

An individual run of slats will begin to scatter sufficient power when approximately a third of a wavelength fits into its length, though once it becomes comparable to wavelength an increasingly more directional reflection results. Consequently its bandwidth of operation is small and a range of slat runs of different sizes is required. Structures whose AACF is optimal, implying a lack of self-similarity, provide the greatest diffusive efficacy. Ultimately however the best arrangements for diffusion are sparse. A sparse array will tend to have smaller runs of slats, and consequently will scatter inefficiently at low frequency. The result is therefore a trade-off between scattered power and diffusive capability.

To achieve diffusion at low frequency (relative to a flat plate of the same size) the diffuser width should be larger than wavelength. To ensure high frequency diffusion the slat size should be no larger than wavelength.

Building on the single layer slat designs, a multi-layer concept may be envisaged, whereby sound incident upon each layer is partially back-scattered and partially transmitted, with dispersion ideally occurring for both. In this manner each separate layer creates 'additional diffusion', which may then be further emphasised due to multiple scattering effects between layers.

Since sparse arrays tend to have very few runs of adjacent slats, individual slats on the order of a third of a wavelength are required to scatter efficiently at low frequency. For a minimum design frequency of $f_{min} = 400\text{Hz}$ this implies a slat size on the order of $d_e = 30\text{cm}$. Sparse layers based on this slat size will inherently be very large, for example based on the array from Figure 4.36 an approximate width of $D = 8\text{m}$ would be required. Consequently these would likely make impractical constructions. In addition as was demonstrated above, due to the narrow frequency over which an individual slat scatters sufficient power whilst scattering in a non-specular manner, their bandwidth of operation is small.

One alternative to the above approach is to provide layers of varying slat size. As has been shown, if the front layers comprise elements large relative to wavelength then little energy will propagate into the array. If the array is designed to have small elements at the front and progressively larger elements towards the back of the array however, then each layer may be targeted to diffuse over a given frequency range. This forms an equivalent to impedance matching seen with absorbers [3]. For example consider a simple three layered array, comprising layers of small, medium and large elements from front to back; comparable in size to low, mid and high frequency wavelengths respectively. At low frequency the front two layers will have little effect, and an incident wavefront will effectively only see the back layer. At mid frequency the front layer will have little effect, and the incident energy will see a combination of the middle and back layers. Finally at high frequency the whole array is seen.

An example of the above is shown in Figure 4.39 for an $M = 5$ layered structure, where layers (from back to front) are based on Golomb ruler sequences of length $N = \{ \dots \} 50, 29, 17, 10, 6$. The array has been designed to scatter efficiently from a lower frequency of $f_{min} = 400\text{Hz}$, with the individual scattered power cut-off frequencies for each of the layers being approximately given as 400Hz, 680Hz, 1.15kHz, 1.96kHz and 3.38kHz respectively. As with the sparse array from Section 4.3.3 the array comprises a set of Golomb rulers where some elements have been selectively removed in order to achieve an approximate 50% line-of-sight through the array. The structure has an overall depth from front to back of 0.5m.

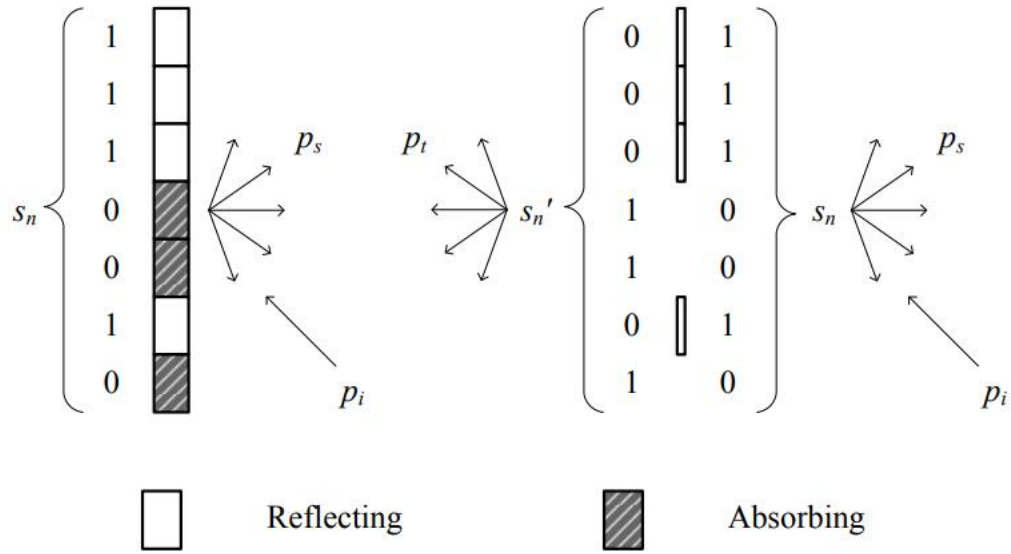


Figure 4.1: Cross-section of a BAD panel (left) and its volumetric slats equivalent (right); surface patches arranged according to the Maximum Length Sequence (MLS) [1 1 1 0 0 1 0]

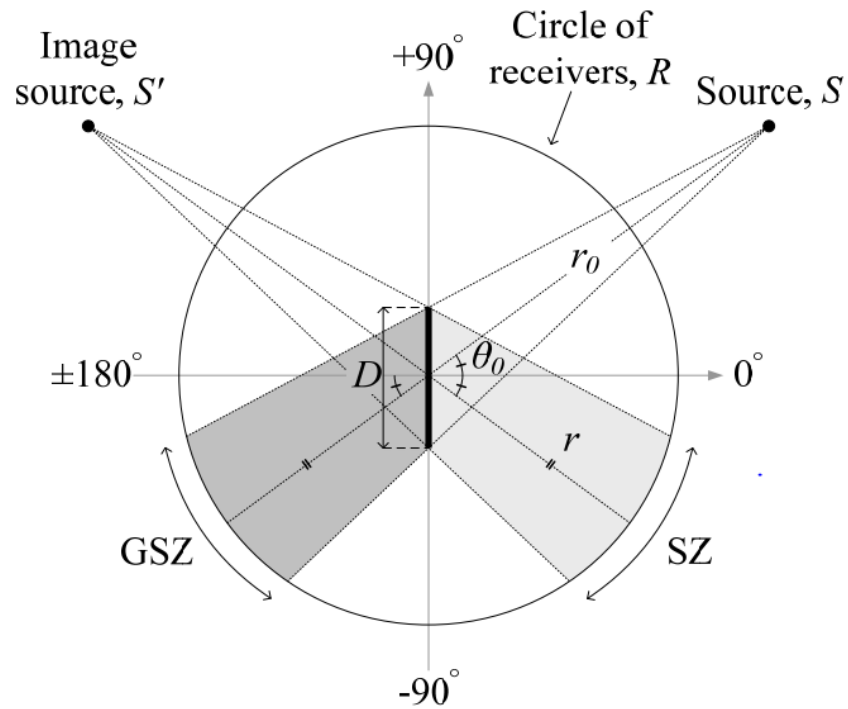


Figure 3.2: Geometry defining the extent of the Geometric Shadow Zone (GSZ) and Specular Zone (SZ) for a flat plate of width, D

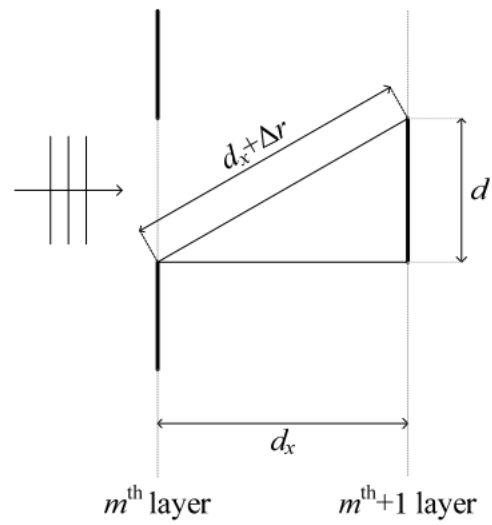


Figure 4.28: Geometry for determining the back-scattered intensity from a slit of width, d , situated at a distance, d_x , behind a slit of the same width

Above a certain frequency the main lobe (as defined above) transmitted through the gap will be narrower than the slit directly behind it, and consequently the majority of the incident energy will be redirected back towards the source. This case was illustrated by the small layer spacing example presented above. Below this frequency however the transmitted lobe will be wider than the slit and consequently part of the sound will miss the slit and be transmitted.