



**Wide-field radio astronomy and the life-cycle of radio galaxies:
combining LOFAR and Apertif for resolved spectral index images**

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The wide-field capabilities of new radio instruments are now providing the community with an unprecedented coverage of the sky and images at different frequencies, which have both high spatial resolution and high sensitivity to diffuse emission. All this opens up new exciting possibilities for the study of radio AGN and their lifecycle. The combination of multi-frequency surveys gives the possibility of deriving spatially resolved spectral index images which can be used to identify elusive objects in extreme phases of their life, and/or the spectral ages of the electron populations. Supermassive black holes at the centers of galaxies can cycle through periods of activity and of quiescence. Characterising this duty-cycle of active galactic nuclei (AGN) is crucial for understanding their impact on the host galaxy. For radio AGN, their evolutionary stage can be identified by a combination of morphological and spectral properties.

I will present recent results illustrating the possibilities offered by combining the newly available images at 1400 MHz from the surveys of Apertif (APERture Tile In Focus) phased-array feed system installed on the Westerbork Synthesis Radio Telescope, and the LOFAR surveys at both 150 MHz (HBA) and 60 MHz (LBA).

The deep, high spatial-resolution images of the LOFAR surveys at 150 MHz provide the necessary sensitivity to low surface-brightness emission and the possibility of statistical studies of radio galaxies in crucial phases of their life, like remnants and restarted sources. The spatially resolved (on ~ 12 arcsec resolution) spectral information obtained by combining them with the Apertif images allows to explore the relatively low radio frequencies (150-1400 MHz) and provides an effective way to find such elusive objects and to date their emission. The addition of the 60 MHz images from the LOFAR LBA surveys (now on-going), allows to further expand the results.

We have used this combination to find – based on extreme spectral properties - radio galaxies in the dying and restarted phase. Our study, limited so far to the Lockman Hole region, reveals a number of them. Their occurrence and properties allow to start constraining the duration of the 'on' (active) and 'off' (dying) phase and compare the results with models of the evolution of radio galaxies. I will present the results of our study and the plans for future expansions.