An Introduction to Radio Interferometry

1-1 Overview

You can find relevant material on my personal webpage

Goal

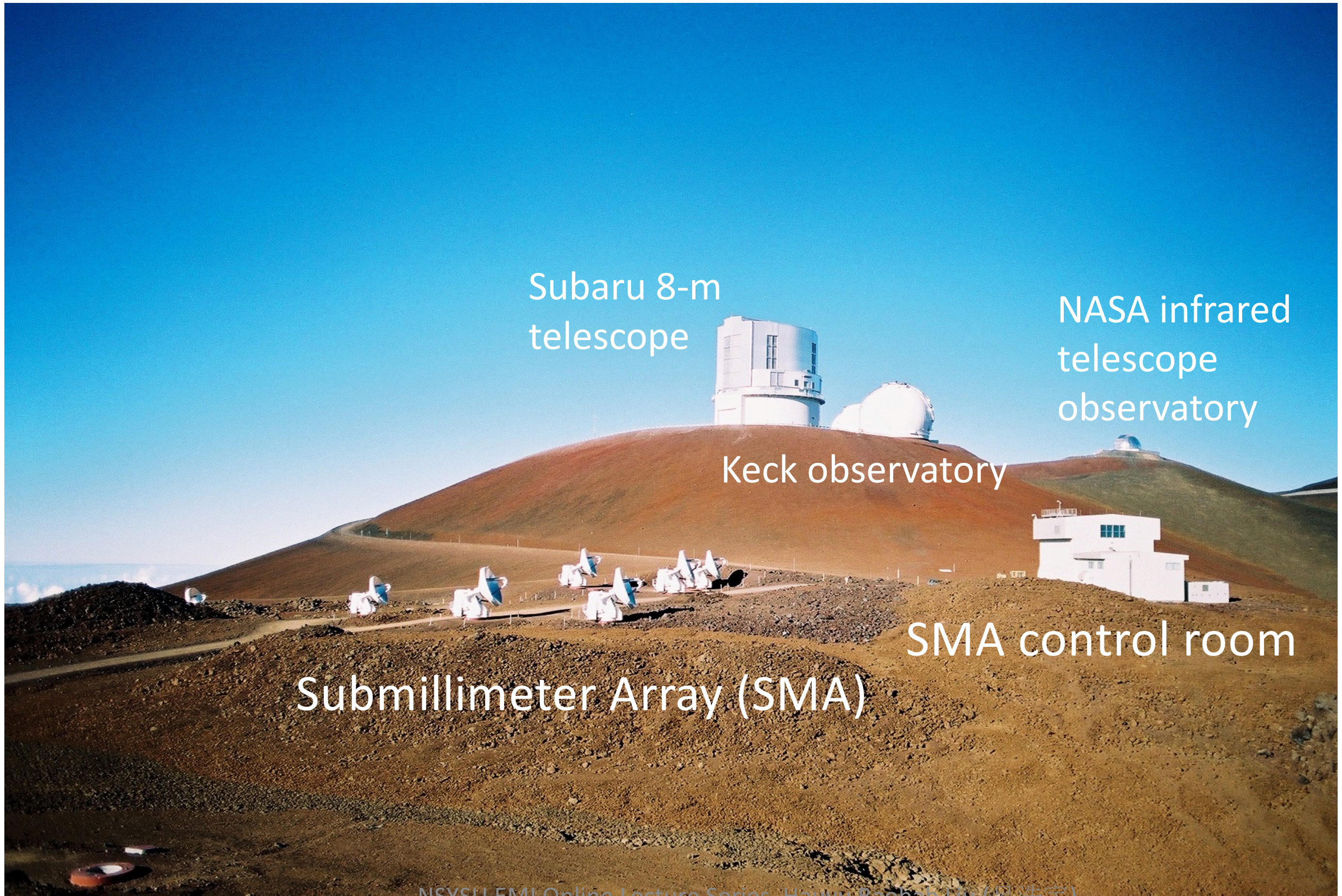
1. Capable of composing and understanding the Technical Justifications of an Submillimeter Array (SMA) , Karl G. Jansky Very Large Array (JVLA), or Atacama Large Millimeter Array (ALMA) observational proposal. **(the very first step of being a radio astronomer)**
   (for more instruction about proposal writing see https://baobabyoo.github.io/pages/students_topics/proposal.html)
2. Able to understand the situation when monitoring an observation, and able to decipher an observing log of the SMA, JVLA, or ALMA.
3. Able to follow the documents of the data calibration software packages on your own (e.g. CASA, Miriad, MIR IDL) to calibrate and image the observing data.

Some Useful Material – My previous lecture @ NTNU

Thanks to

賴品憲(P.-H. Lai)、陳亭蓁(T.-C. Chen)、鍾佳穎(C.-Y. Chung), who contributed to the slides in this lecture series.

How a radio or (sub)millimeter interferometric observatory look like



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Radio Interferometer is an optical device

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1. **Light is EM-wave.**
2. EM-wave at long-distance limit: plane wave $E = E_0 \cos(kx - wt + \phi_0)$
   ϕ_0: phase offset; $w = 2\pi\nu$: angular frequency; ν: frequency
3. The EM-wave propagation can be described by Huygens' principle
   (i) every point on a wave front can be regarded as a new source
   (ii) the wave front is spherically symmetric with respect to the source
4. The solutions of EM-wave equation satisfy the principle of superposition.
5. In vacuum, the speed of EM wave propagation is $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$; in the medium that the index of refraction is n, the speed of EM-wave propagation is c/n, and the wavelength becomes ${}^{\lambda_0}/_{n}$, where λ_0 is the wavelength in vacuum.

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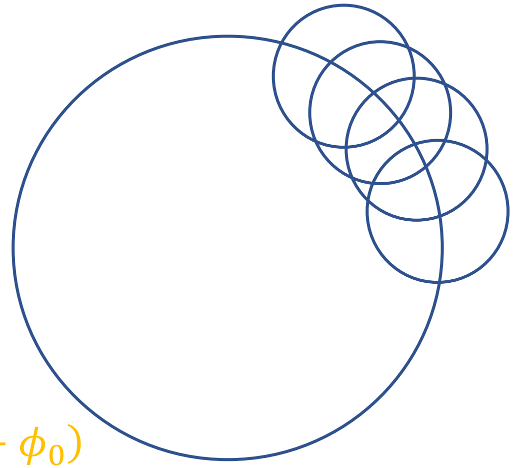
Old
wave
front



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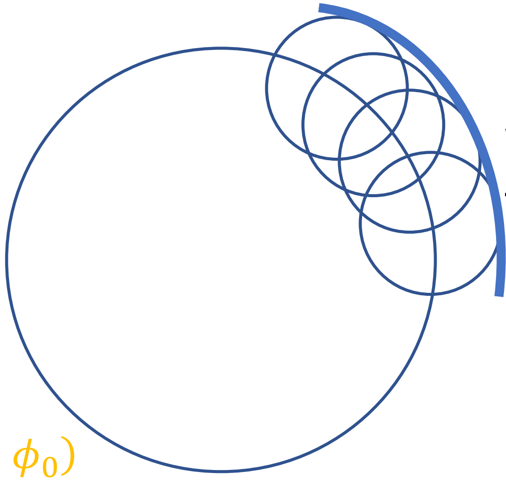

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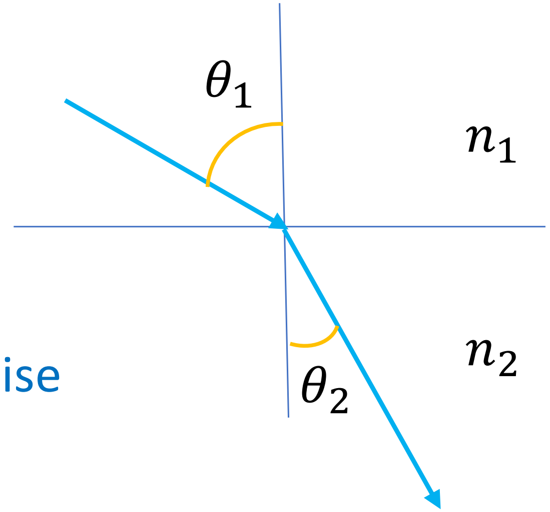
Principle → Reflection, refraction

Principle → Diffraction, interference

Layout, purposes → Systematic errors, thermal noise

Radio Interferometer is an optical device

- Principle
  - Reflection, refraction
    1. Incident angle = reflected angle
    2. Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$
  - Diffraction, interference
- Layout, purposes → Systematic errors, thermal noise



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For every principle, there exists a simple example.

Being familiarized with the simple example helps comprehend the more complicated cases.