3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

The Apertif Imaging Surveys

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1 Extended Abstract

Apertif (Aperture Tile in Focus) is a new phased-array feed for the Westerbork Synthesis Radio Telescope (WSRT), operating at 21 cm with 300 MHz bandwidth and providing forty instantaneous overlapping beams on the sky. The significant increase in field of view turns WSRT-Apertif into a natural instrument for surveys. As of 1 July 2019, Apertif has been dedicated to a large scale survey program, consisting of an imaging survey with a wide and deep tiers plus a time-domain survey. The imaging surveys provide simultaneous sensitive radio continuum, polarization and spectral line data with angular resolution of $\sim$15"x15"/sin(δ) and spectral resolution up to 12.2 kHz. The wide tier covers $\sim$2200 square degrees of northern sky, and the deep tier provides $\sim$3x the depth covering 135 square degrees in focused regions selected for multiwavelength data coverage and interesting large-scale structure. At a single Apertif observation, the continuum images reach a sensitivity better than 40 uJy/beam providing $\sim$3x the angular resolution and $\sim$10x the sensitivity compared to the NRAO VLA Sky Survey (NVSS). The spectral line data are focused on the detection of neutral hydrogen (HI), and provide more than 10x higher angular resolution compared to the state-of-the-art ALFALFA survey, which utilized the single dish Arecibo radio telescope. We review the Apertif imaging surveys and highlight the first data release, which covered the first year of survey observations. Processed data products, including continuum multi-frequency synthesis (mfs) images, Stokes V mfs images, Stokes Q & U cubes, and uncleaned line cubes, along with the primary beam models for each Apertif compound beam, were released via the Virtual Observatory interface (https://vo.astron.nl/). We present a new approach to the primary beam correction based on Gaussian process regression and NVSS data. The method does not imply any a priori assumptions or parametrization, and can be used to probe the compound beam shapes for any given observation date. It allows us to perform the corresponding flux correction and compile continuum source catalog which contains $\sim$250,000 sources. We introduce the catalog and highlight some interesting scientific applications including a search for radio transients via comparison to the NVSS catalog and the spectral index distribution from comparison to LOFAR data. Finally, we discuss plans for future data releases of Apertif.