3. Sound-Source Localization

1. Time difference of arrival (TDOA)
2. Estimation of TDOA by cross-correlation
3. Estimation of TDOA in the spectral domain
4. The geometry of two microphones
5. **Direction of arrival**
6. Using more than two microphones
7. Embedding the microphones in a robot head
8. Learning a sound propagation model
9. Predicting direction of a sound with a robot head
10. Example of sound direction estimation

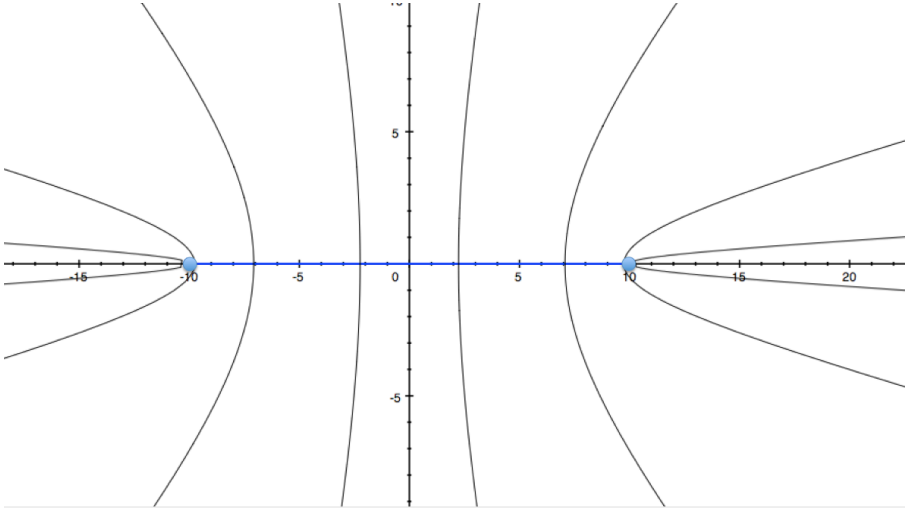
The Azimuthal Plane

We consider an *azimuthal* plane, namely a plane that contains the two microphones, namely the plane $y = 0$:

$$\frac{x^2}{a^2} - \frac{z^2}{b^2} = 1$$

There is a hyperbola for each value of the TDOA

Each Hyperbola Corresponds to a TDOA



Direction of Arrival

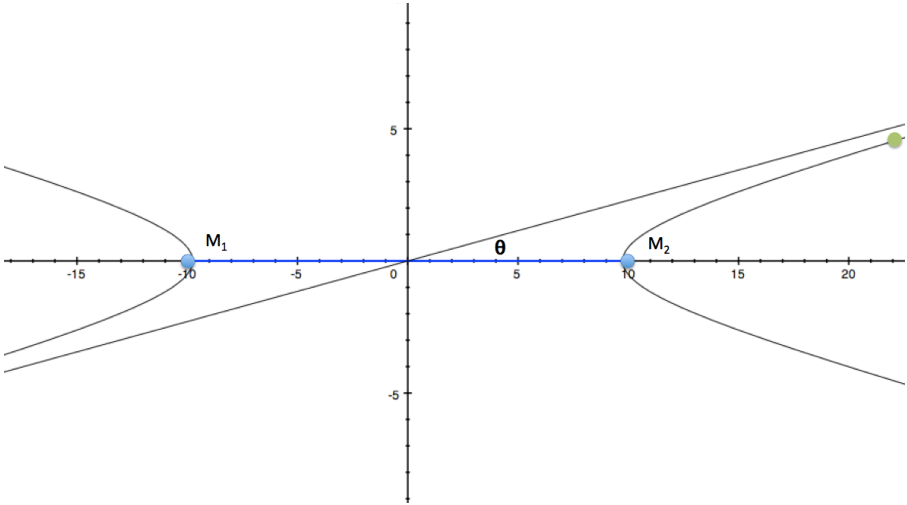
The slopes of the two *asymptotes* of the hyperbole are

$$\tan\theta = \pm\frac{b}{a} = \pm\frac{\sqrt{4m^2 - (\nu\hat{\tau})^2}}{\nu\hat{\tau}}$$

The value of $\hat{\tau}$ selects one of the branches ($x > 0$ or $x < 0$).

The sign of the slope selects front of back side.

Direction of Arrival



Session Summary

- The space is projected onto the azimuthal plane
- In this plane the source lies on a two-branch hyperbola
- The sound direction (azimuth) can be estimated from the asymptote
- One has to solve the left-right and front-back ambiguities.