the NIKA data:
  - a) sometimes in the discussion you refer to mass, X-ray, velocity and other maps that are not present in the paper. It might be interesting to give in the appendix the main simulation maps needed to understand the paper discussion
  - b) the definition of the main features is not always obvious for the reader as you are not using a standard approach. It would be interesting to clarify the definitions by indicating different features directly in some of the figures
  - c) a summary of the main results of the discussion should be introduced at the end of section 3. It would be good to associate the observed features to the physical cause

5) I am glad to see that you have added a full section to discuss systematic induced by the processing of the data, the noise properties and background/foreground emissions. While the latter is quite clear the other two are a bit confusing. In particular some of the noise properties of the filtered maps can be inferred analytically (or at least conceptually): for example in the case of the GGM filter we expect a noise bias in the results and so different S/N regimes. These are given in the text but the discussion is a bit elliptical. Same for the transfer function, which convolves the input signal. If you want we can directly discuss on how to clarify this.

6) The discussion on the NIKA data results is most often qualitative. There is no problem with this. However, I do think we can use terms like: “in very good (excellent) agreement” ... to qualify the results. Obviously it would be great to have a quantitative measure of how plausible the identified feature is but I am not sure this can be done easily. A general discussion on this issue may be of interest in the paper and also across the NIKA2 SZ group. X-ray people may have a much clearer view than myself. In some particular cases like when indicating the relative position of the X-ray, SZ, observed feature center, you may want to quote distances and uncertainties. In the case of the presence of two sub-structure you may want to indicate the SNR of the peak of each and the distance between the two. Looking at the figures I have the impression that there is some interest in correlating the GGM and DoG maps, Xray and tSZ maps, but this probably needs much more investigation. Finally, distinguishing between outside ridges (in merging systems) and inner circular patterns (more relaxed clusters) is sometimes not obvious without some kind of distance measurement with respect to the extension of the cluster – you may want to add some comments on this both for the simulations and the NIKA data results.

7) Section 6 is a bit weak to me. Some of the contents should be more adequate for the introduction (mainly first two paragraphs). I would reserve this section to the discussion of the NIKA2 data assuming you add NIKA data section prior to the simulations.

### **Detailed comments**

We include a scanned version of the annotated pdf file for more detailed editing and language comments. The annotated pdf includes also more specific comments on some the section and on the figures.