An Introduction to Radio Interferometry

5-1 An overview for interferometric data calibration

You can find relevant material on my personal webpage

NSYSU EMI Online Lecture Series Hauyu Baobab Liu (呂浩宇),
Department of Physics

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation

Nightmare

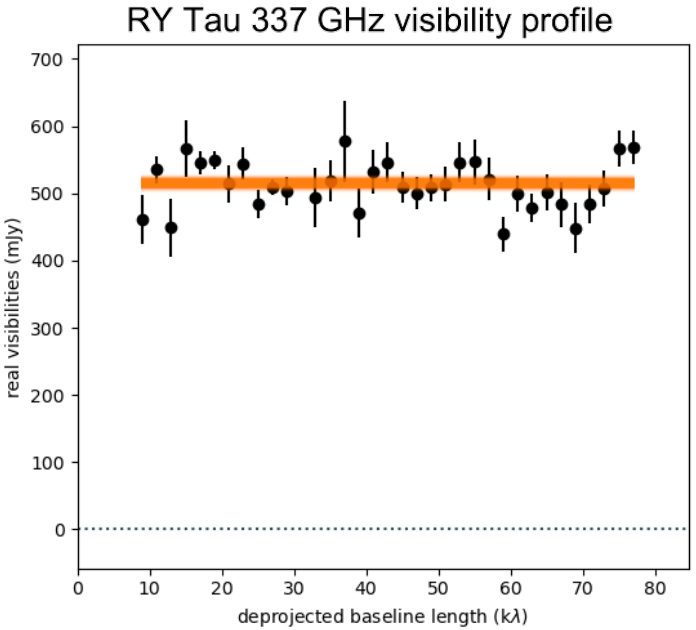
Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation
2. Calibrate out the systematic errors

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors



(Chung, Chia-Ying, Master's thesis, 2023, NTU)

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

Concept

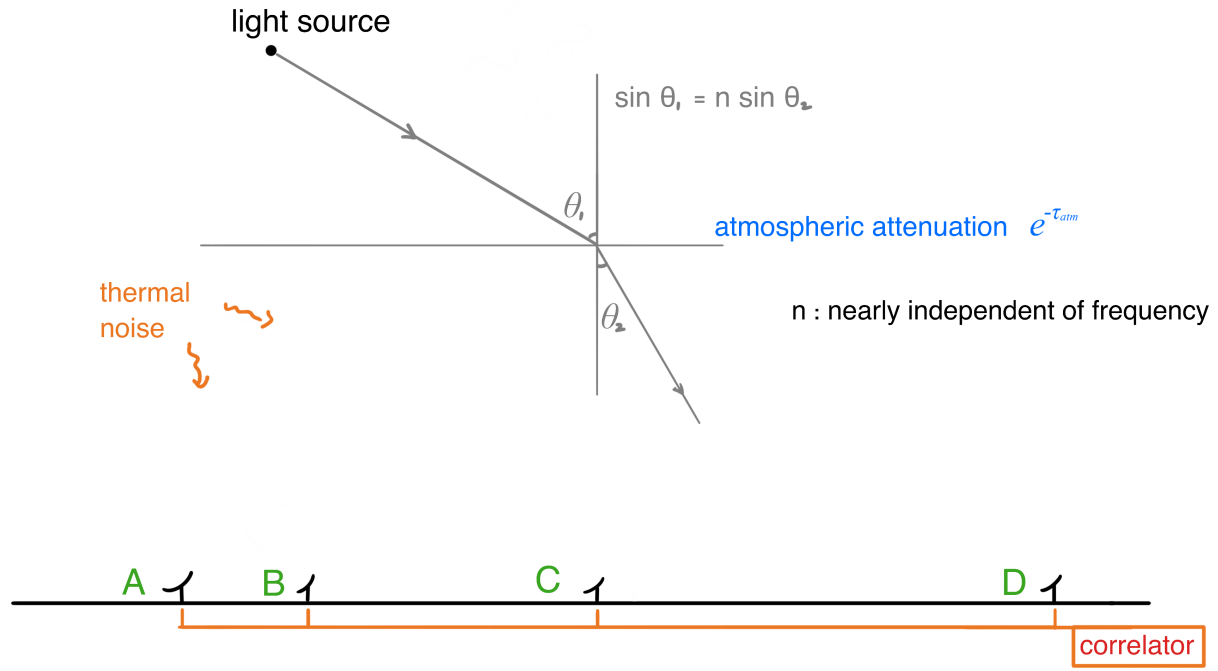
1. Identify the origin and form of systematic errors
2. Based on empirical and theoretical methods to reference the calibration factors
3. There are always some effects that we cannot understand, or we missed, which make the data look like outliers. We have to flag the data as outliers and then exclude them from the subsequent calibration procedure and/or scientific analyses.

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

1. Identify the origin and form of systematic errors



Nightmare

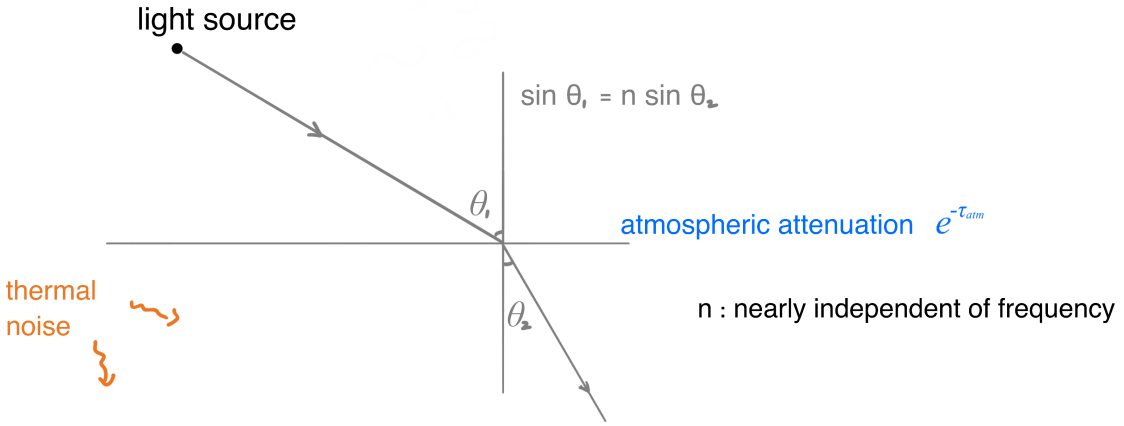
Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

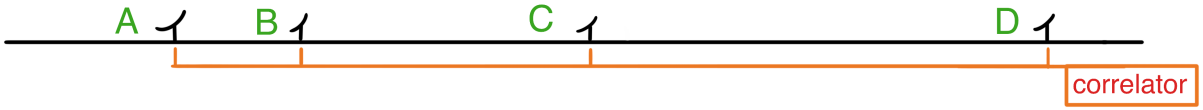
1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

1. Identify the origin and form of systematic errors

Atmospheric effects (or environmental effects, e.g. temperature)

Rapid time variation.
Weak frequency dependence.





Nightmare

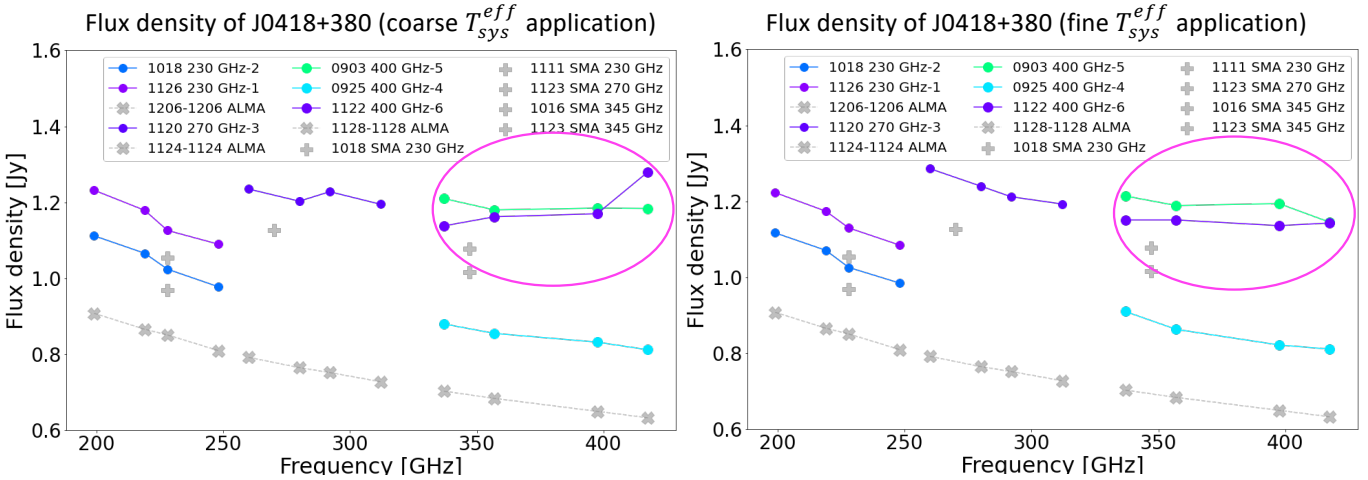
Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

Atmospheric effects (or environmental effects, e.g. temperature)

Rapid time variation.
Weak frequency dependence.

Example of not taking care of the elevation-dependent atmospheric absorption properly



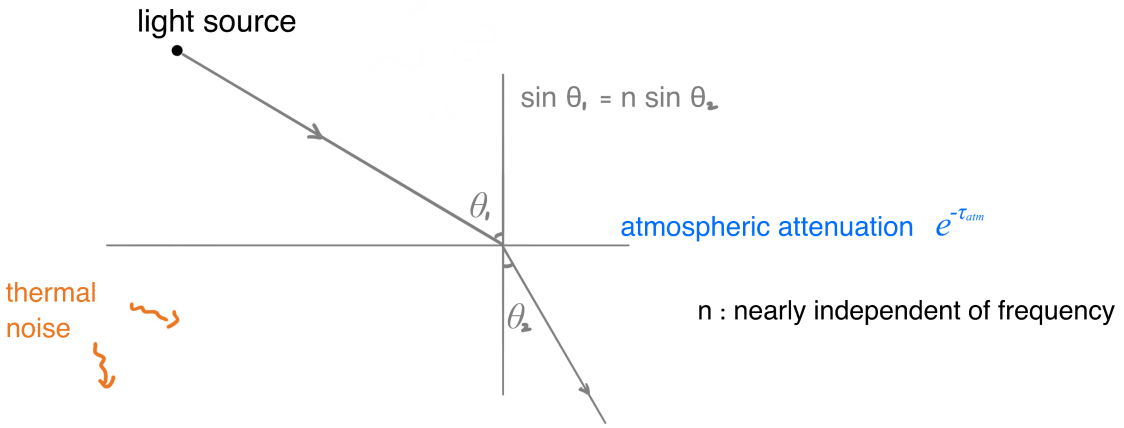
(Chung, Chia-Ying, Master's thesis, 2023, NTU)

Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

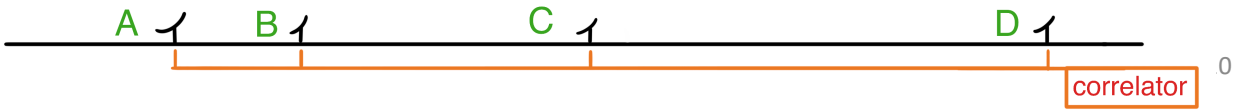
1. Identify the origin and form of systematic errors



Instrumental effects (e.g., receiver response, correlator response, standing wave, RFI, etc)

Stationary.

Depend on frequency.



Nightmare

Observational measurements are subject to thermal fluctuation and systematic errors. After taking the raw observational data, we need to:

1. Characterize the thermal fluctuation (introduce in Lecture Unit 5-3)
2. Calibrate out the systematic errors

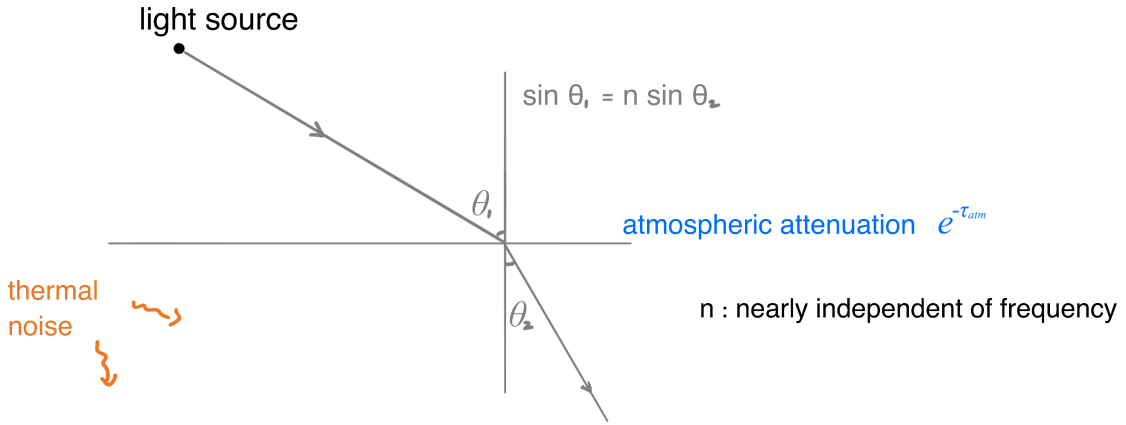
1. Identify the origin and form of systematic errors

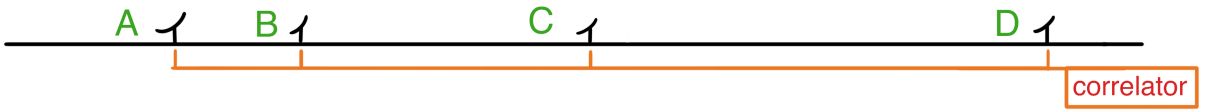
Atmospheric effects (or environmental effects, e.g. temperature)

Rapid time variation.
Weak frequency dependence.

Instrumental effects (e.g., receiver response, correlator response, standing wave, RFI, etc)

Stationary.
Depend on frequency.





Some common issues

To be fixed on-the-fly during the observations, or be dealt with at the beginning of the data calibration procedure

Inspect data and do flagging.

Bugs or mechanical problems: Soure tracking errors (e.g., antennae looking at the blank sky instead of target source), frequency tuning out of lock, phase referencing error, data transfer problems (e.g., tentatively not storing data stream), etc.

Some common issues

To be fixed on-the-fly during the observations, or be dealt with at the beginning of the data calibration procedure

Inspect data and do flagging.

Bugs or mechanical problems: Soure tracking errors (e.g., antennae looking at the blank sky instead of target source), frequency tuning out of lock, phase referencing error, data transfer problems (e.g., tentatively not storing data stream), etc.

Gain curve.

Deformation of mechanical structures: e.g., due to gravitaional force, non-uniform temperature, wind, etc.

Some common issues

To be fixed on-the-fly during the observations, or be dealt with at the beginning of the data calibration procedure

Inspect data and do flagging.

Bugs or mechanical problems: Soure tracking errors (e.g., antennae looking at the blank sky instead of target source), frequency tuning out of lock, phase referencing error, data transfer problems (e.g., tentatively not storing data stream), etc.

Gain curve.

Deformation of mechanical structures: e.g., due to gravitaional force, non-uniform temperature, wind, etc.

Re-quantizer table.

Digitization errors: When using a digital correlator, we may also apply another correction factor called the re-quantizer table to take into account the loss of efficiency during the digitization.

Some common issues

To be fixed on-the-fly during the observations, or be dealt with at the beginning of the data calibration procedure

Inspect data and do flagging.

Bugs or mechanical problems: Soure tracking errors (e.g., antennae looking at the blank sky instead of target source), frequency tuning out of lock, phase referencing error, data transfer problems (e.g., tentatively not storing data stream), etc.

Gain curve.

Deformation of mechanical structures: e.g., due to gravitaional force, non-uniform temperature, wind, etc.

Re-quantizer table.

Digitization errors: When using a digital correlator, we may also apply another correction factor called the re-quantizer table to take into account the loss of efficiency during the digitization.

Reference pointing calibrations.

Antenna errors:

Some common issues

To be fixed on-the-fly during the observations, or be dealt with at the beginning of the data calibration procedure

Inspect data and do flagging.

Bugs or mechanical problems: Soure tracking errors (e.g., antennae looking at the blank sky instead of target source), frequency tuning out of lock, phase referencing error, data transfer problems (e.g., tentatively not storing data stream), etc.

Gain curve.

Deformation of mechanical structures: e.g., due to gravitaional force, non-uniform temperature, wind, etc.

Re-quantizer table.

Digitization errors: When using a digital correlator, we may also apply another correction factor called the re-quantizer table to take into account the loss of efficiency during the digitization.

Reference pointing calibrations.

Antenna errors:

The (systematic) atmospheric effects are introduced in the next lecture.

1. Observations can be affected by systematic errors and thermal noise.
2. Systematic errors may originate from atmospheric effects or instrumental effects.
3. In most cases of observations with modern observatories, the atmospheric effects vary with time but have less dependence on frequency; the instrumental effects are normally rather stationary but may depend on frequency.
4. We need to design our observational strategy such that the effects that lead to the systematic errors can be understood, and the observations are calibratable.