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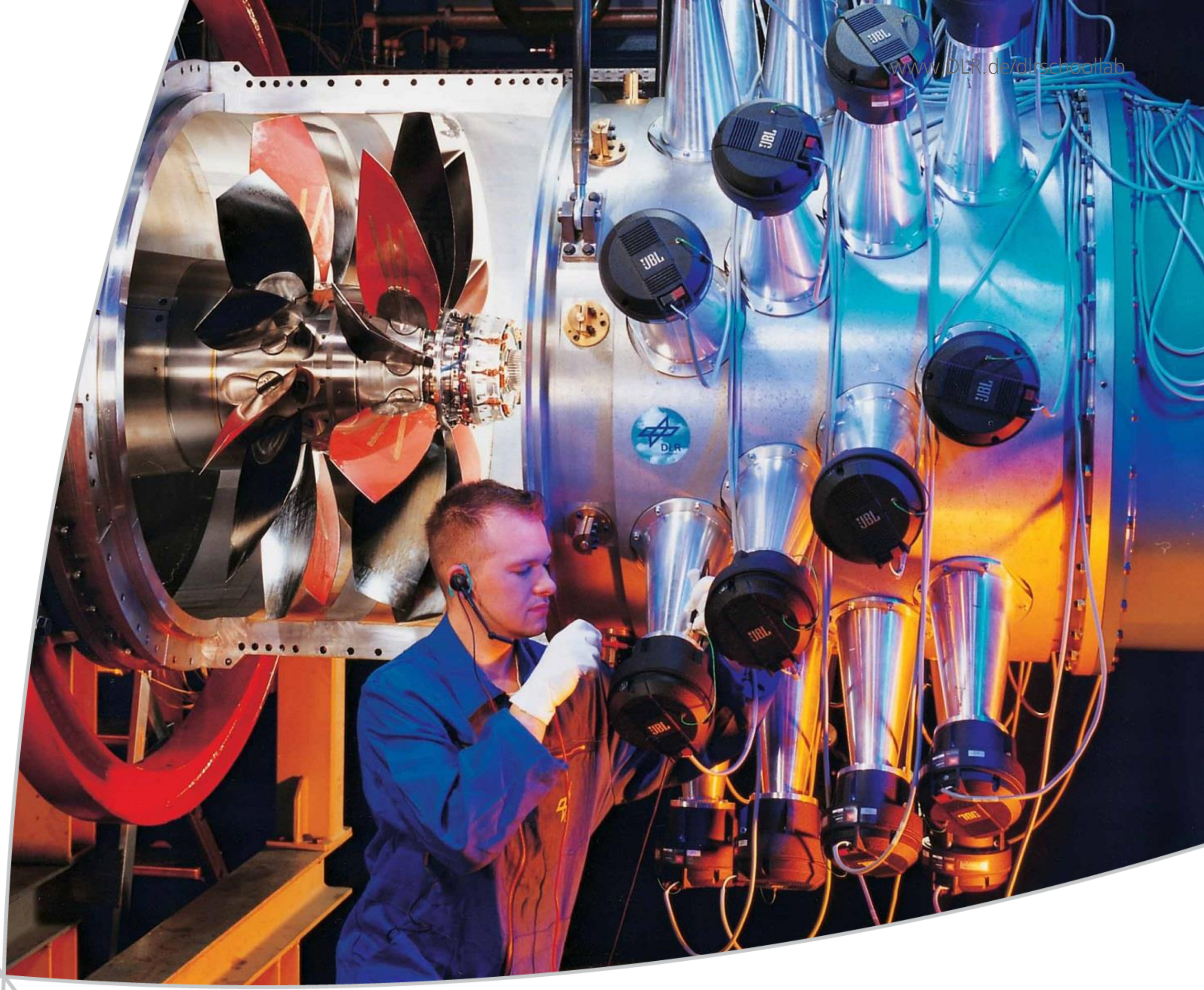

DLR_School_Lab
Köln

Active noise reduction

Reducing noise with noise

We love listening to music after our own taste. The louder, the better. Our neighbours however, might perceive it as an unbearable nuisance. On the other hand, we might hate hearing a noise that is as loud as our music. So whether or not we perceive a particular sound as being pleasant or unpleasant is very subjective.

People who are constantly surrounded by noise can become ill. (Try measuring the volume of your MP3 players.) In very loud environments, windows can be soundproofed in order to lessen the impact indoors. If we wish to block out the sound of somebody snoring, we usually resort to plugging our ears. These methods are examples of passive noise protection.

Making noise

In this experiment, you will actively reduce the amount of noise by producing more noise. But before we can do that, we need to go over some physical basics.

Sound is a special and temporal pressure fluctuation that propagates as wave. Molecules (e.g. of air) vibrate and create vibrations in the surrounding medium, which in turn create vibrations in their surroundings as well.

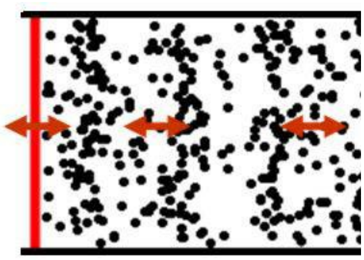

Fig. 1: Within a sound wave, there are areas or higher and lower molecule density (areas of higher and lower air pressure)

A simple sinus wave is created when we hit a tuning fork.

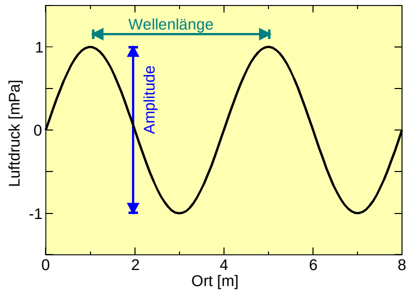

Fig. 2: Sine wave

The greater the pressure differences are (within one note), the louder the note is that we hear. The difference is called the amplitude.

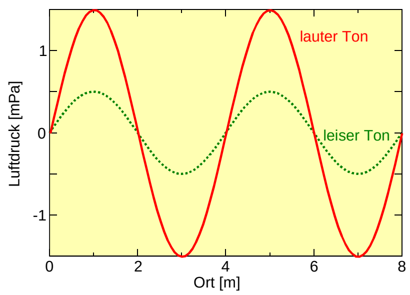

Fig. 3: Loud (red) and quiet (green) sounds

The distance between two wave crests is called the wavelength. A sound wave covers the distance of one wavelength during a wave motion. The wavelength determines the tone pitch, which can also be measured in cycles per second (Hz).

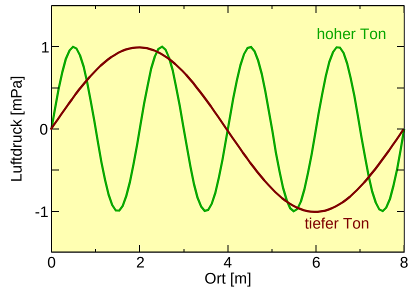

Fig. 4: High (green) and low (brown) pitched sounds

If we lay different waves on top of each other (superposition), their amplitudes are added to each other. This is called interference.

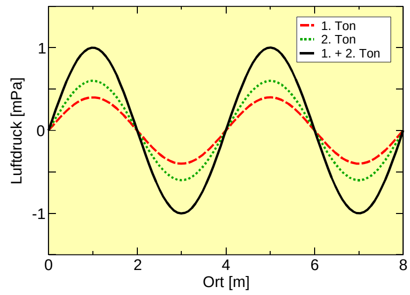

Fig. 5: Amplification of waves through interference

If the superposed waves all have the same wavelengths, as in fig. 5, the sound will be amplified. We perceive an increase in volume.

If two waves of the same amplitude are positioned so that the "wave crests" of one wave meet the "wave troughs" of the other, they will cancel each other out. We will investigate this noise reducing effect more thoroughly.

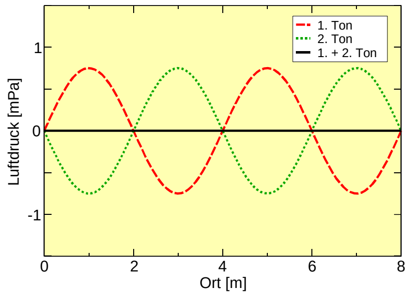

Fig. 6: Cancellation through superposition

Only rarely do we encounter pure tones in everyday life. Usually, sounds of varying wavelengths and amplitudes overlap each other. We can see this if we look at an oscillogram of the vowel "a".

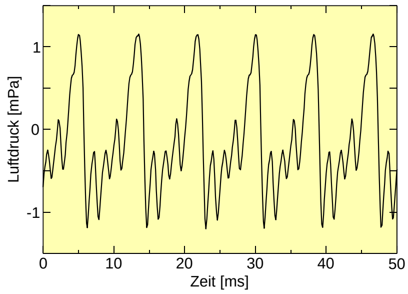

Fig. 7: Oscillogram of the vowel "a"

Using computer technology, we can analyse which frequencies a sound is made up of. We will see a frequency spectrum much like the kind you may know from stereos.

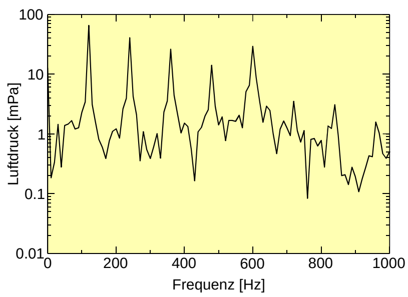

Fig. 8: Frequency spectrum of the vowel "a"

Our experiment

First of all, we will compare different sounds and noises and their sound spectrums and volumes.

Fig. 9: Flow passage. The red box contains the speakers for the anti-sound

In our experiment apparatus, a flow passage, there is a propeller that generates an unpleasant complex noise (Fig. 11). The noise is produced by the air that is dragged behind the rotor blades bouncing off regularly spaced metal bars (stators). This way, we can simulate the noise that is produced in aircraft engines.

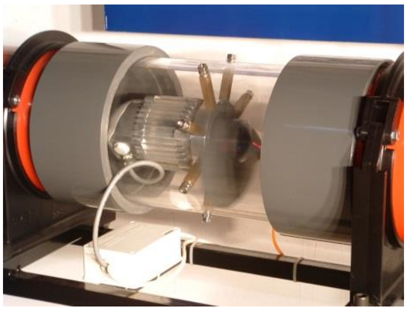

Fig. 10: Propeller and stators in the flow passage.

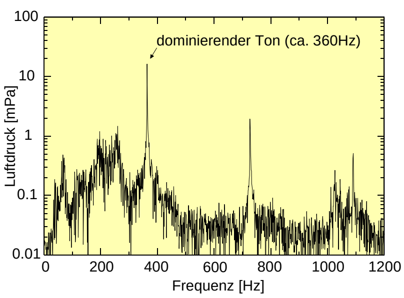

Fig. 11: Frequency spectrum of the engine noise

Systematically countering the noise

Within our spectrogram, we see that one frequency in particular is dominating the sound we hear (in Fig.11 360 Hz). This sound and its first overtone (720 Hz) make up most of the noise.

We will cancel out this sound by producing an anti-sound which we will feed into the flow passage. Before we can do this, we have to connect all the equipment we will need (Fig. 12, 13). Don't worry: we will help you.

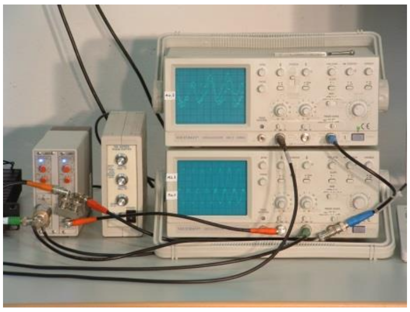

Fig. 12: Instruments to measure and control our experiment. From left to right: two bandpass filters, a phase shifter and two oscilloscopes.

Implementation

This technology is currently still being tested and has not passed into common usage in aircraft engines, as it is not viable to use speakers in these engines. Instead, engineers are trying to devise a way of diverting sound within the engine that will produce its own anti-noise.

Active noise reduction is however already being used in air conditioning, aircraft cabins and cars. Double- glazing windows, where one windows works as a speakers that emits anti-noise, are ready for commercial usage. There are also headphones that use active noise reducing technology. You can try them out in our lab!

Links:

http://www.falstad.com/mathphysics.html

http://www.dlr.de/at/desktopdefault.aspx/tabid-9004/15550_read-38383/

http://www.ksta.de/porz/wissenschaft-laerm-soll-mit-laerm-reduziert-werden,15187570,16999688.html

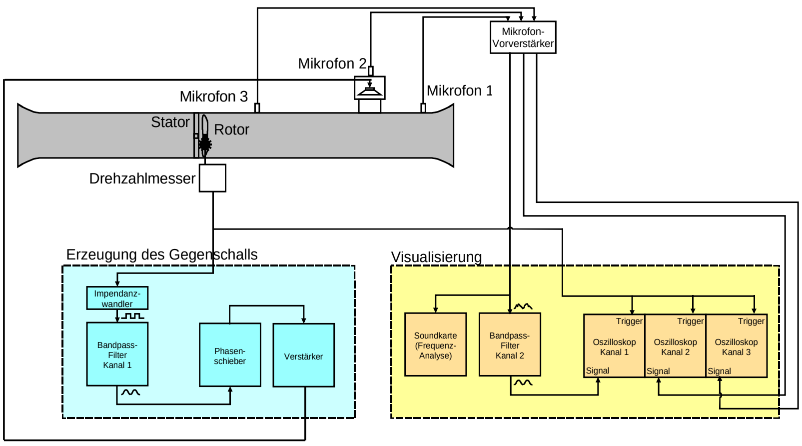

Fig. 13: Connection scheme

About DLR

DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. Two DLR project management agencies oversee funding programmes and support knowledge transfer.

Climate, mobility and technology are changing globally. DLR uses the expertise of its 55 research institutes and facilities to develop solutions to these challenges. Our 10000 employees share a mission – to explore Earth and space and develop technologies for a sustainable future. In doing so, DLR contributes to strengthening Germany's position as a prime location for research and industry.

DLR Cologne

Aviation, space travel, transportation, energy and safety are the research areas pursued in the nine research facilities at DLR Cologne. The basis of the research and development carried out on site are the large testing facilities such as wind tunnels, turbine and materials test benches and a high-flux density solar furnace. The 55 hectare/ 136 acre site is home not only to the research and administrative facilities of the DLR, but also to the European Space Agency's (ESA) European Astronaut Centre (EAC). The DLR has around 1400 employees in Cologne.

Deutsches Zentrum für Luft- und Raumfahrt

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About the experiment:

Recommended for grade(s): 9 to 13
Group size: 5 to 6
Duration: 50 minutes
Subject matter: Physics