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PROPOSALS FOR THE IMPROVEMENT OF ACOUSTICS OF ANCIENT THEATRES

Kostas Moschos (1), Gottfried Schubert (2)

1) Institute for Research on Music & Acoustics, Athens, Greece
e-mail: kostas@iema.gr
2) Acoustical Consultant, Athens, Greece
e-mail: schubert@ath.forthnet.gr

Abstract

The acoustics of the ancient theaters had most probably very high quality. This remark is based not on legends or theories but on their acoustic ability and effectiveness. We can assume that the acoustic on spaces of 5.000 or more seats was able to support the performance of theater plays or of music games in order to satisfy the spectators, something that today is possible only with the help of electro-acoustic support.

Why did this acoustic ability disappeare? Most probably the destruction of big parts of the scene buildings and the deterioration of the existing surfaces is a strong reason for the lost of this legendary acoustic. What are the solutions today if we want to use again these open spaces for cultural performances? A usual solution is the application of power amplification. The results are adequate as far as the hearing ability but not at all satisfying as far as the level of quality. The stereoscopic image of the sound is completely destroyed, while the audience hear the sound coming from a completely different point from the source where it is produced. At the Institute for Research on Music & Acoustics (IEMA) we tried to resolve this trouble in several ways: a) through mechanic open theater acoustics improvement (special designed reflectors) and b) by building a complex digital stereoscopic audio system of non-apprehensible amplification. These suggestions were applied experimentally several times in real performances at the Athens Herodium Theater with interesting results. This paper presents the rationale, the design and the results of the implementation of these experimentations, which we hope they can serve as a permanent solution to the problem.

Keywords

Acoustics improvement, electroacoustic support, stereoscopic audio image, reflectors

1. Introduction

Ancient spaces (Theatres, Odeia, Sanctuaries etc) are very widely used today during summer time for cultural events (theatre and music). Most of the sanctuaries (e.g. Roman Agora) are not prepared to host music or theatre plays. It is mostly the absence of a defined scene environment that makes performing in these ancient spaces difficult. Although these spaces were originally built for such performances, in most cases, the destruction of the scene buildings is preventing the positive acoustical result. The main problem is the lack of reflections from surfaces near the performers not only for the acoustic impression of the audience but also for the synchronisation of the musicians. In our effort to overcome this problem, we have tried simple and economic solutions, using two different approaches (mechanic and electronic), while keeping in mind the restrictions of the archaeological authorities.

2. Sound reflectors

The first effort was to build, as an experiment, ten sound reflectors (panels) in order to catch and reflect the sound that was absorbed or lost by the ruined scene. The reflectors were made from plywood (25mm) and a heavy metal frame. The dimensions of the vertical reflector part were 1200 mm x 2400 mm. The tilted part on top of the element was 1200 mm x 600 mm. The inclination of the upper reflector part can easily be changed by a thread rod.

Figure 1 – Sound reflector

The panels are working as reflectors only at higher frequencies and in a small area in front of them [1].

Figure 2 – Sound reflector installed at the Herodes Atticus Theatre in Athens

The reflectors were installed at Herodes Atticus Theatre more than once for concerts of the "Orchestra of Colours". The acoustic results were positive, but not as expected. The effect of the reflectors in the area of the auditorium was not significant (because of the insufficient number). But the affect in the area of the choir and the orchestra was noticed by the musicians. They have declared that they could hear better each other -even if it was only a psychological effect. In order to obtain significant results, it was necessary to use double amount of reflectors as well as reflectors over the musicians, something that in ancient theatres it is not easy applicable.

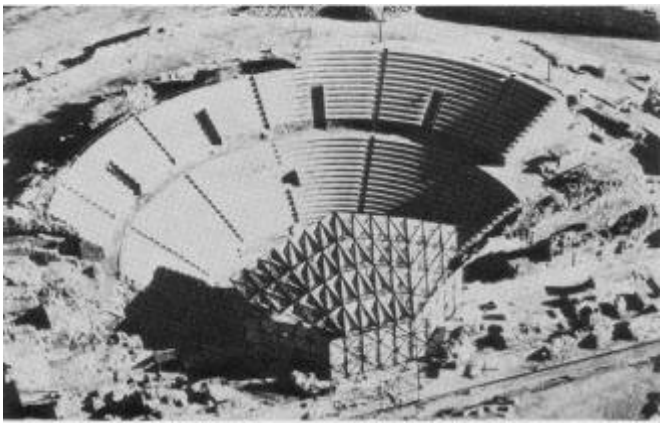
Larger and bigger amount of sound reflectors have been used earlier with satisfying results at the Roman Market in Athens in 1985 [2] during a concert of Manos Hadzidakis.

Figure 3 – Sound reflectors used at the Roman Market

3. Digital stereoscopic audio system with non apprehensible amplification

To enhance musical performances in ancient spaces as well as in every open air concert, it is necessary to provide large reflecting surfaces and it is necessary to think also about reflectors over the musicians.

This means to provide an orchestra shell. But this is almost impossible, not only due to the cost of this construction, but mainly due to the archaeological restrictions.



M. Perrakis and U. Opitz have proposed and planed a large reflector on top of the orchestra for the Herodes Atticus Theatre [4]. The reflector was demountable and stored in simple containers. Unfortunately the proposal was never materealized.

For this reasons, it seems to be more effective to use an electroacoustic system.

Figure 4 – Orchestra shell at the theatre of Caesarea [3]

The usual application of power amplification on open spaces and theaters consists two columns of loudspeakers on both sides of the scene. This solution has two problems: a) the stereoscopic effect is destroyed (the sound is coming from a different direction than the source, while the movement of the actors is not noticed acoustically), and b) there is an unequal distribution of loudness: The front auditors hear much louder the sound than the ones further back.

In order to overcome these problems, we have developed a project based on the idea to simulate through a complex intelligent digital system an imaginary big reflector over the scene.

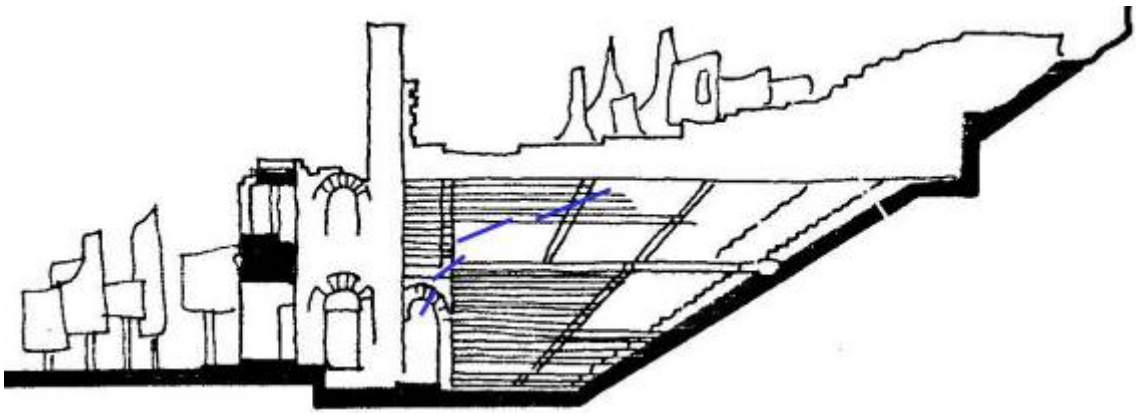


Figure 5 – The virtual reflectors are shown in blue

The simulation of the virtual reflector is based on the following idea: Loudspeakers are placed at different positions of the scene wall. The loudspeakers are acting as the image sources of the virtual reflector.

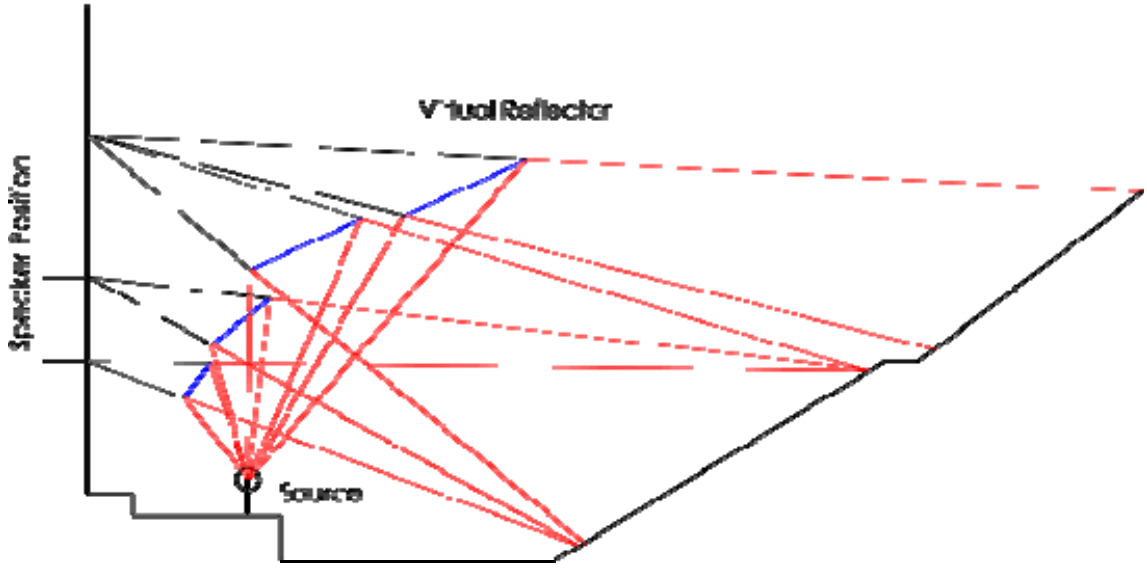


Figure 6 – Speaker positions at the image sources of the virtual reflectors

The time delay of the loud speaker signal (or the virtual reflector) is shown for the different speaker positions. The time delay is helpful for a better clarity in the audience area. The time delay can be raised electronically (up to 50 msec for speech and up to 80 msec for music) to give the impression of a bigger room to the audience. The time delay is calculated from the geometrical difference between the direct and the speaker signal divided by the speed of sound ($\Delta t = \Delta l / (340 m/sec)$).

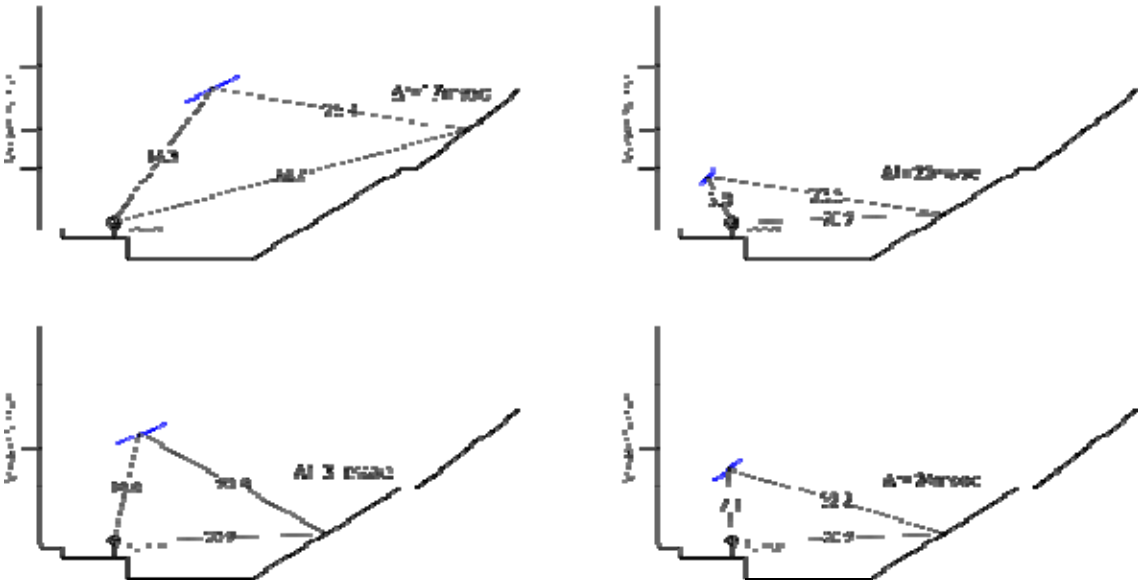


Figure 7 – Signal time delay from loudspeakers or virtual reflectors

In order to preserve the stereoscopic image of the sound source a series of hanged microphones with independent lines were used.

We had the opportunity to test this system on Herodium Theater during the performance of Mikis Theodorakis's opera "Electra" during the Athens Festival in 1995.

In the realization of the project 32 medium size loudspeakers were evenly distributed on the scene wall (marked with red).

Figure 8 – Loudspeaker positions at the scene wall of the Herodes Attikus Theatre

Also 24 microphones were hanged in two lines across the whole scene. Additional 8 pzm microphones where hidden in several positions on the scenery. In this way all the movements of the sound sources were captured and none of the singers had to carry a microphone.

The main core of the system where a 32 channel delay-line system, a 32 line console with direct out, a 32 channel A/D - D/A system and a computer with custom software. The rent cost of the whole hardware where just 20% higher than a conventional PA system.

The loudness of each loudspeaker was lower than the loudness of the source and in this way the impression that the audience had was that the sound comes directly from the singer while it is audible everywhere in the theater.

The microphones were adjusted to be sounded from the corresponding loudspeakers in the stereoscopic image and this way the stereoscopic image was completely preserved.

Although during the development of the project all the parameters were calculated, the final adjustments (delays, gains etc) were made on-site according to the subjective impression.

The result was impressive. In almost every position the audience could hear clear and loud from the true sound direction, having the impression of an extraordinary acoustic behavior. Moreover the view was not disturbed by big loudspeakers installations.

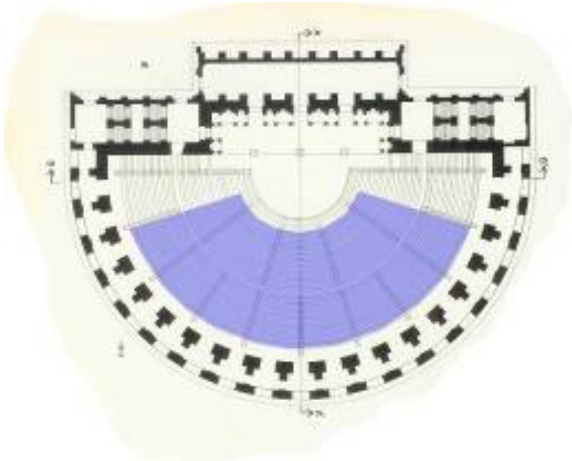


Figure 9 – The area of positive acousticsl results is shown in blue

The only acoustic week points were the two side wings of the koilon and the five first rows. The orchestra is very close to the first rows and this way the balance between the orchestra and the singers is affected. But even that can be corrected with additional small monitors for the first rows.

Unfortunately, in the following years, the EA system for all the events of the Athens Festival were taken only by one contractor who was not willing to repeat the auspicious experiment.

4. Conclusion

There are effective ways to improve the acoustics of ancient spaces applicable also to modern ones. The proposed system can be permanent installed in open theatres during all the season of the performances.

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