We have simulated 3 datasets to illustrate the effect of delay-and-sum beamforming on acoustic sources. We have simulated a 10 element microphone array that receives music from one or more loudspeakers located in the farfield of the array. The speed of sound is 340 m/s (the speed of sound in air). The distance between the elements is 17 cm. Each channel is sampled at 11025 Hz (1/4th of the sample rate on a CD).

Exercise 1

(a)

Plot the beampattern of the array as a function of angle for frequencies ranging from 20 Hz to 5 kHz. Choose an appropriate step size between frequencies.

(b)

For what range of frequencies is the wavefield properly sampled such that spatial aliasing is avoided?

Exercise 2

In this exercise we will process and listen to the three different sets of data using Matlab.

Dataset 1: Array gain

In the first dataset we have simulated a loudspeaker located in the farfield, perpendicular to the array. The angle of arrival of the signal it is transmitting is then 0 degrees. We have also added white noise.

In the directory */hom/dsb/www_docs/inf5410data/* you will find the file *Data1.mat* (or alternatively: http://www.ifi.uio.no/∼dsb/inf5410data/). This file can be loaded into Matlab using the command *load*. You will get a matrix, X, in which each row represents one channel (the output of a single microphone), and the columns are time samples.

First, listen to one channel. This can be done in Matlab by making an object *P=audioplayer(X(:,1), 11025)*, and playing it using *play(P)*.

Then, listen to the sum of M channels (up to $M = 10$), and hear how the signal-to-noise ratio changes as M is increased. The sum corresponds to a delay-and-sum beamformer steering towards 0 degrees (hence, no delays are required).

Plot the frequency spectrum of a part of the output from one channel (*e.g.* the spectrum of X(1,1:256)) and then the spectrum of the sum of the 10 channels. Explain the differences you observe between the two spectra.

Dataset 2: Suppression of interference

This dataset simulates two loudspeakers playing different music. The signals arrive at angles 0 and 15 degrees. You will find the data in *Data2.mat*.

Repeat the procedure from the previous exercise, and hear how the sound from one of the loudspeakers is suppressed as the channels are summed (which corresponds to steering towards the signal arriving at 0 degrees).

Discuss whether this array is able to suppress signals arriving from 15 degree angle.

Dataset 3

In this dataset, *Data3.mat*, we have simulated one signal arriving at an angle of 43 degrees. First, play a single channel, and then the sum of all channels (we still steer towards 0 degrees). While playing the sum of all channels you will hear a high-frequent sound. Why?