Searching for low-frequency radio-synchrotron emission from the filaments of the Cosmic Web with NenuFAR

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Level of the project: Masters

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Project title: Searching for low-frequency radio-synchrotron emission from the filaments of the Cosmic Web with NenuFAR

Description of project, including the aims and anticipated outcomes, what will be expected of the student, and any special qualifications required: The Cosmic Web houses some of the largest-scale structures in our Universe: galaxy clusters and filaments. The formation history of these structures may result in their hosting a hot gaseous component, which would account for the vast majority of the baryonic mass of the Universe. Furthermore, this component may emit radio-synchrotron emission which could be directly detected by radio instruments operating at the lowest frequencies. This detection is one of the key scientific goals of the SKA-Low, as it may help determine whether there could be a cosmological origin to large-scale (Mpc) magnetic fields, or whether they form strictly throughh astrophysical processes (e.g. structure formation, AGN activity).

This project consists of imaging data taken with an SKA precursor operating at very low frequencies, the NenuFAR telescope located near the village of

Nançay, France. This is a very sensitive array with unusual observational properties (low resolution, large field of view, high sensitivity), which makes it an ideal test-bed for next-generation radio interferometry at the lowest frequencies. The candidate will reduce NenuFAR data taken as part of NenuFAR's Cosmic Filaments and Magnetism Long-Term project. The resulting images will be analysed and cross-matched with the known objects in the vicinity of the clusters. This may result in a publication in a peer-reviewed scientific journal, time permitting.

Skills required: The student is expected to show interest in radio-interferometric data reduction as well as good skills in Python programming. The student will be taught the use of reduction software such as `DP3` and `wsclean`, but previous experience will be highly appreciated.

Data availability and resources: The NenuFAR data of this project will be made available to the student.

Timeline: the project timeline is envisioned as:

- Literature review: first two months
- Data reduction and imaging: next six months
- Thesis/paper writing: last four months

The data reduction step includes everything from the student getting familiar with interferometric dataset structures, calibration and imaging software, and the creation of publication-ready images. If significant delays are incurred in the specific process of reducing the NenuFAR data, the existing NenuFAR pipelines will be deployed to ensure progress continues apace. These are relatively simple, however, and are therefore an excellent pedagogic exercise for a Masters-level student to reproduce. This will ensure that the best-case scenario will result in the candidate being proficient in radio-interferometry data handling (a valuable skill to continue working in research in radio astronomy, should they wish to do so); a worst-case scenario will result in the candidate being familiarised with the data and software without risking their ability to achieve results on schedule.