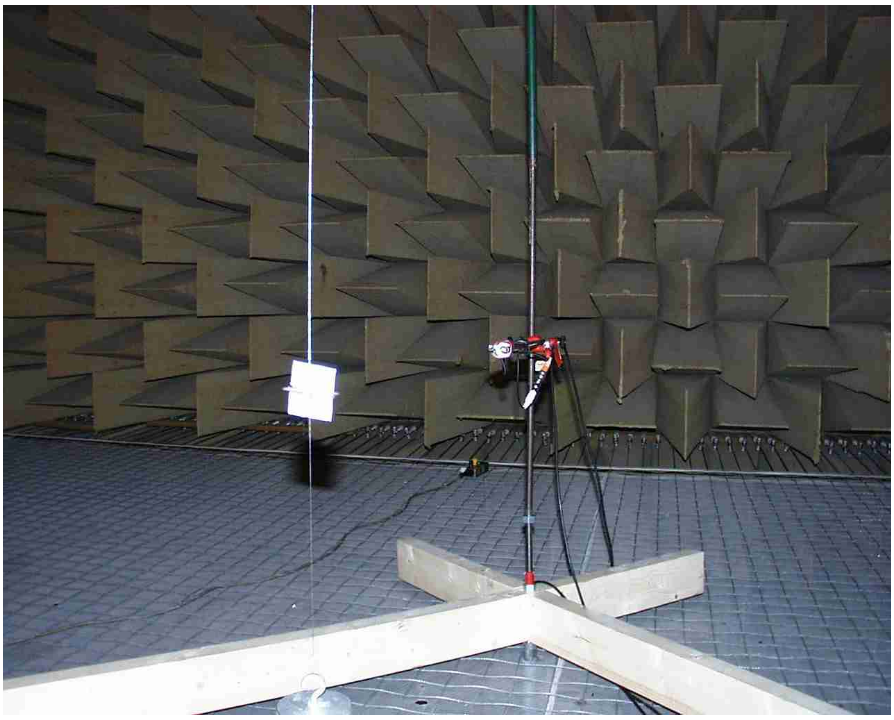
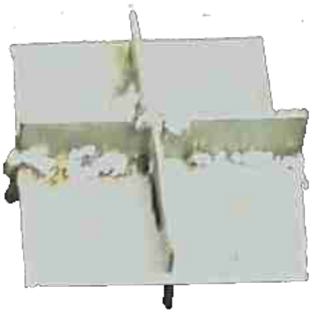
Detecting the Speed of a Moving Object

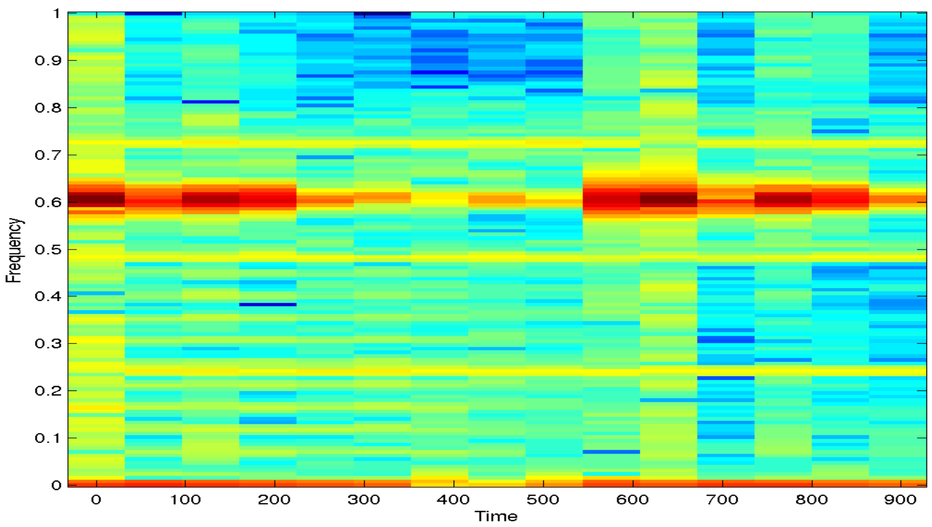
The first experiment was to simulate the way bats find out the speed of their preys. They do this by using the doppler effect. Our setup was the following; a sender and a receiver, separate for simplicity (it is not in the case of bats). For a moving object, we had a pendulum with a weight (for stabile movement) and a metal prism for reflection.



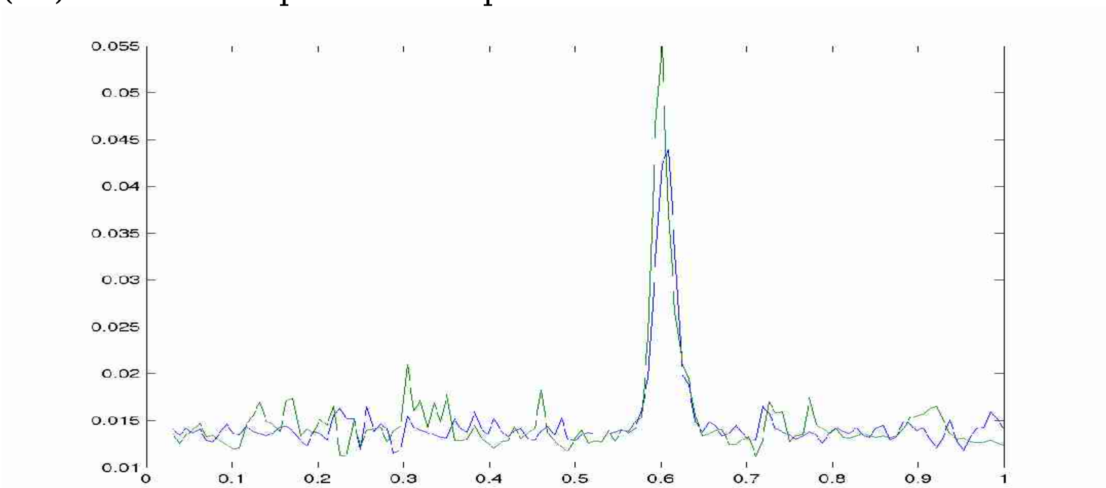
The prism has orthogonal edges, as it at least it theory will cause the waves to reflect in the opposite direction. In practice, it worked so-so.



The sender is of pulse type as to not drench the receiver. A first shot at figuring out the frequency drift was a spectrogram:



The shift in frequency is barely visible; to get a numerical value out of it, we use MUSIC (Multiple signal classification). Considering the noise and the difference we want to try and find, we can't take too many points in time; timespan 0-150 and 150-300 are the ones used. As we wish to find a small detail, we pick the number of sinoids high (70). The two frequencies are plotted below.



Picking the central values in the two peaks, we get a drift of 0.042 normalized units. The signal out is at 0.606 normalized units. As this corresponds to a mean in the two intervals, and we want the two outmost extremes, we can round it up to maybe as high as 0.05.

The frequency shift is described by

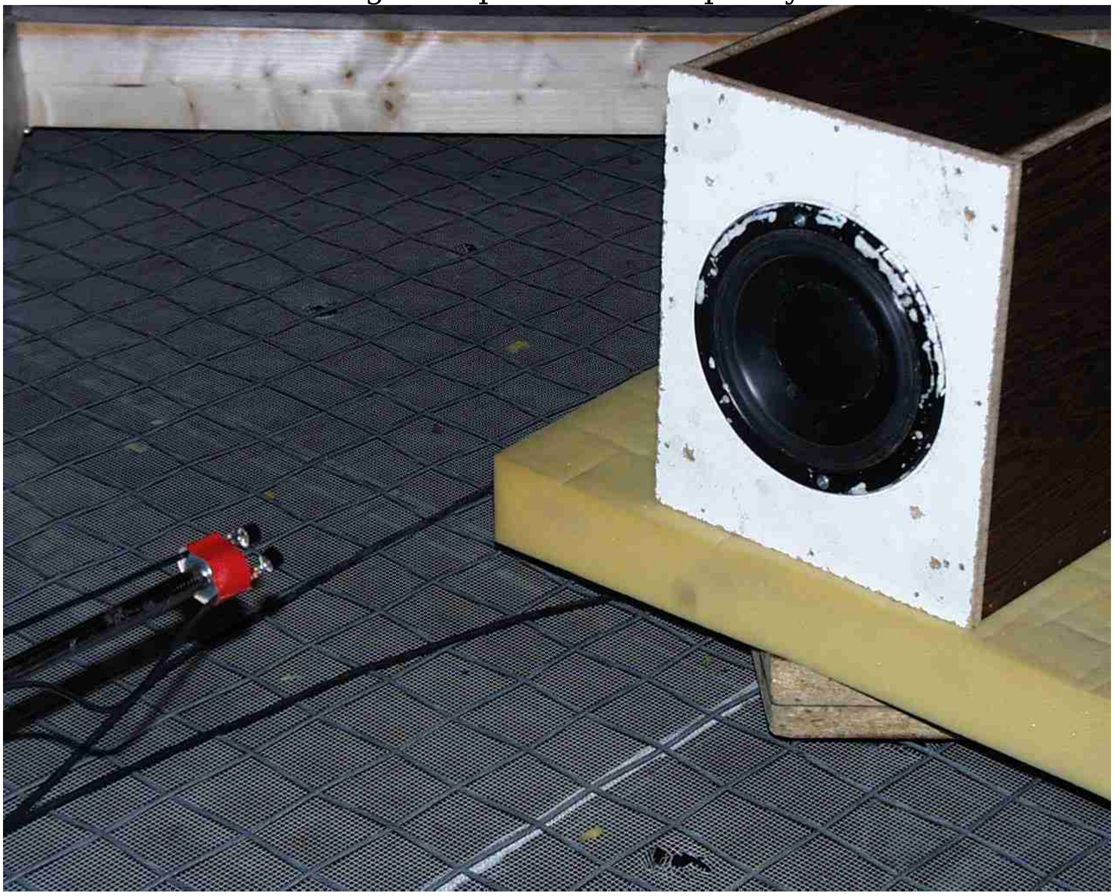
$df=-2v_r*f/c$

$|df*c/(f*2)|=|v_r|$

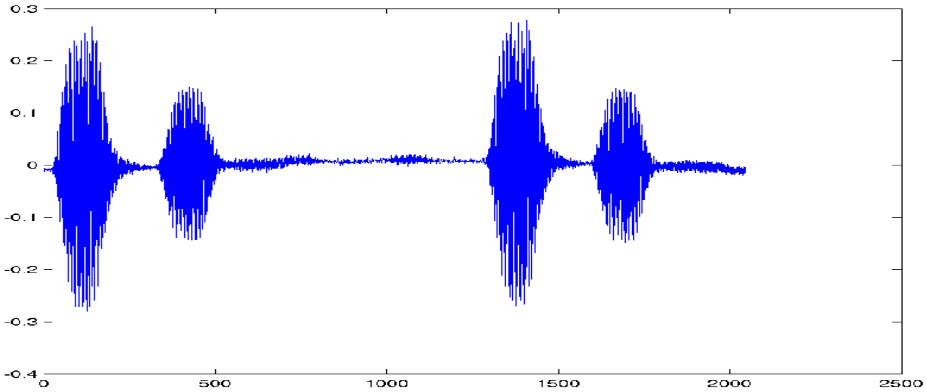
Inserting our values, we get 12m/s which sounds way high; but then the measured data was of horribly low precision.

Detecting the Distance to an Object

Our second experiment was about measuring distance to other objects. Our setup was a very low-frequency woofer and the usual receiver and sender. Again separate for simplicity.



The sending was done in short pulses. The wanted information hides in a signal-time diagram:



The first big peak is when the receiver is being drenched by the sender. The second peak is when the echo returns; of course weakened by various things like resistance in air, imperfect reflection etc.

We know the relationship s=vt and the speed of sound in air, 344m/s. It takes as long time to travel back from the object as the time to travel to it, hence s_0=vt/2. The time is to be taken out of the diagram. As the signal is smeared out (there is nothing like dirac distributions in real life), we have to pick a value as a reference point. In this case, we can assume the first wave out will be the first wave in. This saves us from errors in picking an evened value in the middle (which might be hard to find). The distance between the first two peaks turns out to be 309 samples. With a sample rate of 129kHz, we end up with the time taken to be 0.0024s. Inserting into the above formula, we get s_0=about 4.1dm which sounds reasonable.