Report from the Short Term Mission – STM

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RadioNet has received funding from the EU's Horizon 2020 research and innovation programme under the grant agreement No 730562

Report:

1. Topic

- Please describe briefly the topic of the performed visit addressing its relevance to the RadioNet goals.

Apertif is a new phased-array feed (PAF) for the Westerbork Synthesis Radio Telescope (WSRT), dramatically increasing its field of view and turning it into a survey instrument. A key part of the Apertif project is the Apertif Long Term Archive (ALTA), which is a RadioNet infrastructure that will serve data products from the Apertif surveys to the broader (including RadioNet) community. A key aspect of ALTA is that it is not only an archive for raw data, but will also serve higher level scientific data products produced by the Apertif surveys. ALTA's provision of higher level data products to the community is a fundamental part of its mission. The backbone higher level data products of the imaging surveys are images and data cubes served on a defined grid over the sky. While the infrastructure to create images and cubes from individual compound beams is in place, making mosaics is more complicated. In order to create these data products, new mosaicking techniques have to be implemented due to the intrinsic nature of a phased array feed (PAF). In particular, compound beams have correlated noise, which needs to be taken into account when mosaicking adjacent beams. In addition, different compound beams may have different primary beam shapes and hence require a different correction.

2. Proposed and Performed Work

- Describe the goals of your visits and achieved work. Specify the highlights and occurred problems, providing the solution.

During the one month visit, Dr. Pisano shared his knowledge of phased array feed data reduction, specifically how to mosaic covariant images, obtained from his own experiences and the broader literature, with the Apertif team at ASTRON. He implemented a mosaicking algorithm using Jupyter notebooks and Miriad tasks within the Apercal framework that properly accounts for the shapes of the different compound beams and the measured correlation between them. This algorithm was successfully tested with data from another PAF system, ASKAP. During the visit, ASTRON staff measured the compound beam shapes, but results arrived only at the end of the stay and were not included in the final code. Similarly, code exists to measure the noise correlation between the compound beams, but Dr. Pisano ran out of time to generate a full noise correlation matrix needed for mosaicking. Fortunately, the code was designed to easily include newly measured correlation matrices and beam shapes. One month was not enough time to deploy this code in a robust manner as part of the Apercal pipeline, but the existing framework should be easy to import once local resources become available.

Proper mosaicking is essential to maximize the scientific output of the Apertif surveys and ALTA for a number of reasons. While science could be done with individual beams of Apertif, the sensitivity is dramatically improved when overlapping beams are properly combined. Further, the ability to do science on extended sources, larger than a few arcminutes in extent, requires combining data from neighboring Apertif beams both to see all of the emission and to recover the emission on all spatial scales. Ongoing work on imaging the Andromeda galaxy, with a diameter of 5 degrees, demonstrates these benefits.

3. Cross-Disciplinarity

- Please specify the cross-disciplinary fertilization; especially transfer of scientific knowledge to the next generation of scientists and engineers.

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The algorithms developed for Apertif can easily be used for other PAF data around the world. Dr. Pisano is working with students in the US to properly account for beam shapes and noise correlation when making single-dish maps with the Focal L-band Array for the Green Bank Telescope (FLAG) PAF. This work will also be directly applicable to the PAF being developed for Arecibo, ALPACA (Advanced cryogenic L-band Phased Array Camera for Arecibo).

4. IMPACT

- Please explain the impact on collaboration of European radio astronomy engineers with industry and a wider community (scientific, technical, industry).

The code that was developed will enable European astronomers to work directly with higher-level data products, specifically large area mosaics. This will make it possible to study radio emission on larger scales than is feasible with single beam observations and allows for the full scientific exploitation of Apertif data in ALTA. The code developed is freely available from GitHub at https://github.com/apertif/commissioning.

5. PUBLICATIONS

- in case of future publication - please provide additional information: place & date. Remember to insert the acknowledgment of the RadioNet support:

The project leading to this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

At present, there have been no publications resulting from this work. An ongoing study of the neutral hydrogen in the Andromeda galaxy (M31) over the full 3 degree extent of the galaxy disk should result in a publication in the near future.