1.4 GHz continuum imaging of an extended object with different ATCA configurations: The starburst galaxy NGC 1511

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Abstract

I show here the characteristics of data obtained with different configurations of the ATCA: A synthesis with the 375-m configuration, one with a 6-km configuration, and a multi-configuration dataset, all of the same target, NGC 1511.

1. Introduction

NGC 1511, a relatively nearby edge-on starburst galaxy, is an extended object, i.e., resolved by the ATCA. We are obtaining images to gain information on the distribution of emission from both its disk and also its halo that has been detected by us.

2. Interferometers as Fourier filters

The angular resolution of an interferometer (its synthesised beam) is the Fourier transform of the coverage of the 2-element baseline tracks in the uv-plane of the synthesised telescope.

Interferometers with short baselines sample extended structures on the sky, while synthesis telescopes with long baselines sample compact structures. A combination of visibilities from both compact and large configurations will combine sensitivity to extended emission from the short baselines with the resolving power of the long baselines.

3. Imaging with a compact configuration – the 375-m array

- **uv–coverage**

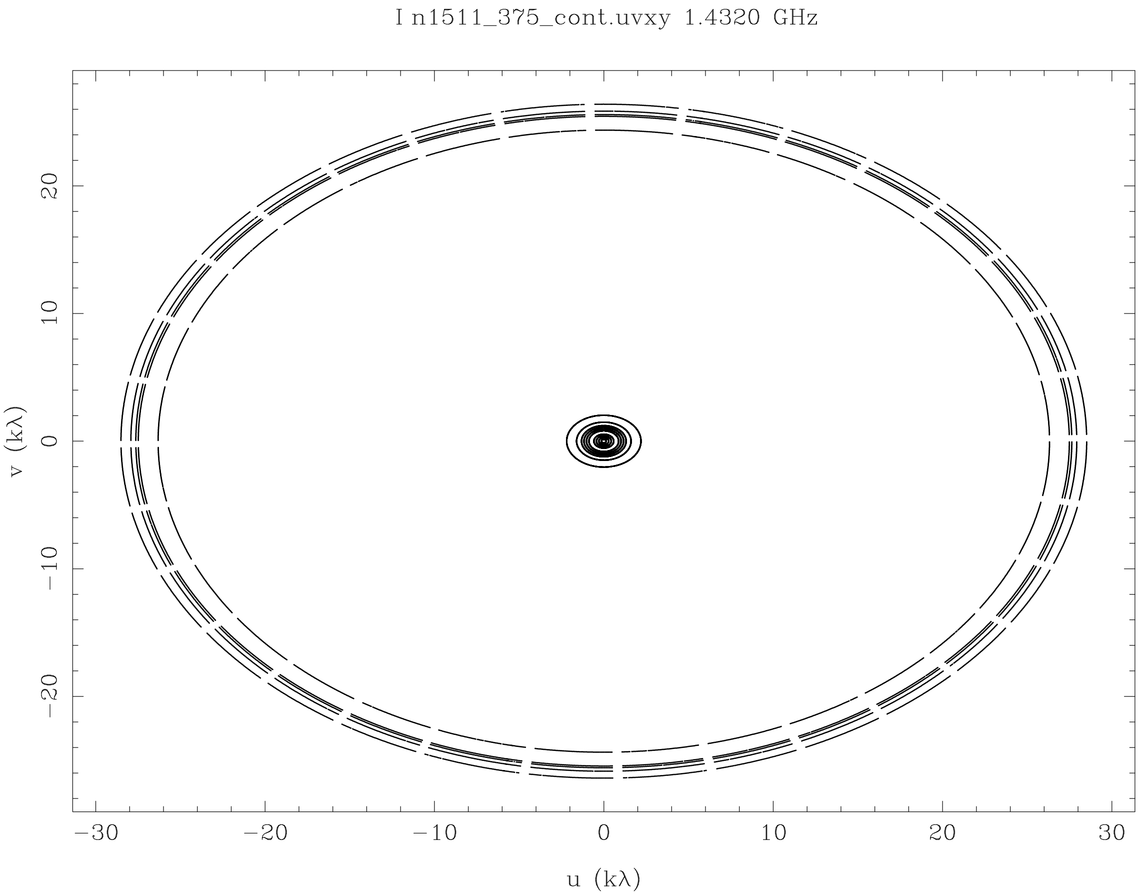

Figure 1: ATCA 375-m configuration uv coverage for a complete 12-hour synthesis.

Baseline lengths are most naturally described in units of wavelengths, λ. The "uv-plane" is the surface of our synthesised large telescope.

The 375-m configurations provides very short baselines (central tracks). The long baselines with antenna 6 cannot be used for imaging, because it is not possible to synthesise such a huge telescope without having information in the empty areas.

- **"dirty" image**

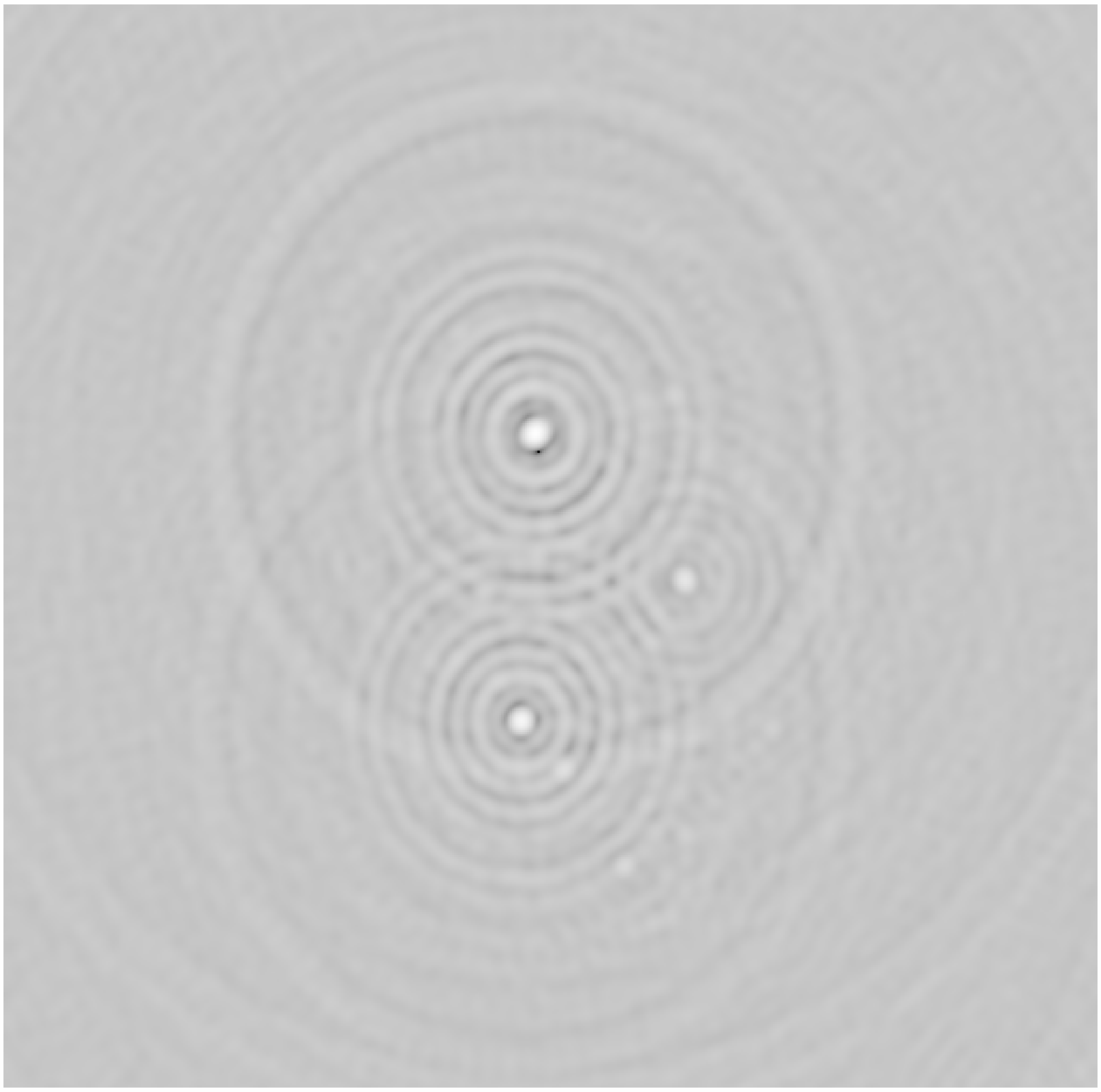

Figure 2: ATCA 375-m configuration dirty image of NGC 1511 and its surroundings; the field of view is ca. 30 arcmin across.

The uv-coverage (central area only!) displayed in Fig. 1 leads to a low-resolution image, still with the characteristics of the interferometer beam in it, a so-called "dirty" image.

It has low resolution, but high sensitivity to extended emission.

- **“clean” image**

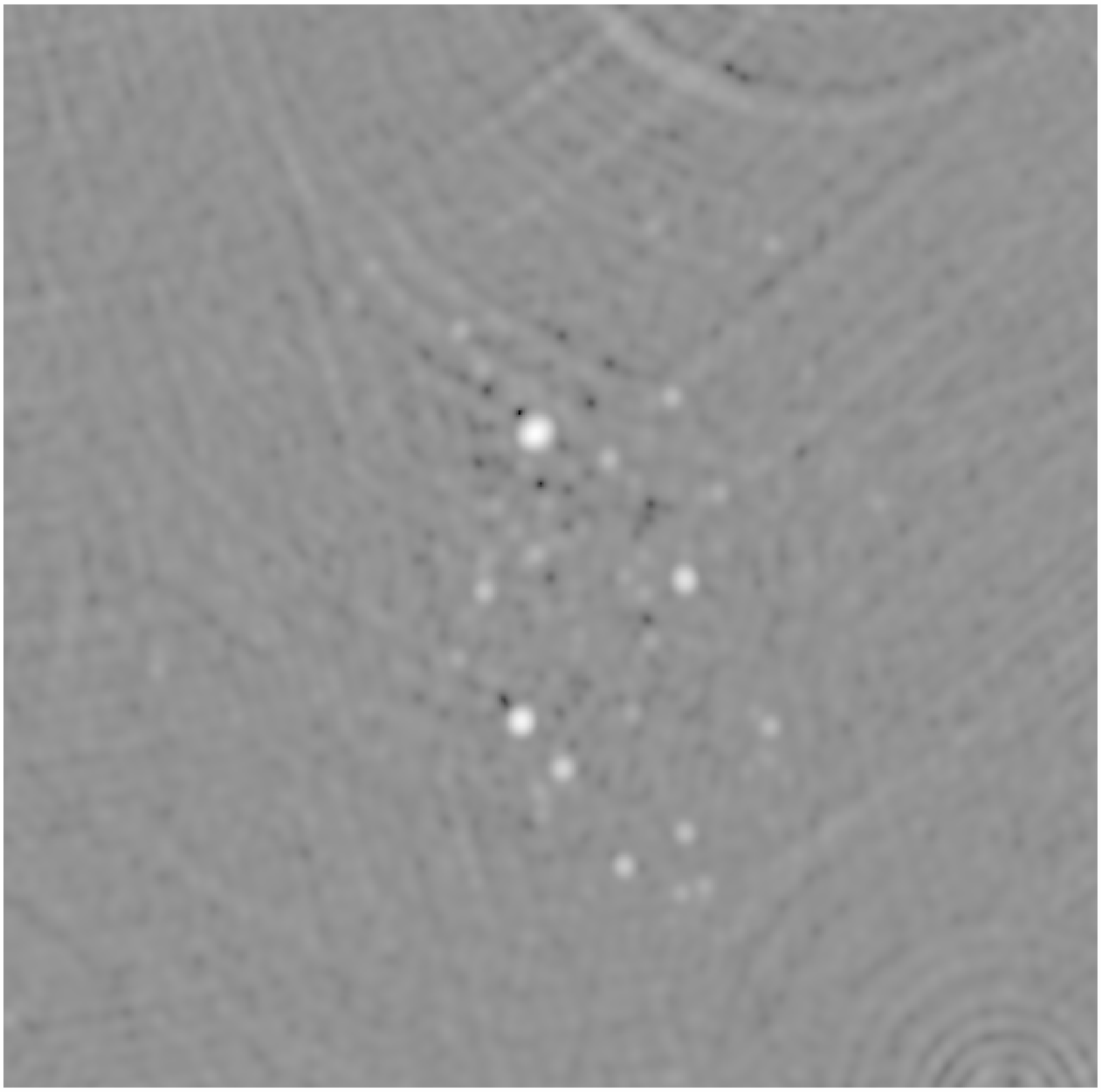

Figure 3: ATCA 375-m configuration cleaned image of NGC 1511 and its surroundings.

Correction for the effect of incomplete sampling (“clean”ing) leads to an improved low-resolution image. Note that the image is not final yet; several artefacts can still be seen that will be removed at a later stage of the data reduction.

4. Imaging with a large configuration – the 6-km (A) array

- **uv–coverage**

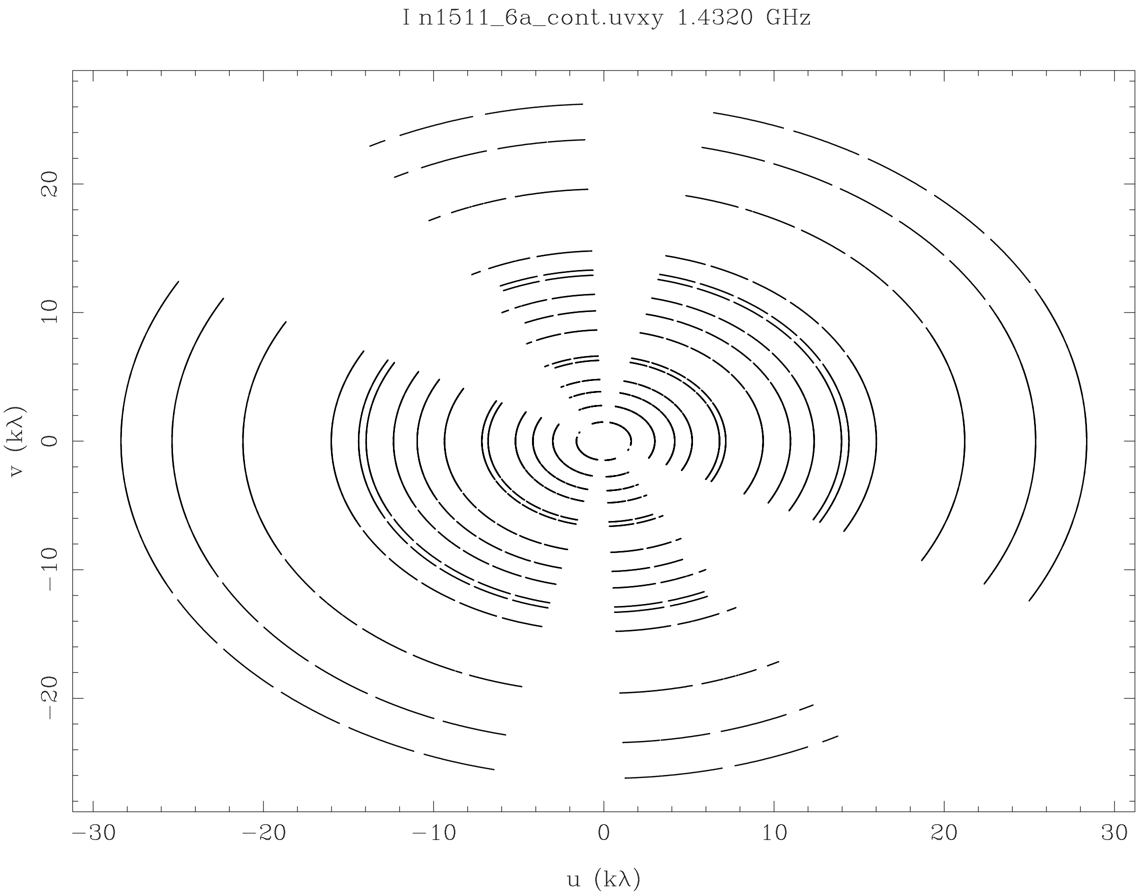

Figure 4: ATCA 6-km configuration uv coverage for an incomplete synthesis (less than 12 h of observing time).

The 6-km array configurations provide long baselines, which produce images of high resolving power, but lack sensitivity to extended emission because of the empty central area of the uv-plane.

- **“dirty” image**

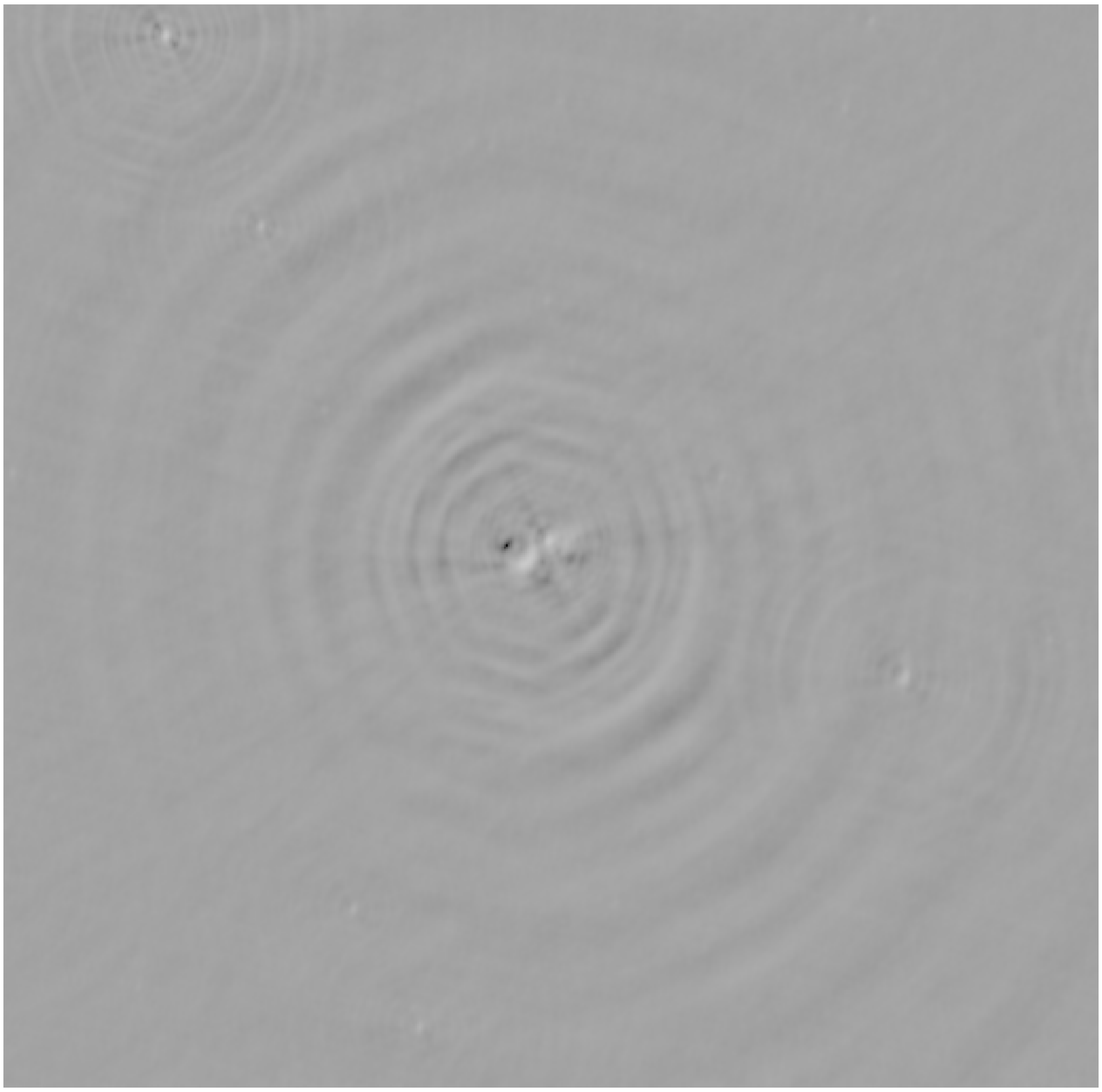

Figure 5: ATCA 6A configuration dirty image of NGC 1511 and its surroundings. Note: The field of view displayed here is smaller than for the 375-m configuration (otherwise one would not see the details).

The uv-coverage displayed in Fig. 4 leads to a high-resolution dirty image as shown in Fig. 5. Substructure becomes visible not only in the primary target, NGC 1511, but also in several background sources (e.g. the one to the right).

- **“clean” image**

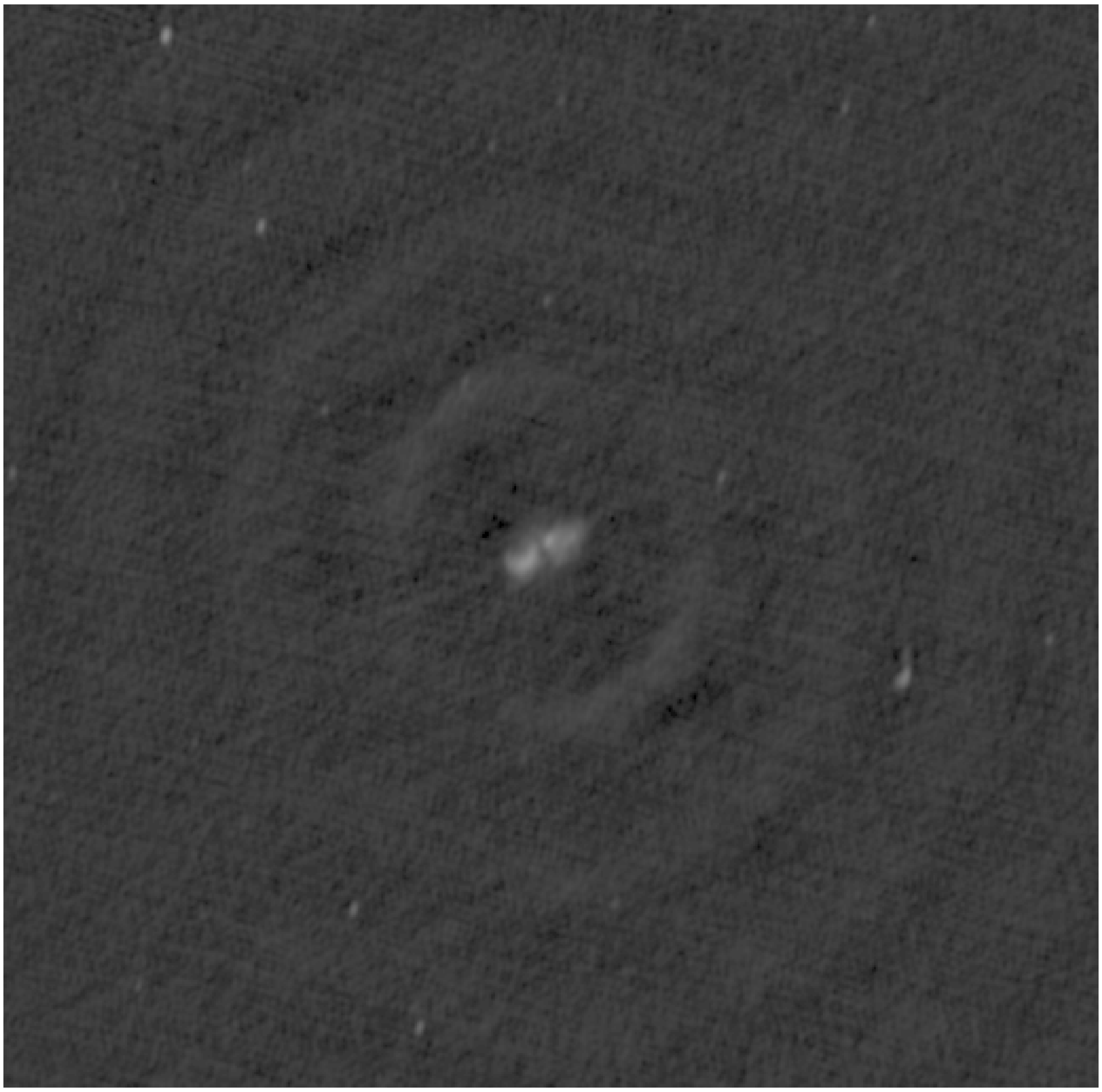

Figure 6: ATCA 6A configuration cleaned image of NGC 1511 and its surroundings.

Cleaning leads to an improved high-resolution image. However, NGC 1511 appears to lie in a negative “bowl”, surrounded by a concentric ellipsoidal pattern. This is due to the fact that short spacings are missing.

5. Combined array data: 7 different configurations

- **uv–coverage**

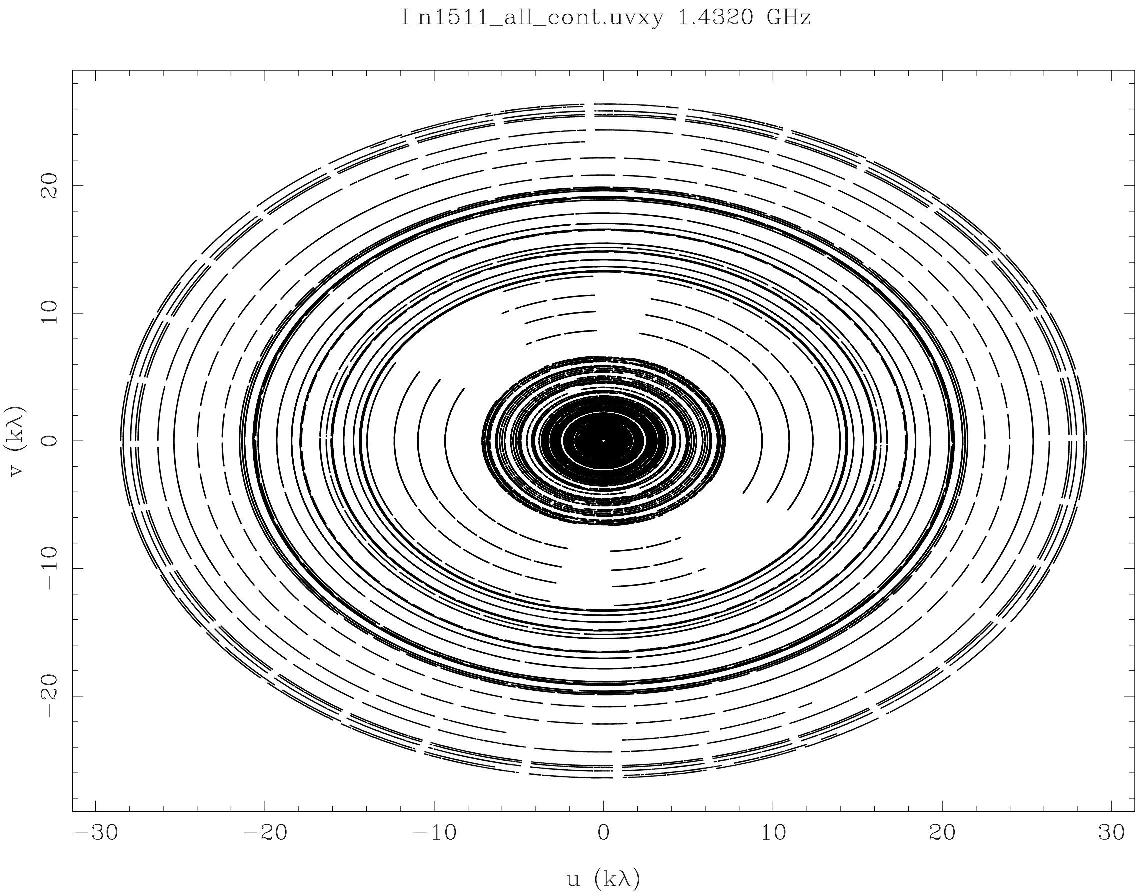

Figure 7: Observations obtained with 7 different configurations of the ATCA illustrate how the uv-plane is filled, synthesising an almost completely filled aperture.

Densely filled uv-plane using 7 configurations, with few sparsely populated areas in between. Such data lead to a very well-defined beam pattern producing high image quality.

- **“dirty” image**

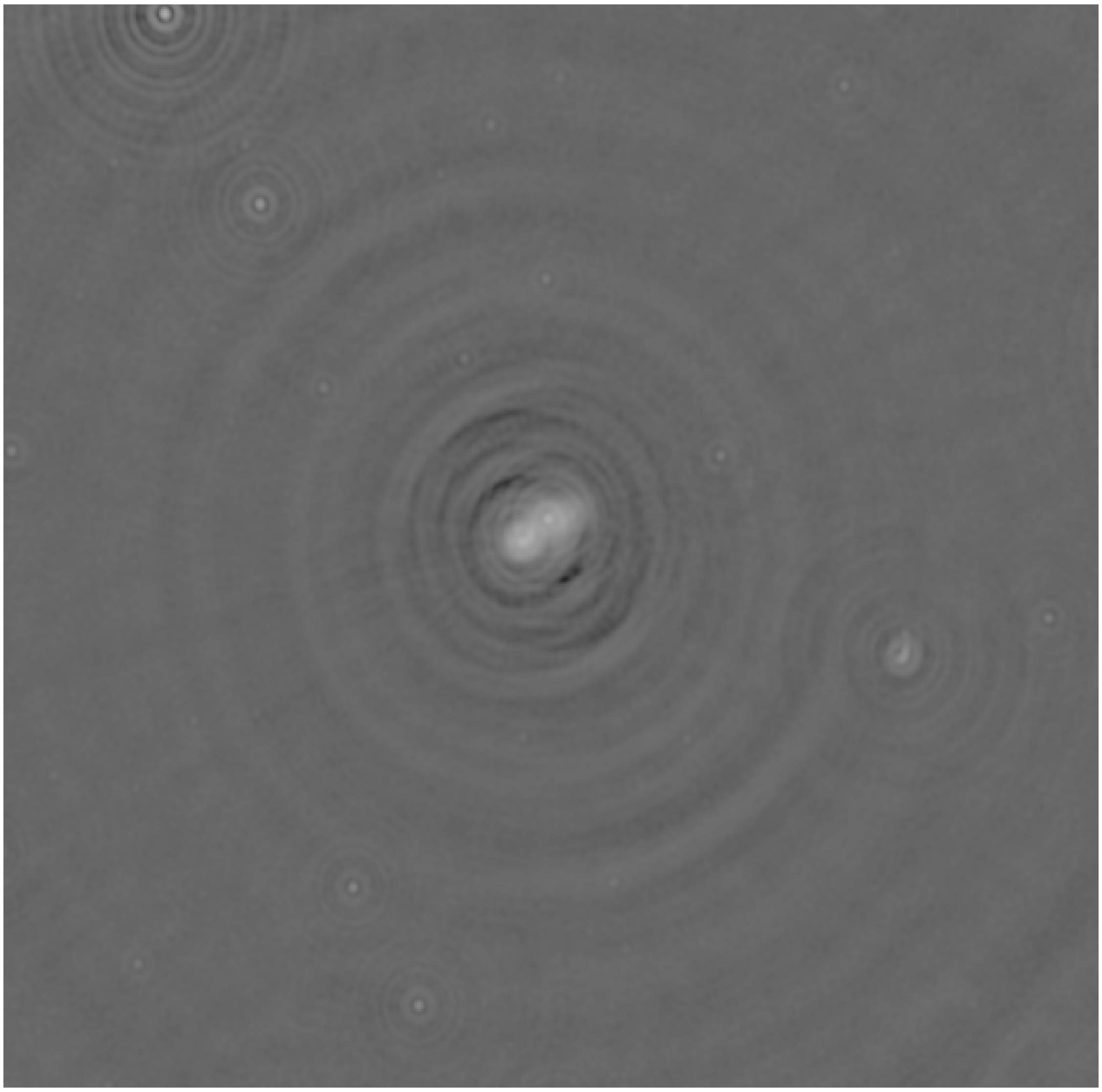

Figure 8: ATCA multi-configuration dirty image of NGC 1511.

Now the image “flatness” improved drastically, even before cleaning, and the sensitivity has increased because millions of visibilities enter the image.

- **“clean” image**

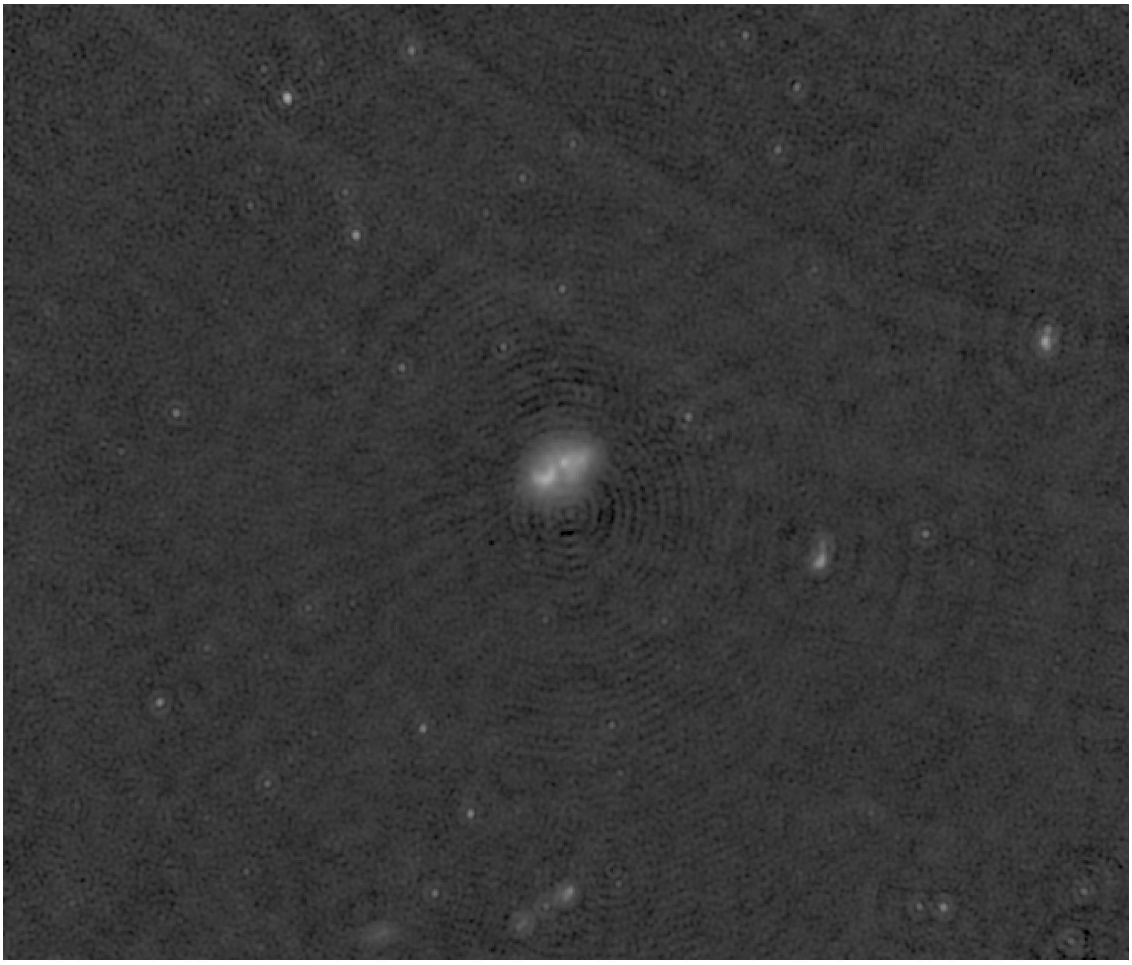

Figure 9: ATCA 6A configuration cleaned image of NGC 1511 and its surroundings.

Now the full source flux, both extended plus compact sources, is recovered by the observations. A residual error is visible in the form of concentric ellipses around the phase centre, which was placed 1 arcmin south of the galaxy centre.

- **displaying only features above a certain flux density level**

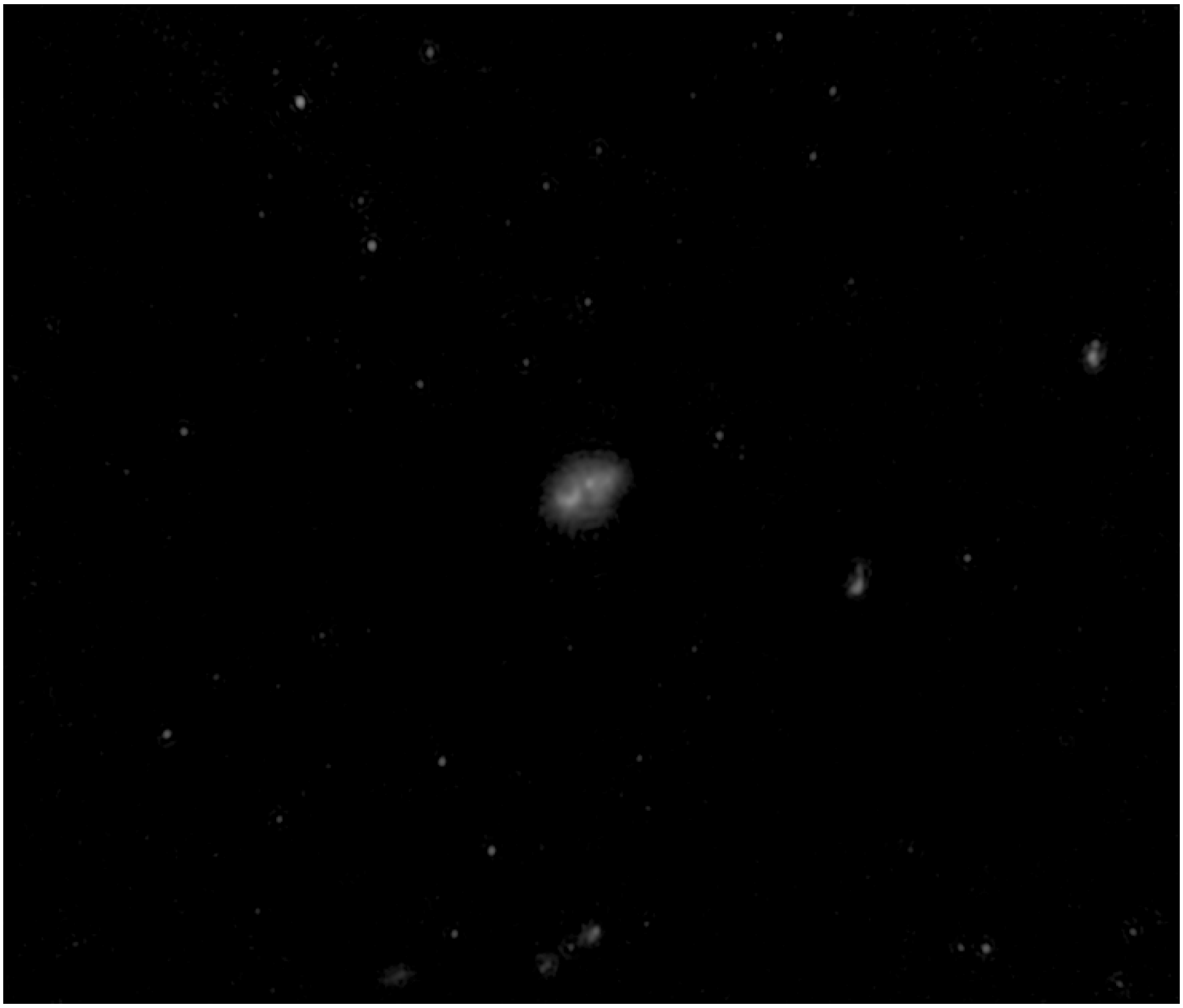

Figure 10: Image of NGC 1511 and its surroundings above the level of systematic errors visible above. Almost all the features visible in this display can be considered to be real.

Although already very sensitive, the quality of the data still needs to be improved in order to remove the various systematic errors that can be seen. However, for the time being one can look at "real" emission features by chosing a colour lookup table that hides the low-level errors.