Final Review, Part 3

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1 Interferometry basics

Remember that angular resolution is $\theta \sim \lambda/D$. We cannot control the wavelengths at which the source emits, but we *can* change the diameter of the telescope. However, at some point, building a larger, single-dish telescope becomes impossible, for mechanical and financial reasons. Therefore, we build interferometers instead, which can be thought of as "pieces" of a huge telescope. We will gain in angular resolution, but we will have to do some extra work to make sense of the signals we receive. Much of the following text is based on `http://www.cv.nrao.edu/course/astr534/Interferometers1.html`.

Let us consider a simple two-element interferometer. That is, we have two antennas, separated by some baseline $\vec{b}$, inclined at an angle θ relative to the horizon; call this pointing direction $\hat{s}$. Both antennas intercept plane-parallel waves from some source. See the diagram in Figure 1.

From the diagram, we see that there is a path length difference between the left and right antennas: The antenna on the left receives the same wave that the antenna on the right receives at a time $\tau_g = \vec{b} \cdot \hat{s}/c$ later, where c is the speed of light; we call this the geometric delay.

The signals at the antennas can be written as

$$V_1 = V_0 \cos[\omega\,(t - \tau_g)] \tag{1}$$

and

$$V_2 = V_0 \cos \omega t. \tag{2}$$

The signals are multiplied and then time-averaged to yield

$$R = \langle V_1 V_2 \rangle = \left(\frac{V_0^2}{2} \right) \cos \omega \tau_g \tag{3}$$

where the high-frequency term $\cos[\omega\,(2t - \tau_g)]$ gets averaged out. So the correlator output varies with the change in the source direction $\hat{s}$ (we assume the antennas are stationary for now). The sinusoids are called **fringes**, and the **fringe phase**

$$\phi = \omega \tau_g = \frac{\omega}{c} b \cos \theta \tag{4}$$

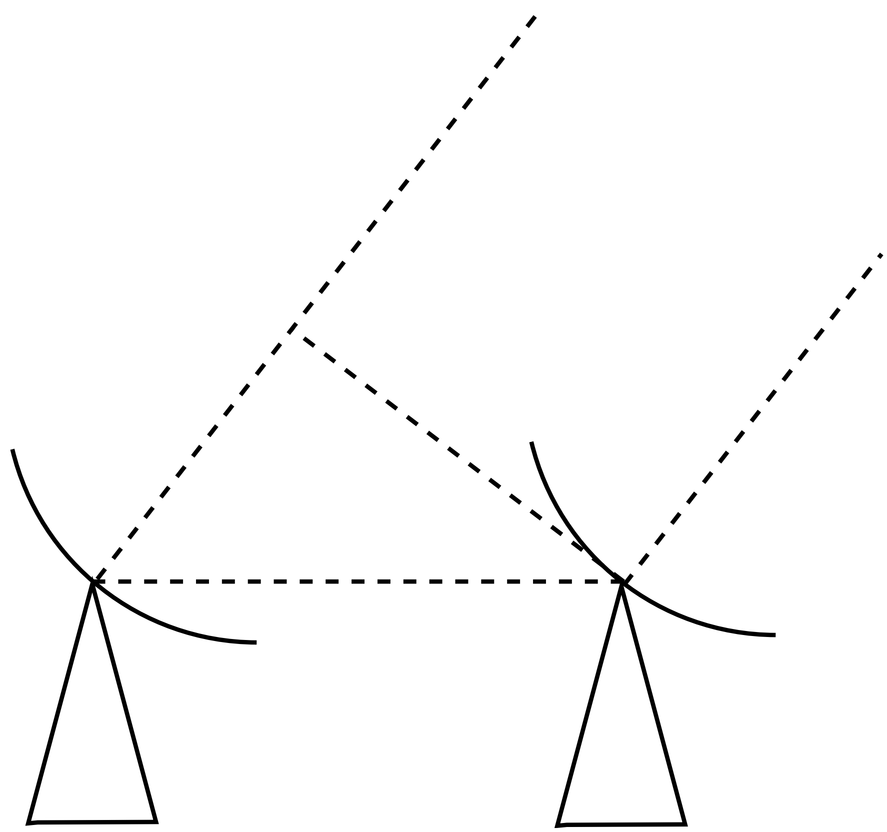

Figure 1: A simple interferometer.

depends on θ, the elevation angle of the source. The **fringe rate** is

$$\Delta\phi = \frac{\omega}{c} b \sin\theta \Delta\theta. \tag{5}$$

2 Masers

Masers are an astrophysical phenomenon in which the "upper" state of a molecule (frequently water, but not always — there is a full list of species on Wikipedia if you are interested) is more populated than the "lower" state of the molecule. If we work through the math, this gives us a *negative* absorption coefficient, meaning that the specific intensity increases as it passes through the maser. The brightness temperature of a maser is $\gg 10^6$ K and can be up to 10^{15} K. Remember that this is brightness, not physical, temperature!