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Deep Learning Generative Models to Infer Mass Density Maps from SZ, X-ray and Galaxy Members Observations in Galaxy Clusters

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In our previews works, e.g., arXiv:2209.10333, deep learning techniques have succeeded in estimating galaxy cluster masses in observations of Sunyaev Zel'dovich maps, e.g. in the Planck PSZ2 catalog and mass radial profiles from SZ mock maps. In the next step, we explore inferring 2D mass density maps from mock observations of SZ, X-ray and stars using THE THREE HUNDRED (The300) cosmological simulation. In order to do that, we investigate state-of-the-art deep learning models that have been proven to be successful for image generation in multiple areas of research including astrophysics and medical imaging. These models are conditioned to observations, e.g. SZ maps, to generate the most likely matter 2D distribution given our dataset, composed of around 140 thousand mock maps from The300. We show that these models can successfully infer the 2D matter distribution with a scatter of around 14% in their pixel distribution and reproduce the matter power spectrum when comparing the generated maps with the ground-truth from the simulations. One of the main advantages of these generative models, is that they can effectively combine several inputs views and extract the useful features of each of them to infer mass density maps. By combining SZ, X-ray and stars in a multichannel approach, the scatter is reduced by a factor of 2 in comparison with the scatter that is computed when considering only the single-view models.

The next natural step of this project is to apply DL models on high resolution SZ observation, such as NIKA2, SPT and ACT. However, mock images needed for training deep learning models must fully take into consideration the observational impact of the telescopes in order to mimic real observations.

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