Sound Fields: Free versus Diffuse Field, Near versus Far Field

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DETAILS

Direct YouTube link: https://youtu.be/PcwFjB6z17A

In the world of acoustics, there are many terms that are used to describe the acoustic field around a sound emitting object. Four of the most important are listed below:

- Near Field
- Far Field
- Free Field
- Diffuse Field

This article explains the differences and usage of these acoustic sound field terms.

Near Field versus Far Field

As one may suspect, the acoustic terms "near field" and "far field" have to do with the physical distance from the sound source *(Figure 1)*. Depending on how far away an observer is from a sound emitting object, the acoustic energy produced by the sound source will behave quite differently. It is therefore important to understand these differences, and design measurements carefully.

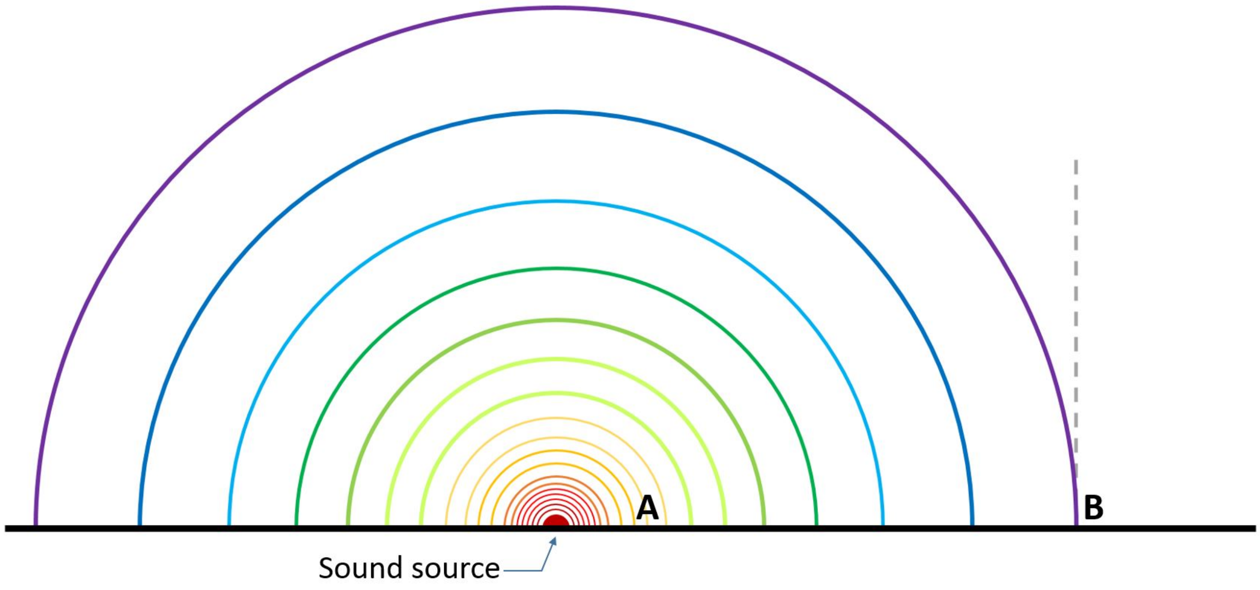

Figure 1: Sound waves behave differently in the near field (A) and far field (B).

Far field

The acoustic far field begins approximately at a distance of 1 wavelength away from the sound source, and extends outward to infinity *(Figure 2)*. As wavelength is a function of frequency, the start of the far field is also a function of frequency. The far field is defined as the region where the sound pressure and acoustic particle velocity are in phase, and where the sound pressure level decreases by 6 dB for each doubling of the distance from the source.

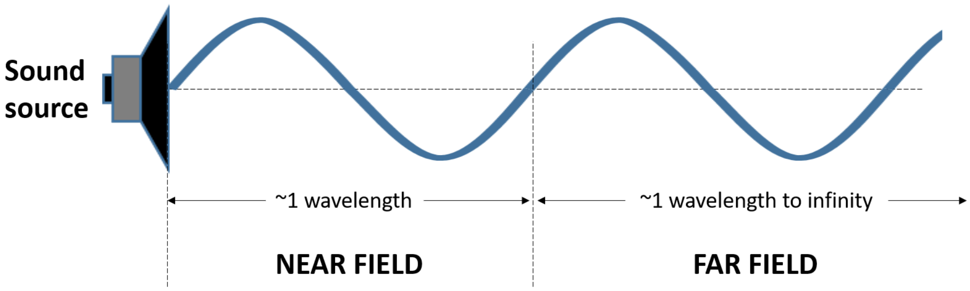

Figure 2: The far field begins at approximately 1 wavelength away from the source.

In the far field, the source is far enough away to essentially appear as a point in the distance, with no discernable dimension or size. At this distance, the spherical shape of the sound waves have grown to a large enough radius that one can reasonably this distance, sound pressure level is governed by the inverse square law, and a single microphone sound recording will give reliable & predictable results. For each doubling of distance away from the source, the sound pressure will drop 6 dB in the far field, assuming no reflections (see "free field" below).

In many acoustic standards, measurements are often specified at a distance of at least *one meter* from the sound emitting object to ensure that the measurement is taken in the far field for the most critical frequencies.

Near Field

When close to a sound emitting object, the sound waves behave in a much more complex fashion, and there is no fixed relationship between pressure and distance. Very close to the source, the sound energy circulates back and forth with the vibrating surface of the source, never escaping or propagating away. These are sometimes called “evanescent” waves. As we move out away from the source, some of the sound field continues to circulate, and some propagates away from the object *(Figure 3)*.

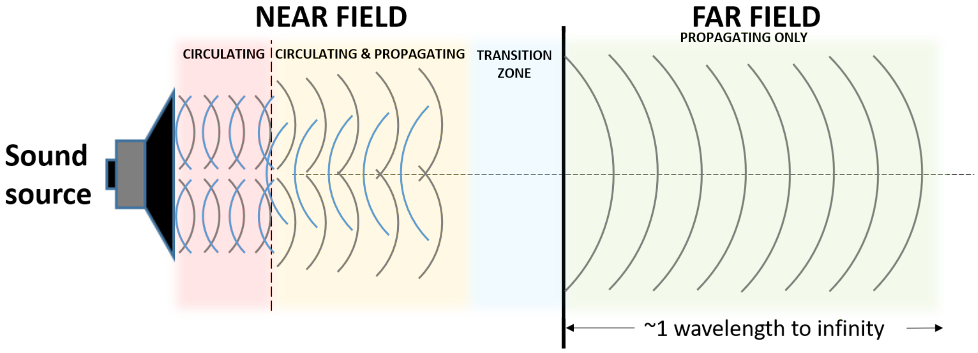

Figure 3: The near field is complex, with sound energy both circulating and propagating.

This transition from circulating to propagating continues in an unpredictable fashion until we reach the threshold distance of roughly a wavelength, or three times the largest dimension of the sound source, whichever is greater. This complex region is known as the acoustic "near field". This mix of circulating and propagating waves means that there is no fixed relationship between distance and sound pressure in the near field, and making measurements with a single microphone can be troublesome and unrepeatable. Typically, measuring in the near field requires the use of more than one microphone *(Figure 4)* in order to accurately capture the energy borne by the circulating and propagating waves.

Figure 4: Acoustic arrays featuring many microphones can be used close to a source to accurately capture sound energy in the near field.

Free Field versus Diffuse Field

When sound radiates from an object, it can reach an observer directly by traveling in a straight line, or indirectly via reflections. Reflected sound waves can bounce off surfaces such as walls, the floor, ceiling, as well as other objects in the area. Often when we experience sound, we are receiving both direct and reflected sound waves. Under carefully controlled circumstances, however, we can experience the extreme ends of this continuum: 1) an acoustic field where zero reflections are present, and only the direct sound is observed, and 2) the opposite acoustic field, where zero direct sound is observed, and only reflected sound is present. The names given to these two extreme acoustic environments are FREE FIELD and DIFFUSE FIELD respectively *(Figure 5)*.

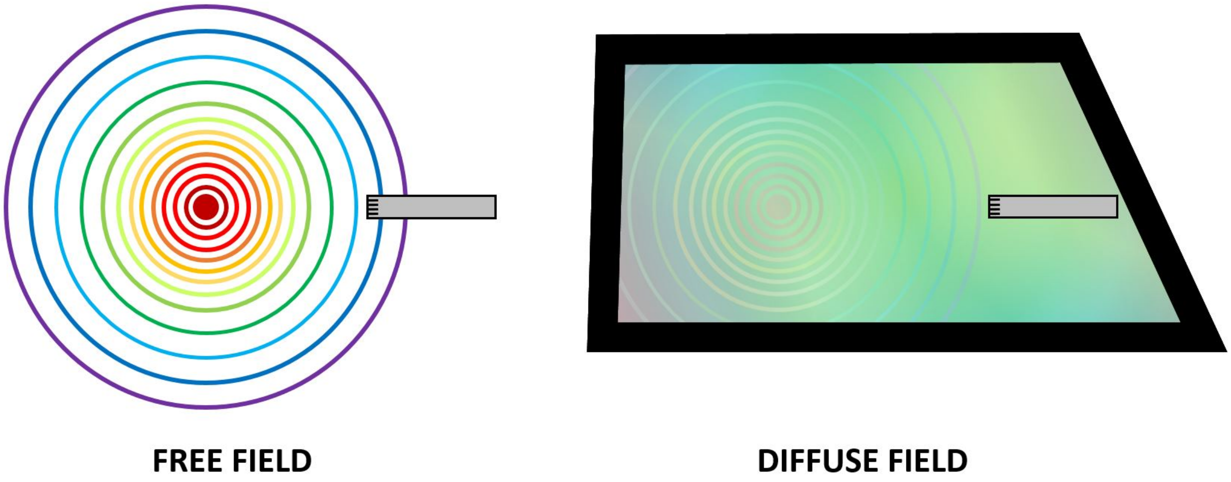

Figure 5: Illustrations of the free field (zero reflections) and diffuse field (only reflections).

Free Field

In an acoustic free field there are no reflections; sound waves reach an observer directly from a sound emitting object. The sound wave passes the observer exactly once, and never returns.

Two common examples of acoustic free fields are:

- The sound source is far enough away that it appears as a single point source, far in the distance. Visualize an airplane flying high overhead on a clear day.
- An anechoic chamber is a special facility constructed to approximate an acoustic free field by using materials to absorb sound waves before they can be reflected *(Figure 6)*.

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