Summary – Week 1

Sarrvesh S. Sridhar & Mubela Mutale

ASTRON & U. of Hertfordshire

July 5, 2019

Overview

- Why do we need radio interferometry?

Overview

- Why do we need radio interferometry?

$$\text{Resolution,}\theta = \frac{\lambda}{\text{D}} \tag{1}$$

- Instead of bigger dishes, we build longer baselines.

Overview

- Why do we need radio interferometry?

$$\text{Resolution}, \theta = \frac{\lambda}{\text{D}} \tag{1}$$

- Instead of bigger dishes, we build longer baselines.
- If we have N stations, how many baselines do we form?

Overview

- Why do we need radio interferometry?

$$\text{Resolution}, \theta = \frac{\lambda}{\text{D}} \tag{1}$$

- Instead of bigger dishes, we build longer baselines.
- If we have N stations, how many baselines do we form? N(N−1)/2 baselines

Overview

- Why do we need radio interferometry?

$$\text{Resolution}, \theta = \frac{\lambda}{\text{D}} \tag{1}$$

- Instead of bigger dishes, we build longer baselines.
- If we have N stations, how many baselines do we form? N(N−1)/2 baselines
- Instead of making a direct image of the sky, an interferometer simply fills the *uv* plane.

Overview

- Why do we need radio interferometry?

$$\text{Resolution},\theta = \frac{\lambda}{\text{D}} \tag{1}$$

- Instead of bigger dishes, we build longer baselines.
- If we have N stations, how many baselines do we form? N(N−1)/2 baselines
- Instead of making a direct image of the sky, an interferometer simply fills the *uv* plane.
- Apply **Inverse Fourier Transform** to get a representation of the sky.

ASTRON

Overview

- What happens if I remove high (spatial) frequencies in my *uv*-plane?

Overview

- What happens if I remove high (spatial) frequencies in my *uv*-plane?
  - Resolution of the image goes down.

Overview

- What happens if I remove high (spatial) frequencies in my *uv*-plane?
  - Resolution of the image goes down.
- What happens if I remove low (spatial) frequencies in my *uv*-plane?

Overview

- What happens if I remove high (spatial) frequencies in my *uv*-plane?
  - Resolution of the image goes down.
- What happens if I remove low (spatial) frequencies in my *uv*-plane?
  - Resolution remains the same.
  - Sensitivity to large scale emission is reduced/lost.

Overview

- What happens if I remove high (spatial) frequencies in my *uv*-plane?
  - Resolution of the image goes down.
- What happens if I remove low (spatial) frequencies in my *uv*-plane?
  - Resolution remains the same.
  - Sensitivity to large scale emission is reduced/lost.
- How did we do all this in Python?

Overview

- Before we can do **imaging**, we need to

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** - Plot the data in various ways.

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** - Plot the data in various ways.
- **flagmanager** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** - Plot the data in various ways.
- **flagmanager** - Create a copy of your FLAG table.

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** - Plot the data in various ways.
- **flagmanager** - Create a copy of your FLAG table.
- **fringefit** -

Overview

- Before we can do **imaging**, we need to **flag** and **calibrate** the data.
- **listobs** - Summary of the measurement set
- **flagdata** - Flag bad data
- **plotants** - Plot the antenna locations.
- **plotms** - Plot the data in various ways.
- **flagmanager** - Create a copy of your FLAG table.
- **fringefit** - Derive phase/delay corrections.

ASTRON

Calibration

Calibration

- Single-band or instrumental delays
- Multiband delays
- Bandpass calibration
- Elevation dependent gain calibration

Applying the corrections

- We apply the corrections using **applycal**
- Creates a new column called **CORRECTED_DATA**.
- Data size grows by a factor ~ 2.
- If we want, we can also split the data with **split**

ASTRON

Deconvolution

- From the lecture, we saw

$$\mathrm{I}_{\mathrm{True}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \tag{2}$$

Deconvolution

- From the lecture, we saw

$$\mathrm{I}_{\mathrm{True}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \qquad (2)$$

- But, we do not measure $V(u, v)$ for all values of u and v.

Deconvolution

- From the lecture, we saw

$$\mathrm{I_{True}}(l, m) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \tag{2}$$

- But, we do not measure $V(u, v)$ for all values of u and v.
- So, we define a window function $W(u, v)$

$$\mathrm{I_{Obs}}(l, m) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} W(u, v)\ V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \tag{3}$$

Deconvolution

- From the lecture, we saw

$$\mathrm{I}_{\mathrm{True}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \qquad (2)$$

- But, we do not measure $V(u, v)$ for all values of u and v.
- So, we define a window function $W(u, v)$

$$\mathrm{I}_{\mathrm{Obs}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} W(u, v)\ V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \qquad (3)$$

$$\mathrm{I}_{\mathrm{Obs}}(l, m) = \mathcal{F}^{-1}[W(u, v)\ V(u, v)] \qquad (4)$$

ASTRON

Deconvolution

- From the lecture, we saw

$$\mathrm{I}_{\mathrm{True}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \tag{2}$$

- But, we do not measure $V(u, v)$ for all values of u and v.
- So, we define a window function $W(u, v)$

$$\mathrm{I}_{\mathrm{Obs}}(l, m) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} W(u, v)\ V_{\mathrm{True}}(u, v)\ \mathrm{e}^{i2\pi(ul+vm)}\ \mathrm{d}u\ \mathrm{d}v \tag{3}$$

$$\mathrm{I}_{\mathrm{Obs}}(l, m) = \mathcal{F}^{-1}[W(u, v)\ V(u, v)] \tag{4}$$

$$\mathrm{I}_{\mathrm{Obs}}(l, m) = \mathcal{F}^{-1}[W(u, v)]\ \circledast\ \mathcal{F}^{-1}[V(u, v)] \tag{5}$$

ASTRON

Deconvolution

- From the previous slide,

$$\mathrm{I_{Obs}}(l, m) = \mathcal{F}^{-1}[W(u, v)] \circledast \mathcal{F}^{-1}[V(u, v)] \tag{6}$$

  - $\mathcal{F}^{-1}[W(u, v)]$ is called "dirty beam"
  - $\mathrm{I_{Obs}}(l, m)$ is called the "dirty image"
  - $\mathcal{F}^{-1}[V(u, v)]$ is the "true sky"

- The "dirty image" is the "true sky" convolved by the "dirty beam".

- To get the "true" sky image → we deconvolve our "dirty image" with the "dirty beam"