Basic Imaging Tutorial

D. Jacobs & the ASU HERA Team
Arizona State University
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Note: This is adapted from a course given at the HERA CHAMP Bootcamp, at Cal Poly Pomona, June 2017 (and in Santa Fe in 2018 and 2019)

Here we will image some VLA data of a supernova remnant. Progressively add data to see how the image quality improves, seeing in practice the effects of uv coverage by increasing the number of antennas, and then the amount of time.

Caveat: We will be using CASA, an imaging package developed by the National Radio Astronomy Observatory for use with radio telescopes like the VLA. Because of the unique nature of HERA, many collaboration members do not use CASA.

Caveat: We are using VLA data because HERA is still under construction, we're still working out how to calibrate it.

Caveat: The VLA data here are stored in "ms" files. Other formats you will see in the collaboration are uvfits which will end in ".uvfits," uvh5 which will end in ".uvh5," and miriad which will end in… you guessed it: ".uv" (or, more likely, with a more complicated filename like .uvcRRE).

Let's leave the real world behind for a moment and use nicely calibrated data to make images of something cool.
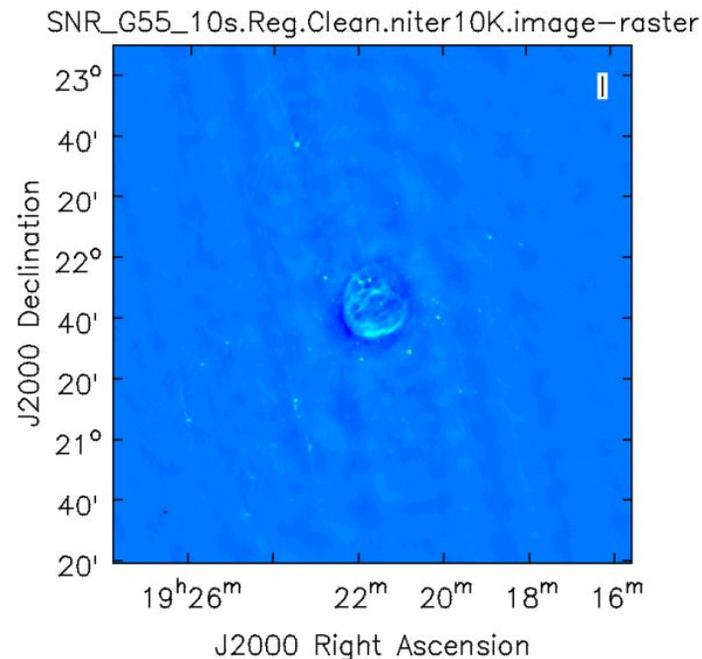
Setup and get data
note that the CHAMP students were previously set up with laptops that had casa preinstalled

The goal of this tutorial is to examine the various ways "aperture synthesis" can be affected. The quality of an image has a direct relationship to the amount and kind of samples of the fourier plane.

UV density/ antennas

Adding VLA antennas. Start with a single baseline.

bash $ cd ~/data/casa_tutorial
bash$ casa
casa> infile = '/data4/HERA_Crash_Course/data/SNR_G55_10s.calib.ms'
#Make a uv plot of a single baseline (it will be kind of silly)
casa>plotms(vis=infile, selectdata=True, timerange='05:48:18~05:48:28', spw='1:32', antenna='0&4', xaxis='u', yaxis='v')
#make a single baseline image
casa> tclean(vis=infile, imagename='SNR_G55_10s.2ant', weighting='natural', imsize=540, cell='8arcsec', niter=0, interactive=False, antenna='0&4', timerange='05:48:18~05:48:28', spw='1:32')
casa> viewer('SNR_G55_10s.2ant.psf')#look at the psf
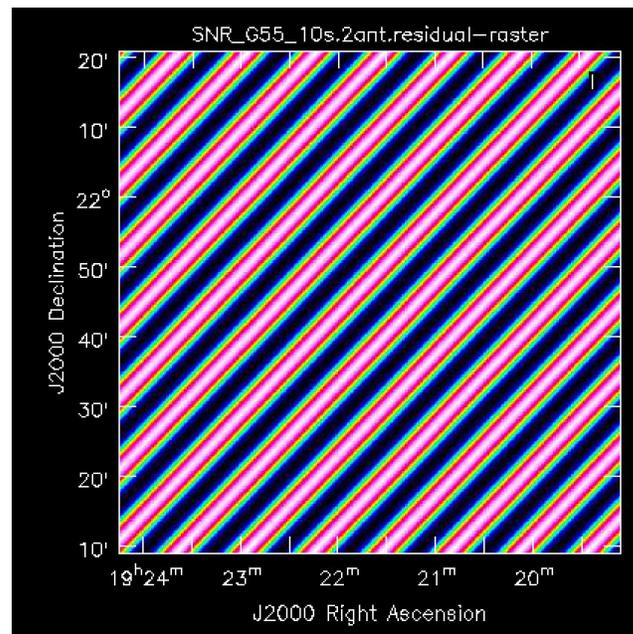
casa> viewer('SNR_G55_10s.2ant.residual')#look at the image
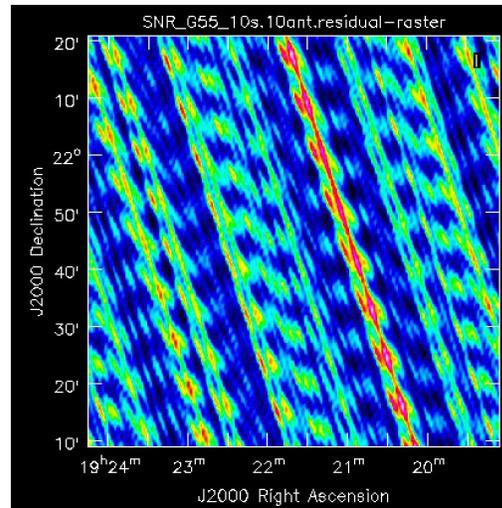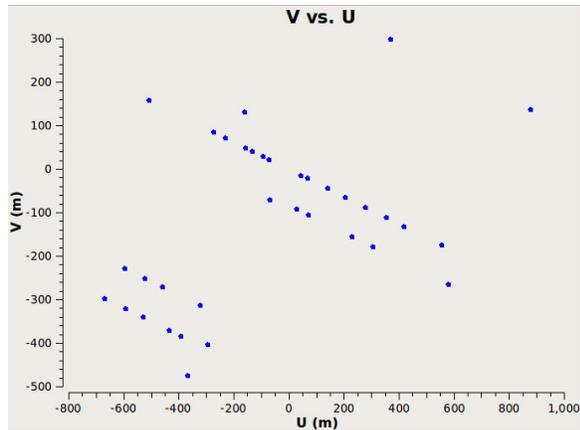

Now 10 antennas.
#make a uv plot of 10 antennas

casa>plotms(vis=infile, selectdata=True, timerange='05:48:18~05:48:28', spw='1:32', antenna='0~10&', xaxis='u', yaxis='v')
#Make an image with 10 antennas
casa> tclean(vis=infile, imagename='SNR_G55_10s.10ant', weighting='natural', imsize=540, cell='8arcsec', niter=0, interactive=False, antenna='0~10&', timerange='05:48:18~05:48:28', spw='1:32')
casa> viewer('SNR_G55_10s.10ant.psf')#look at the psf

casa>
viewer('SNR_G55_10s.10ant.residual')#look   at
the image

The full array!
#make a uv plot with all antennas
casa> plotms(vis=infile, selectdata=True, timerange='05:48:18~05:48:28', spw='1:32', xaxis='u', yaxis='v')
#Make an image with all antennas
casa> tclean(vis=infile, imagename='SNR_G55_10s.allant', weighting='natural', imsize=540, cell='8arcsec', niter=0, interactive=False, timerange='05:48:18~05:48:28', spw='1:32')
casa> viewer('SNR_G55_10s.allant.psf')#look at the psf
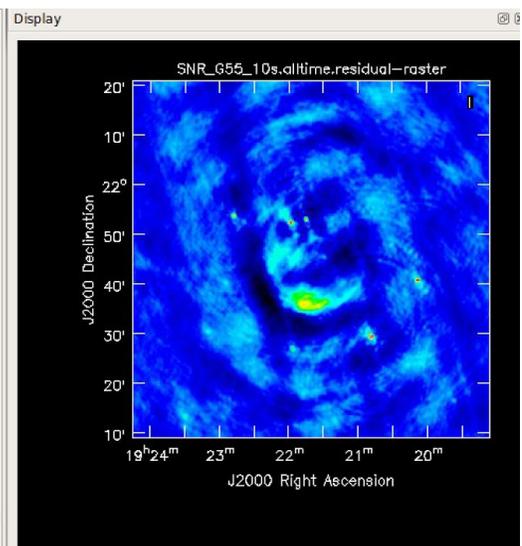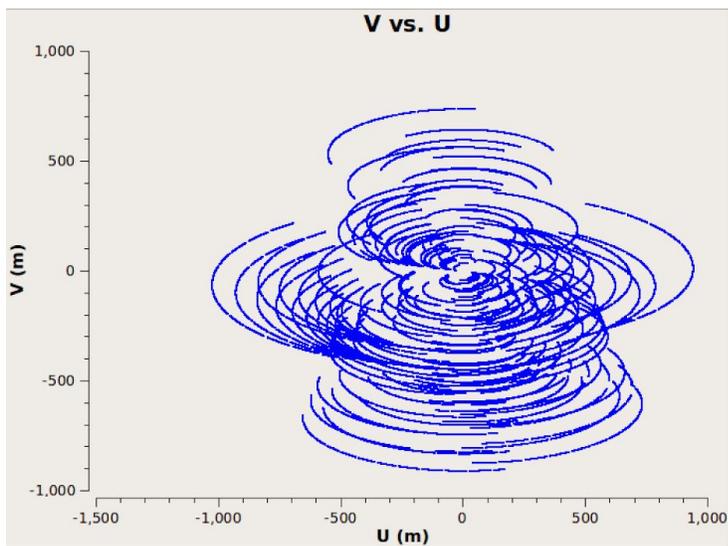casa> viewer('SNR_G55_10s.allant.residual')#look at the image
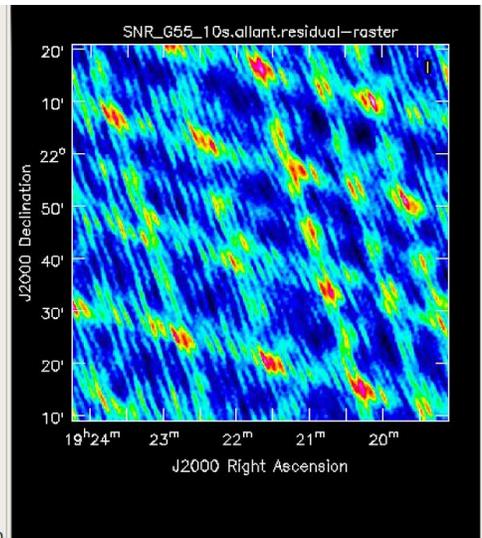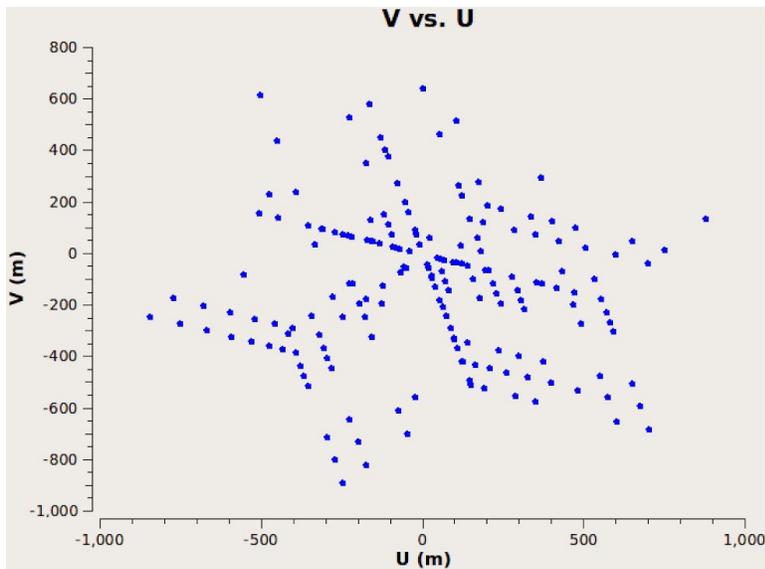
Time

#lets increase the amount of time data from 10 seconds to 9 hours
casa> plotms(vis=infile, selectdata=True, spw='1:32', xaxis='u', yaxis='v')
casa> tclean(vis=infile, imagename='SNR_G55_10s.alltime', weighting='natural', imsize=540, cell='8arcsec', niter=0, interactive=False, spw='1:32')
casa> viewer('SNR_G55_10s.alltime.psf') #look at the psf

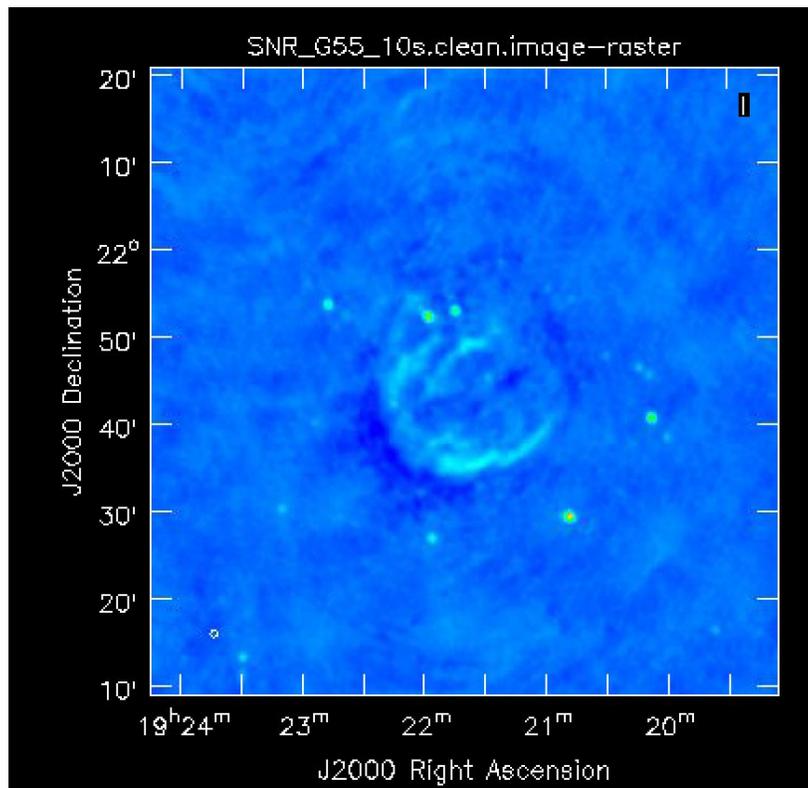casa> viewer('SNR_G55_10s.alltime.residual') #look at the image

Clean

Deconvolves or removes the psf.
#pause for a short explanation of what clean is
casa> tclean(vis=infile, imagename='SNR_G55_10s.clean', weighting='natural', imsize=540, cell='8arcsec', niter=10000, interactive=False, spw='1:32')
casa> viewer('SNR_G55_10s.clean.psf') #look at the **dirty image**
casa> viewer('SNR_G55_10s.clean.image') #look at the **cleaned image**

casa> viewer('SNR_G55_10s.clean.residual') #look at the **residual image**

Source material for imaging workshop
https://casaguides.nrao.edu/index.php/VLA_CASA_Imaging
https://casaguides.nrao.edu/index.php?title=VLA_Continuum_Tutorial_3C391