

# **Mozarabic Chant anechoic recordings for auralization purposes**

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## **Abstract**

The Hispanic Rite is the liturgy celebrated by Christians of the Iberian Peninsula before the imposition of the Roman Rite in the mid-eleventh century. As in other early Christian liturgies, music was the core of the Hispanic Rite. This music, known as Mozarabic Chant is one of the richest musical repertoires of the Middle Ages.

Currently, a research project is underway involving the restoration of the Hispanic Rite sound, using techniques of acoustic virtual reality. The project aims to perform the auralization of the sound of Mozarabic Chant in his primitive environment, that is, taking into account the acoustic characteristics of the pre-Romanesque churches in their original state.

For this purpose, anechoic recordings were made for a number of musical pieces representative of the Mozarabic Chant repertoire. In total eight (8) musical pieces have been recorded and interpreted, each of one, by six (6) different singers. The recordings were made using a spherical array composed by 32 microphones.

This paper describes the more relevant aspects related to the recorded musical material, the technical specifications and installation details of the recording equipment, the data processing, and a summary of the results

## **1 Introduction**

The Hispanic Rite is one of the most interesting cultural manifestations of the Middle Ages. This is the name given to the liturgy celebrated by Christians of the Iberian Peninsula prior to the introduction of the Roman cult in the mid-eleventh century.

As in other early Christian liturgies, music was the core of the Hispanic Rite. This music, known as “Mozarabic Chant” is considered without doubt, one of the richest musical repertoires of the Middle Ages, exceeding in variety to the Gregorian chant itself, since the Hispanic rite was much more prolix than the Gallo-Roman rite.

Currently, a research project is underway involving the restoration of the Hispanic Rite sound, using techniques of acoustic virtual reality. The project aims to perform the auralization of the sound of Mozarabic Chant in his primitive environment, that is, taking into account the acoustic characteristics of the pre-Romanesque churches in their original state.

Auralization is a process in which an anechoic stimulus (a sound signal recorded in an anechoic environment) is convolved with the modeled or measured binaural impulse response of a space, so that

the listener can have a binaural listening experience corresponding to the sound stimulus played in this space [1].

Anechoic recordings can be made with a single microphone in the frontal direction of the source, but if the sound source does not have an even radiation in all directions, this recording technique does not represent correctly his acoustical properties. Therefore the source directivity knowledge is important in auralization for modeling the source radiation correctly.

In order to perform the auralizations of the ancient Hispanic rite, anechoic recordings of a series of pieces of the original Mozarabic Chant repertoire have been recorded. The recordings were made with a spherical array composed of 32 microphones, in order to obtain information on the directivity of the noise emission of the singers. These directivity data will be used to simulate the directional radiation of the sound sources in the auralizations.

## **2 The Hispanic Rite and the Mozarabic Chant**

In the expansion of Christianity, by East and West in the early centuries of the Christian era, each local community adapted the liturgy in accordance with its own idiosyncrasies. Despite this, there were a number of factors of cohesion that made that different local liturgies maintained a common core. These unifying factors were, among others, the adoption of Latin as a common language for the liturgical celebrations, the reading of the sacred texts (the Holy Bible, Old and New Testament), and the tradition, inherited from the Jewish liturgy, to ornament these texts with singing.

We call "Hispanic Rite" to the liturgy of the Hispanic Church that was widely practiced by Christians in the Iberian Peninsula until the imposition of the Roman Rite in the mid-eleventh century.

Little is known about the formation of the rite and the connections and influences with other early Christian liturgical traditions. It seems that the new faith had a rapid implementation in Hispania, thanks to the evangelizing work done by the first bishops. The invasion of the Visigoths was, in its early days, a strain in the consolidation of the Hispanic liturgy, since they were followers of the Arian sect. The dispute ended when the Visigoth king Recaredo, abjured Arianism at the III Council of Toledo (589), and with him, all his court. Since then, began in Hispania a period of great creativity in terms of liturgical literature fostered by the Visigothic Court, whose peak in terms of consolidation and dissemination of the liturgy was in The 7<sup>th</sup> century, when this rite was celebrated all over the Iberian Peninsula.

The Arab invasion of the Iberian Peninsula was a severe blow to the evolution of the Hispanic Rite. Many Visigoths convert to Islam, making the Catholics of the conquered lands become minority. Despite the social and economic pressure exerted by the invaders on the inhabitants who did not convert to Islam, the Christian minority decided to persevere in its liturgy. This group of people was called "Mozarabic", ie Arabized.

When the Franks reconquered the territory corresponding to the present Catalonia, several Benedictine monasteries settled there and introduced the common rite in Rome and in the Frankish kingdom, known as the Roman rite. In addition, Pope Alexander II, began a gradual replacement of Hispanic Rite by the Roman one. The process would culminate by Pope Gregory VII, when he got that in 1080, King Alfonso VI convened the Council of Burgos which abolished the Hispanic Rite in the kingdoms of Castile and Leon.

A few years later, Alfonso VI reconquered Toledo. The Mozarabs of the city were granted with a number of privileges in recognition of their resistance and cooperation in the fight against the Arabs. Among the conferred privileges, The King granted them continuing holding their ancient liturgy in the then existing six parishes. Thus, the Hispanic Rite survived, though not without difficulties, in the following centuries, transmitted orally from generation to generation.

Cardinal Francisco Jiménez de Cisneros, when taking possession of the archbishop's seat of Toledo in 1495, became aware of the religious and cultural value of the Mozarabic liturgy, and also warned of the dangers of extinction that threatened it. To ensure the continuity of this cult, Cardinal Cisneros established the Mozarabic Chapel, assigned the chapel of Corpus Christi of the Cathedral, so that there will be held every day the office and Mass in the ancient rite, and ordered the print edition of the liturgical books and song books of the Hispanic liturgy.

The music of the Hispanic Rite is known as "Mozarabic Chant". From what we know of it, is a vocal, monodic, diatonic and rhythm free music, whose musical forms present a number of analogies with those of the Roman rite, but also presenting appreciable differences.

The liturgy of the Hispanic Rite has been documented in a large number of manuscripts. These manuscripts also contained the music that accompanied the text, but written in a kind of primitive notation that does not decrypt the sounds pitch, which makes it impossible to be interpreted. Unfortunately, the development of musical notation to a system that accurately determined the pitch of the sounds occurred simultaneously with the abolition of the Hispanic Rite in favor of the Roman rite. For this reason the copyists did not take the work of transcribing, with the new notation, a body of liturgical music that in fact was actually out of use. The oral transmission of the repertoire for centuries caused the melodies transcribed by Cisneros at the end of the 15<sup>th</sup> century, differ significantly from the ancient ones.

To date, it has only been possible to recover the music of about twenty pieces of the original repertoire [2]. Sixteen pieces from the *Oficio de Difuntos* (Office of the Dead) and three antiphons from the Office of Holy Thursday are preserved. In both cases, the melodies have been known thanks to the fact that in two original manuscripts [3] [4], someone deleted the original Visigothic neumes of these pieces and rewrote the music with Aquitanian notation. Also, and based on the comparison of the content of various manuscripts, had been recovered the original melodies of six pieces from the "Ordo de la consagración del altar" (Ordo of the consecration of the altar) and several "Preces" (invocations).

### **3 Anechoic Recordings**

#### **3.1 Recorded material and performers selection**

The musical pieces recorded have been performed by members of the musical group Schola Antiqua. Since its foundation in 1984 Schola Antiqua has focused its activities towards the study, research and interpretation of early music and especially Gregorian Chant. All of its members were formed as choirboys at the Choir School of the Sta. Cruz del Valle de los Caídos Abbey. Its repertoire covers the whole Western liturgical monody (Beneventano, Ambrosian, Mozarabic...) in its different forms, as well as the early polyphony of S. Marcial de Limoges, Notre-Dame, Ars Antiqua and Ars Nova.

Its records which are dedicated to pieces of Gregorian Repertoire are a result of its investigations and are reconstructed according to the most ancient manuscripts. They have made numerous recordings, including a monograph on the old Hispanic liturgy where the songs of the *Oficio de Difuntos* (“Office of the Dead”) according to the mozarabic tradition appear for the first time according to the mozarabic tradition. This certifies them as one of the most important musical groups in the world in the study and interpretation of this code.

A total of eight pieces of the Mozarabic Chant repertoire have been recorded. Seven of them belong to the Office of the Dead, and the eighth to the Rite of Consecration of the Altar. In order to characterize different vocal timbres, the recording has been made by six different singers. Each of them has played all the musical pieces chosen.

The music selection has been made attempting the sample to be representative of the set of parts recovered from this repertoire. Music pieces have been chosen with a varied vocal range, so that pieces were selected with different Tenor notes. Efforts were also made that there was variety in regards of his melodic style, for which pieces have been selected with different melodic characters: melismatic, pneumatic and syllabic. Finally, we tried the sample possessed diversity of musical forms, including both responsorial and antiphonal styles.

### **3.2 Recording technique**

The chosen methodology has been to record separately to each of the singers in an anechoic chamber. We performed a simultaneous recording of the sound signal with two types of microphone systems: a main system consisting of a pair of high quality and low noise microphones, to get the master signal, and a spherical array of microphones intended to measure the directivity of the voice of the singers in real-time.

To achieve proper synchronization between the different singers in anechoic recordings, a reference video was previously recorded, that pictured the indications of the director of the choir, and whose soundtrack was the full choir sound signal. The reference video was played during the recordings using a tablet that stood in the light of the singer.

In order to achieve that, during the anechoic recording, the singer had a feeling as close as possible to the perceived in a normal interpretation with the full choir, a monitoring system was mounted that provided the musician, through headphones, the sound signal from the complete choir (the soundtrack of the reference video), mixed with his own voice to which we have added some artificial reverberation.

Intentionally, the singers were not instructed in their gestures during performance. Simply they had indications on the direction in which they should sing. Thus, the directivity functions obtained shall be representative of the normal behavior of musicians, including natural movements produced during performance.

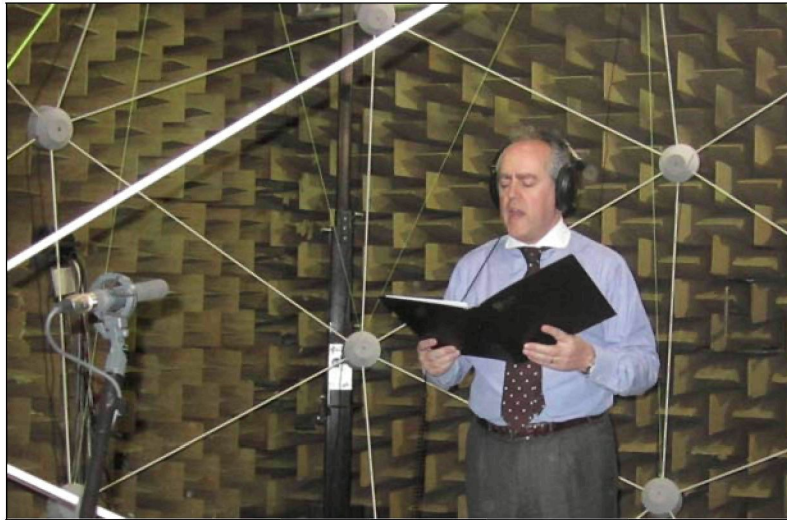


Figure 1 – Picture of one of the recording sessions.

### 3.3 Recording equipment

To manage the signal routing in a simplified manner and to provide a low noise recording environment the scenario was strictly divided into an anechoic and low noise recording room and a control room. Only one musician is in the recording room at a time minimizing possible noise contributions. The recording engineer stays in the control room, which is separated by thick walls and isolated cable ducts, to ensure noiseless recordings.

Inside the recording room 31 Sennheiser KE4 electret condenser microphones are placed symmetrically around the singer at a distance of 2.08 m. The full setup of the array places one microphone at each face of a truncated dodecahedron [5]. The microphone position underneath the singer, however, is left blank to allow a support for the musician. Two low-noise Schoeps MK2 condenser microphones are placed in front of the musician with the same distance to the singer as the array microphones and a distance of approx. 20 cm apart from each other to record a high quality audio signal for auralization. The position was chosen according to the average main direction of the directivity pattern of a singer.

All microphones are connected to stage boxes that are connected via multi-core cables to the control room. A headphone for the singer is connected via a headphone preamplifier inside the anechoic chamber. The stereo audio signal from the video playback on the Apple iPad is routed via two DI-boxes to the control room to avoid hums.

The microphones are calibrated using a pistonphone in order to account for the individual sensitivities. Custom-made absorbers around the microphones yield similar sensitivities for the directions on-axis and directions slightly off-axis, so that slight variation in the direction of the incoming sound does not change the recorded sound significantly.

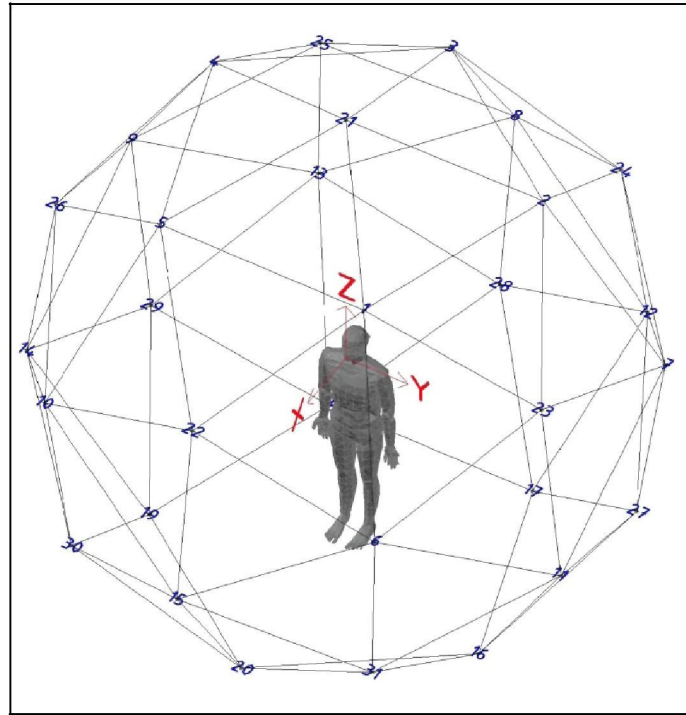


Figure 2 – Microphone array geometry.

In the control room all Sennheiser KE4 microphone channels are connected via multi-core cables to RME OctaMic microphone preamplifiers. These are connected to the PreSonus Firestudio Lightpipe via ADAT. The clock synchronization is also realized via ADAT. The Schoeps MK 2 channels and the iPad channels are connected to a PreSonus Firestudio 26x26 including microphone preamplifiers. Both PreSonus Firestudio devices are connected via Firewire protocol to an Apple MacBook Pro in a cascade and appear as a joint multi-channel sound card in Apple's Core Audio.

The signals from the Schoeps MK 2 are also used for monitoring purposes. A mixed mono signal is split and sent over an Alesis MidiVerb 4 to add some slight reverberation to the anechoic recording and then sent to a Yamaha AW2400 mixing console. The iPad audio channels are also split and sent to the mixing console where these signals are mixed with the wet microphone signals as monitoring and sent back to singer's headphones. The block diagram of the full setup as used for the recordings is depicted in Figure 3.

For multi-channel recording a software based solution was chosen consisting of an Apple MacBook Pro with Firewire and the digital audio workstation (DAW) software REAPER. All signals are synchronously recorded as independent channels and directly written to the internal hard disk of the laptop.

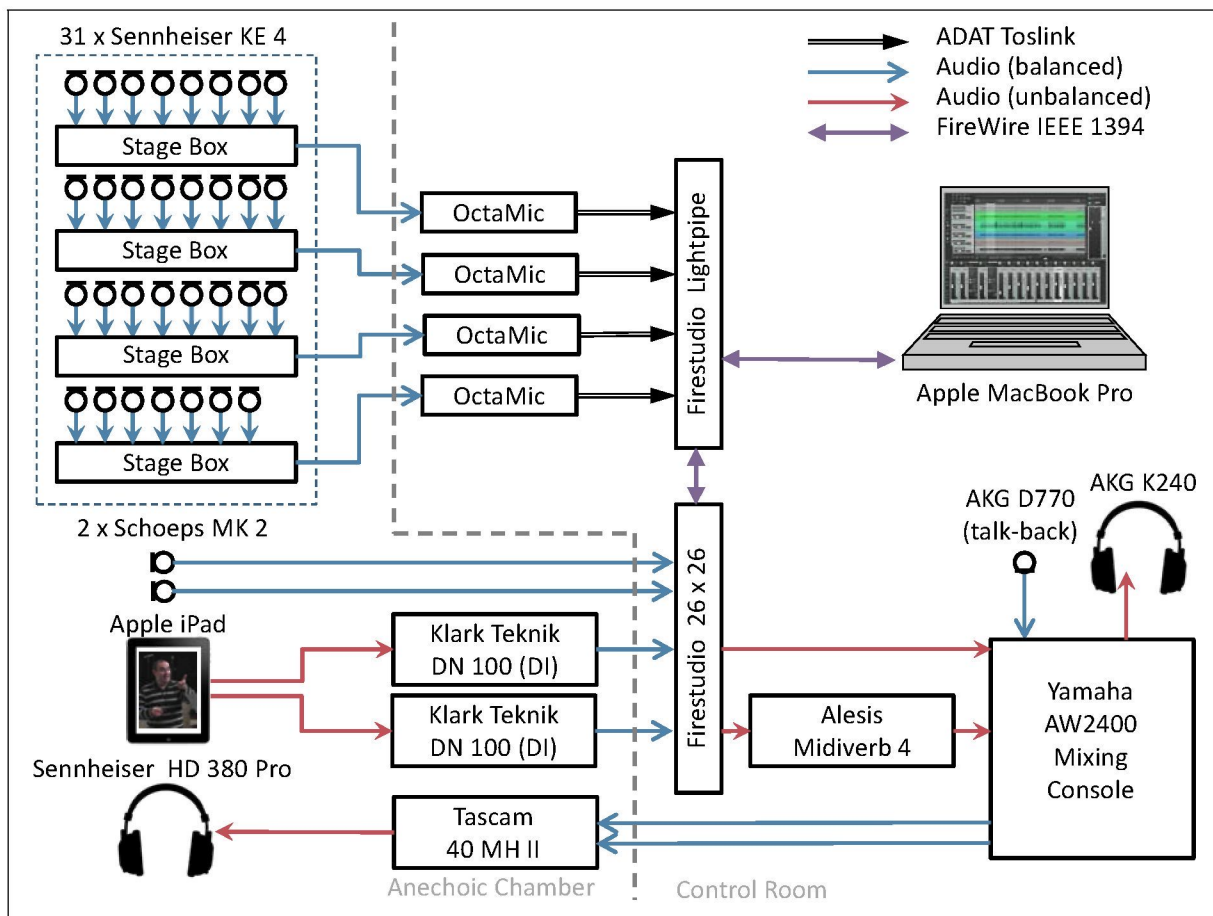


Figure 3 – Block diagram of the recording equipment.

### 3.4 Data post-processing

The result of the recording is a multi-channel audio file with synchronized data of the 31 microphones of the spherical array and the high-quality stereo recording of the studio microphones. This data can either be used as raw data in order to auralize the tone color of the singers in the discrete directions, or interpolated on a full sphere in order to obtain a spatially continuous and time variant directivity pattern of each singer. The latter is especially useful in combination with room acoustical data that are obtained for variable directivity patterns, making the auralization of the singers in different rooms or acoustic spaces possible [6]. Furthermore, the iPad channels are used to synchronize the recorded tracks from different singers.

The simulation of the full choir can be done for the individual singers at different positions, possibly even with changing positions over time, enhancing a realistic auralization and the immersion into the virtual environments.

The interpolation of the data onto a higher spatial resolution can be done by a Spherical Harmonic Transformation (SHT) of the recorded data. The discretely measured points at the 31 microphones are represented as a set of Spherical Harmonic base functions, which are continuously defined for all possible directions of sound radiation. Assuming a suitable high spatial resolution for the recordings, this transformed data can then be used to derive the sound radiation for any arbitrary direction.

## 4 Conclusions

Anechoic recordings of the music of the ancient rite Hispanic have been performed. Recorded material are planned to be used in pre-Romanesque Hispanic churches auralization, as well as in investigating the acoustical properties of singing voice.

Because of the similarities between the Mozarabic Chant and other forms of medieval liturgical monody, recorded material could also be used for the auralization of other types of medieval churches.

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