Sound Anthology: Program Notes

Binaural Representations of HDLA Music: Eric Lyon, Curator

This edition of *Computer Music Journal*'s Sound and Video Anthology complements two special issues devoted to computer music composed for high-density loudspeaker arrays (HDLAs), *CMJ* 40:4 and *CMJ* 41:1. The intent of this anthology is to share the experience of listening to music for HDLAs, to the extent that it can be reproduced, in binaural recordings. The recordings included on this anthology are all intended for headphone listening. All seven works were composed for HDLA performance. Five were recorded on-site at HDLA facilities, and the remaining two were produced with 3-D spatialization plug-ins.

This is the first *CMJ* anthology presented exclusively in binaural format for headphone listening. Binaural recordings and music performed on HDLAs both enable listeners to focus on spatial attributes of music. In other ways, listening to binaural music is nearly the polar opposite to the HDLA experience. Whereas experiencing spatial music at an HDLA performance space is inherently a social experience, headphones provide the most private listening space possible, short of internally imagined sound. And whereas HDLA facilities are still few and far between, headphones are nearly ubiquitous. And this ubiquity makes headphone listening an ideal medium for listeners who do not have access to an HDLA facility to get a sense of the spatial richness that is possible for HDLA-conceived music.

The HDLA spaces represented here are The Cube at Virginia Tech (Hagan and Nichols), The SARC Sonic Lab at Queen's University Belfast (Sazdov), and the Zentrum für Kunst und Medien (ZKM) Klangdom (Brümmer). It is fascinating to listen to these on-site HDLA recordings, which convey an impressive amount of spatial information, especially regarding elevation cues. The differences in acoustic properties of the HDLA spaces are also very much in evidence on these recordings. At the same time, the limits of on-site binaural recordings must be acknowledged. Any ambient noise in the space will be captured on the recording. And, having experienced multichannel music in the Cube, Klangdom, and Sonic Lab, I can attest that a binaural recording represents a significant reduction from the full experience of inhabiting an HDLA space during a musical performance, where one is free to move one's head, and sometimes one's body as well, to interactively explore spatially articulated sound. A binaural recording, by contrast, reports only a fixed perspective of the space. And despite the considerable spatial information conveyed with these binaural recordings, the spaces also seem to be smaller in headphone listening, as if they were shrunken around one's head for the benefit of the listening process. The remaining binaural recordings on this anthology in which the 3-D spaces were artificially produced (Barrett and Lopez-Lezcano) provide an important contrast to the on-site HDLA recordings. The artificial recordings would seem to have an advantage, in that they are using spatialization plug-ins for their intended purpose: to create a binaural impression of 3-D projection of sound into space. These recordings sound both spatially rich and qualitatively different to my ears than the on-site recordings. I'm pleased that we can offer examples of both methods of producing spatial music for binaural listening, so that listeners can form their own opinions.

Although we have focused primarily on technical aspects in these notes, this collection is, above all, a set of elegant pieces of computer music, created by artists with a keen sense of the possibilities of spatial articulation as a central element in musical construction. There is much to be learned by careful listening to each of these works. After listening once for technical details, I hope you will then go back and enjoy the collection again as a curated concert for headphone listening. As with all headphone use, I recommend listening at a moderate volume level. It is not necessary to play this music loudly to appreciate its spatial subtleties.

About the Music

We begin with *Spin*, a large-scale work by Ludger Brümmer. The main material for the work is produced through interpreting data files as sound. This noisy material is articulated harmonically, formally, and timbrally, and then orchestrated and clarified by spatial articulation in 32 discrete channels for the ZKM Klangdom. The spatial element is both contrapuntal, and, in some very beautiful passages, articulated by slow spinning of the sound field. As with the rest of the music on this anthology, *Spin* is best enjoyed with eyes closed. The work was recorded on-site on the Klangdom of the ZKM Kubus, and this recording bears traces of the lovely acoustics of that wood-paneled hall.

Robert Sazdov's rich, dramatic composition *Sveti Kliment* focuses on creating the subjective impression of *engulfment* for the listener. This recording is particularly effective at capturing elevation cues necessary for the effect that Sazdov is working to achieve. The work was recorded in the Sonic Lab of the Sonic Arts Research Centre at Queen's University Belfast.

Kerry Hagan's *Morphons and Bions* is based on noise-like sounds, and largely retains the broadband aspect of these sources, which are optimal for localization. The algorithmic design of Hagan's composition lends itself well to reconfiguration for alternative HDLA performance spaces. In this recording, a fixed-media 32-channel version was prepared for binaural recording in the Cube at Virginia Tech. *Morphons and Bions* starts out quite sparsely, and gradually builds

to considerable density and intensity. Even at its points of maximum density, the spatial articulation remains clear.

In Charles Nichols's *Il Prete Rosso*, a live violinist's sound is captured, recombined, and spatialized throughout the performance hall. Violinist Sarah Plum performs the virtuosic part with vigor and intensity. The work was composed for the 124.4 HDLA in the Cube at Virginia Tech, where this binaural recording was produced. The spatial trajectories, including elevation cues, are clear and vivid in this recording, benefitting from both the dry acoustics of the Cube and the familiarity of the violin sound. The canny choice of bariolage arpeggiation as the primary musical material provides rapid articulations that are much easier to localize in space than more sustained material would be. A motion sensor, designed and built by the composer and mounted on the violinist's right wrist, provides a layer of filtering on the violin sound, directly connecting changes in timbre to the physical motion of the performer's bowing.

Natasha Barrett's *He Slowly Fell and Transformed into the Terrain* is the first recording on this anthology that was not recorded on-site at an HDLA facility, but rather directly encoded to binaural format with the Harpex encoder. Listeners will find it of great interest to compare this recording with the on-site HDLA recordings, particularly in their different senses of spatial environment. This composition provides a spatial feast for the ears, with a wide variety of spatial trajectories, perceived distances, and elevations, often presented simultaneously in a rich spatial counterpoint. The work owes much to the acousmatic tradition, with a striking and varied gestural language and a broad vocabulary of sound sources that lend themselves

well to spatial articulation. It is very easy to imagine the additional power that this work would take on when projected over an HDLA.

Fernando Lopez-Lezcano's *Space, S[acred | ecular]* is also directly encoded to binaural format. The model for the artificial acoustic space of this work comes from Hagia Sophia, one of the great surviving examples of Byzantine architecture, whose acoustics have been studied by researchers at Stanford with the goal of digital recreation of the acoustics of the space. *Space, S[acred | ecular]* thus brings a rich existing acoustic model to its spatial world, as is readily apparent in the binaural version presented here. Having heard the work performed in the Virginia Tech Cube, I can attest that *Space, S[acred | ecular]* benefits greatly from being able to breathe freely in an HDLA facility, given the magnificent physical architecture that underwrites its spatial imagination.

The anthology concludes with *mirage 4* by Gerriet K. Sharma. This work was recorded in the Karl-Schussler Hall at Technische Hochschule Köln. This hall does not have an installed HDLA. Instead, the spatial projection is accomplished with an icosahedral loudspeaker, which projects beams of sound in all directions. Simultaneous projection of multiple trajectories is a striking feature of this work, which translates well to the binaural recording presented here. The slow and sparse textural language of the composition allows us to end the collection on an appropriately pensive note.

1. *Spin*—Ludger Brümmer

After working with granular synthesis and physical models, I became interested in a sound quality that was more or less already present in all of the

techniques used: noise. The sounds I have used in this work started with digital noise. These sounds resulted from video or data files that were read as raw data into a sound editor, then modified so that the information structure inside the video file became audible. Of course, I was looking for files with a considerable amount of periodic information included so that this could be interpreted as a more-or-less pitched or repetitive sound quality. After modifying these sounds, they were cross-composed with other algorithmic structures I had previously created. This process resulted in different, more-or-less noisy sounds ranging from hiss to "dirty" timbres.

In conjunction with samples of string instruments and modified voices, I created the narrative form of *Spin* with the intention of generating an experience of noise. The sound structures were mixed and separated again for the 32-channel spatial version of the work, which on this recording is reduced to stereo. It was the aim to mix the dense structure in the concert space by moving it through a cluster of speakers. This enables the listener to experience a world of sound containing a perceptual and auditory focus from inside an individual perspective, while revealing many other features. Of course, the stereo version can only reproduce a fraction of this, but it still provides a good idea of the potential of the work.

Production Notes

The recording took place on 1 December 2016 in the Kubus of the ZKM Karlsruhe (http://veranst.zkm .de/Kubusindex.html). The recording engineer was Alexandre Rodrigues. A Neumann KU100 dummy-head microphone was placed at a height of 1.5 meters in the center of the Klangdom. The Klangdom consists of

Figure 1. Ludger Brümmer.

Figure 2. Robert Sazdov.

43 Meyer Sound UPJ-1P loudspeakers and 4 HP700 subwoofers.

Ludger Brümmer was born and raised in Werne, Germany. He received his master's degree in psychology and sociology at University Dortmund and completed composition studies with Nicolaus A. Huber and Dirk Reith at the Folkwang Hochschule Essen. He collaborated with choreographer Susanne Linke on the work *Ruhrot* and with the Nederlands Dans Theater with his orchestral work *Riti Contour*. International performances of his work have taken place at GRM, Paris, and at ICMC conferencess in San Jose, Tokyo, Banff, and Thessaloniki. He has been a visiting scholar at the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford University; a teaching assistant at the Folkwang Hochschule, the Technische Universität (TU) Berlin, and the School of Design Karlsruhe; a research fellow at Kingston University; and a lecturer for composition at the Sonic Arts Research Centre Belfast. Since 2003 he has been the head of the Institute for Music and Acoustics at ZKM Karlsruhe and guest professor at the School of Design. He is a member of the Academy of the Arts, Berlin. Notable performances include the operas *Amazonas* (Biennale Munich and SESC [Social Service of the Commerce] Pompeia, São Paulo, 2010) and *The Origin of Noise—The Noise of Origin* (Donaufestival Krems, 2012).

Brümmer's focus is in physical modeling of sound, video, granular synthesis, other techniques for sound synthesis, spatial music, and databases. Awards: Folkwang Award Essen, WDR Award Cologne; Busoni Award Academy of the Arts, Berlin; Golden Nica Ars Electronica 1994 and second prize at the Ars Electronica 1997; Larry Austin Award from ICMA; Pierre d'Or Bourges 1997 and 2001; first prize at the rostrum for electroacoustic music by UNESCO; Musica Sacrae 2001, Fribourg Switzerland; Menzioni D'Onore at the Luigi Russolo Award, Italy; and the Stockholm Electronic Music Award.

2. *Sveti Kliment*—Robert Sazdov

The composition *Sveti Kliment* (2007) implements various spatialization techniques based on perceptual research and psychoacoustics. These include techniques to exploit the elevated loudspeakers within the multichannel setup in the Sonic Lab of the Sonic Arts Research Centre (SARC), Queens University, Belfast. The aim was to generate a sense of being covered by sound—*engulfed*, and not simply *enveloped* ("surrounded by sound"). The composition was inspired by Saint Clement of Ohrid (ca. 840–916 CE), patron saint of Ohrid, the Republic of Macedonia, and the Macedonian Orthodox Church, whose life was committed to research, teaching, and improving the lives of those in his diocese. He was considered the most learned of Saint Cyril's and Saint Methodius's disciples, and he not only improved the Cyrillic alphabet, but was also a prolific writer and translated various texts using the Cyrillic script. In 886, he established in Ohrid a center of higher learning, best described in modern terms as a university, which during its existence taught literature, language, medicine, music, art, and agriculture to over 3,500 students.

Production Notes

The recording was undertaken in the Sonic Lab at SARC. The Neumann KU100 dummy-head microphone was used for the recording and positioned in the "sweet spot" of the audience seating area. The KU100 was set up at a height of 120 cm to reflect the average height of a seated person. The acoustic panels in the Sonic Lab were lowered to create a reverberation time RT60 of 0.2 sec as used in electroacoustic music concerts such as the Sonorities Festival of Contemporary Music. The recording was done by the composer and recorded using a Digidesign Digi 002 interface and Digital Performer software on 25 February 2007.

Robert Sazdov is a composer and experimental psychologist. His compositions have received prizes and

Figure 3. Kerry L. Hagan.

awards from various organizations and institutions including the Pierre Schaeffer Competition, the Musica Nova Competition, the Sonic Arts Awards, the Bourges International Competition, and the Audio Engineering Society. His work has been performed at festivals and concerts, with recent performances at inSonic–ZKM, STEIM, the International Conference on Spatial Audio, the New York Electronic Music Festival, PURE Ambisonics–IEM, and Gaudeamus. Sazdov's current research focus is on the perception of three-dimensional sound and formulating compositional approaches for immersive loudspeaker setups, as well as formulating terminology for describing three-dimensional sound. He has taught at institutions including the Western Australian Academy of Performing Arts, Edith Cowan University; Digital Media and Arts Research Centre, University of Limerick; the Film Academy; University of Goce Delchev; and the Sydney Conservatorium of Music, University of Sydney. He was recently employed as a scientific researcher at Fraunhofer Institute (IIS), International Auditory Laboratories, Erlangen. He currently teaches in the School of Communication at the University of Technology, Sydney.

3. *Morphons and Bions*—Kerry L. Hagan

Morphons and Bions is a real-time Pd composition that explores noise-based synthesis techniques and random processes to create the impression of living mechanisms. These mechanisms live and grow independently until reaching a critical mass, when they become a single organism. The morphologically independent sounds combined with the sounds that behave together as a single organ give rise to the title. As a real-time piece, the details of each realization change from performance to performance, although the consistent timbres and overall form of the work retain the piece's identity.

All sounds in the work are synthesized. The sound sources rely fundamentally on white noise and digital noise mediated by classical synthesis techniques and random processes. Because the work is built on a substrate entirely made of noise, the piece is situated within certain philosophical and aesthetic issues surrounding noise, its use, and its definition. This piece is not, however, "noise music." Despite the acoustic groundings in noise, the sounds exhibit harmonic and quasiharmonic behaviors, especially as the sounds develop in the course of the work. Ultimately, the piece crosses back and forth over the thin line of "sound" and "noise," where both are valid musical materials.

Production Notes

Recorded in the Cube at Virginia Tech on November 28, 2016. Sound engineer: Tanner Upthegrove. Microphone: G.R.A.S. 45BB KEMAR Head and Torso Simulator.

Kerry L. Hagan is a composer and researcher working in both acoustic and computer media. She develops real-time methods for spatialization and stochastic algorithms for musical practice. Her work endeavors to achieve aesthetic and philosophical aims while taking inspiration from mathematical and natural processes. In this way, each work combines art with science and technology from various domains. Her works have been performed in San Diego, Belfast, Dublin, Paris, Berlin, Tokyo, New York, Toronto, Sydney, and Perth, among others. As a researcher, Hagan's interests include real-time algorithmic methods for music composition and sound synthesis, spatialization techniques for 3-D sounds, and electronic and electroacoustic musicology. Her research has been presented at ICMC, SMC, and EMS conferences in Montreal, Berlin, Belfast, Crete, New Jersey, Perth, Texas, and elsewhere. In 2010, Hagan led a group of practitioners to form the Irish Sound, Science and Technology Association, where she served as President until 2015. Currently, Hagan is a lecturer at the University of Limerick in the Digital Media and Arts Research Centre. She is the principal investigator for the Spatialization and Auditory Display Environment (SpADE).

4. *Il Prete Rosso*—Charles Nichols

Il Prete Rosso, for amplified violin, motion sensor, and computer, was inspired by the violin concertos of Italian baroque composer and virtuoso violinist Antonio Vivaldi, who was nicknamed The Red Priest because of his red hair and Catholic ordination. In the piece, the amplified violin is recorded live and played back in four parts, spatialized around the audience, as an accompaniment with itself. Following the violinist, a computer musician triggers wah,

Figure 4. Charles Nichols.

Figure 5. Natasha Barrett.

phaser, and delay effects that process the amplified violin. A motion sensor on the hand of the violinist tracks bow-arm performance gestures, to interactively control the frequency sweep of the wah effect. The piece was written for Sarah Plum, with a commission from Drake University. The full premiere was performed in the 124.4-channel spatial audio system installed in the Cube of the Moss Arts Center at Virginia Tech.

Production Notes

The Cube of the Moss Arts Center at Virginia Tech; Holophone H3 surround sound microphone, Allen & Heath GSR24M preamplifier with 48-kHz sample rate and 24-bit depth, Steinberg Cubase, MacBook Pro; Recording engineer: Tanner Upthegrove, 1 December 2014.

Composer, violinist, and computer music researcher **Charles Nichols** (www.charlesnichols.com) explores the expressive potential of instrumental ensembles, computer music systems, and combinations of the two, for the concert stage, and collaborations with dance, video, and installation art. His research includes motion capture for musical performance, spatial audio, data sonification, telematic performance, and haptic musical instrument design. He teaches Composition and Creative Technologies at Virginia Tech, and is a Faculty Fellow of the Institute for Creativity Arts and Technology. He has earned degrees from Eastman, Yale, and Stanford, and previously taught at the University of Montana, where he directed the Mountain Electroacoustic Laptop Ensemble (MELEe) and the Composers' Workshop Pierrot Ensemble. He has conducted research as a visiting scholar at the Sonic Arts Research Centre at Queen's University Belfast, taught computer music workshops at the Banff Centre, Charlotte New Music Festival, University of Rome, and the Center for Computer Research in Music and Acoustics at Stanford University, and composed as a resident at the Ucross and Brush Creek artist retreats. His recent premieres include *Beyond the Dark*, ambient synthesized sound for installation art and 3-D projection; *Epimetheus Gift*, a densely textured and spatialized piece for amplified bassoon, computer, and ambisonics, inspired by the Swedish extreme metal band Meshuggah; *Sound of Rivers: Stone Drum*, a multimedia collaboration with sonified data, electric violin, and computer music, accompanying narrated poetry, dance, animation, and processed video, based on scientific research into the sound of rivers; and *Nicolo, Jimi, and John*, a three-movement concerto for amplified viola, orchestra, and computer, inspired by the virtuosity of Paganini, Hendrix, and Coltrane.

5. *He Slowly Fell, and Transformed into the Terrain*—Natasha Barrett

"The metal horses had lost their colour. The leaves dry, the stones worn, the ice froze, then waned. He slowly fell, and transformed into the terrain."

This composition—a fiction—takes the listener on a journey in the mind of a character born to explore the harmony between human constructions and nature. As constructions begin to take over, he needs to find a new balance. He slowly falls from the enjoyment of a fairground carousel, and the allure of the natural terrain overwhelms his being. The new balance gradually embodies a landscape of dry leaves and lost children, worn stones, melting snow, and a final release into abstraction. *He Slowly Fell, and Transformed into the Terrain* is in two sections: a main journey and a final coda. The work was commissioned by Electric Audio Unit (EAU) with funds from the Norwegian Cultural Council.

Production Notes

The work has been composed in sixth-order 3-D Ambisonics (HOA). The spatialization applied IRCAM's Spat package (http://forumnet .ircam.fr/product/spat-en), the

Figure 6. Fernando Lopez-Lezcano.

composer's own unpublished 3-D higher-order Ambisonics (HOA) granulation software Granddad, and Ambisonics recordings using the Soundfield SPS200 microphone. The binaural version has been rendered with Harpex (http://harpex.net) from the Ambisonics encoded stream.

Natasha Barrett (www.natashabarrett .org) is a composer, performer, and researcher in the field of contemporary electroacoustic art music. She received her doctoral degree in 1998 from City University in London and has since followed a career predominantly as a freelancer.

Her work encompasses acousmatic and electroacoustic concert composition, sound installations, theater music, large-scale outdoor media productions, sound-architectural works, and interactive art. She regularly collaborates with designers and scientists, as well as musicians and visual artists. Her work is inspired by acousmatic sound and the aural images it can evoke, particularly in terms of the evocative implications of space. Besides her compositional activities, she has been employed as a researcher at the Department for Musicology, University of Oslo, and is currently engaged as a professor in electroacoustic composition at the Norwegian State Academy for Music.

Barrett's works are performed and commissioned throughout the world and have received a long list of prizes. These include the Nordic Council Music Prize (Nordic Countries), first prizes in the Giga-Hertz Award (Germany), Edvard Prize (Norway), jury and public first prizes in Noroit-Leonce Petitot (France), five first prizes and the Euphonie d'Or in the Bourges International Electroacoustic Music Awards (France), Musica Nova (Prague), CIMESP (Brazil), Concours SCRIME (France),

International Electroacoustic Competition Ciberart (Italy), two prizes in Concours Luigi Russolo (Italy), two first prizes in the International Rostrum of Electroacoustic Music, and an honorary mention at Ars Electronica.

6. *Space, S[acred | ecular]—* **Fernando Lopez-Lezcano**

Hagia Sophia in Istanbul, Turkey, was once a cathedral, then a mosque, and is now a secular museum. Its main dome rises up to a height of 180 ft (55 m) and the building is one of the greatest surviving examples of Byzantine architecture. The Icons of Sound group at CCRMA, Stanford University, and the Arts and Art History Department at Stanford sought to digitally recreate its acoustics so that music created centuries ago for that space could be "heard" again as intended (at least virtually). The highlight of the still-ongoing project was a Stanford Live concert in the 2013 opening season of the Bing Concert Hall at Stanford ("From Constantinople to California"), in which the Cappella Romana singers, a group specializing in Byzantine chanting, performed live within a computer-simulated 3-D rendering of the Hagia Sophia acoustics, inside Bing itself.

This recreation of Hagia Sophia remains frozen in the digital domain, and was the foundation and inspiration for the creation of this piece over a week of intense work in the Kubus at the Zentrum für Kunst und Medien (ZKM), Karlsruhe. It was also the testing ground of a new reverberation architecture that enabled the composer to work completely in the Ambisonics domain, creating sound fields that are independent of the number and location of the rendering speakers. This 3-D environment

created a natural and convincing re-creation of this enormous space, in which the reverberation supports and maintains the spatial information of the music rendered within it. More work on the piece was done later at the CCRMA Listening Room and the composer's private studio.

The interplay between the secular and sacred aspects of Hagia Sophia, as well as the precise tailoring of percussion and vocal sounds into musical form inside the simulated space, created the rest.

Production Notes

This binaural rendering was created from the original fifth-order Ambisonics master by using the Ambix Ambisonics binaural decoder. The composer used the SARC Sonic Lab reduced set preset, which includes separate early and late impulse response components and decodes the full fifth-order Ambisonics signal to 32 virtual sources, which are convolved with the stereo impulse responses of each speaker as recorded in the hall (the recordings were done with a Neumann KU 100 dummy head).

Fernando Lopez-Lezcano enjoys imagining and building new things, fixing them when they don't work, and improving them even if they seem to work just fine. The scope of the word "things" is extensive, and includes

Figure 7. Gerriet K. Sharma.

computer hardware and software, controllers, music composition, performance, and sound. His music blurs the line between technology and art, and is as much about form and sound processing, synthesis, and spatialization as about the algorithms and custom software he writes for each piece. He has been working in multichannel sound and diffusion techniques for a long time, and can hack Linux for a living. At CCRMA, Stanford University, since 1993, he combines his backgrounds in music (piano and composition), electronic engineering, and programming with his love of teaching and music composition and performance. He discovered the intimate workings of sound while building his own analog synthesizers an exceedingly long time ago, and even after more than 30 years, "El Dinosaurio" is still being used in live performances. He was the Edgard Varèse Guest Professor at the TU Berlin during the summer of 2008. In 2014, he received the Marsh O'Neill Award for Exceptional and Enduring Support of Stanford University's Research Enterprise.

7. Mirage 4—Gerriet K. Sharma

The work *mirage 4* was developed and composed in 2015 for and with the IKO, the icosahedral loudspeaker developed at the Institute of Electronic Music and Acoustics (IEM) at ZKM. It is part of the series of 6 works that summarize the artistic research on "Sculptural Sound Phenomena in Computer Music" from the composer's doctoral project.

The composition blends the three basic sculptural categories kernel plastic, spatial plastic, and kernel–shell principle, all deduced from theories of sculpture and translated into spatial sound composition in the loudspeaker domain.

The Mirage project is not meant as a collection of experimental practices nor as yet another spatial composition—it aims for an aesthetic practice that composes space, using space as a plastic, sonic material. The project aims to find a poetic approach to using complex environments in contemporary media art for creating self-evident and unique experiences that make a strong difference to ordinary setups as in cinema, television, or home 5.1 surround sound, and that invite the listener to share an extended ontology of sonic spatial arts.

Production Notes

17 November 2016, 8 PM

IKO Cologne Concert, at Karl-Schüssler Hall, Technische Hochschule Köln (TH Köln – University of Applied Sciences)

Binaural recording and editing: Neumann KU100 (#01316) (positioned approximately in the middle of the room), 1.2 m ear height -> RME Babyface (48 V, +30 dB) -> Mac Book Pro -> Reaper (24-bit, 44.1 kHz) -> +10 dB -> NoiseShaping -> Rendering WAV 16-bit, 44.1 kHz.

Recording engineer: Frank Schultz (Sonible).

Room characteristics: average reverberation time RT60 = 1.35 sec, bass ratio BR = 1.05.

Gerriet K. Sharma (www.gksh.net) is a composer and sound artist. He studied Media Art at the Academy of Media Arts Cologne and Composition and Computer Music (KUG) at the University of Music and Performing Arts Graz. In October 2016 he completed his doctorate at the KUG with a dissertation on "Composing Sculptural Sound Phenomena in Computer Music." Gerriet K. Sharma lives in Cologne, Luzern, and Graz. In the last ten years he was deeply involved in spatialization of electroacoustic compositions in Ambisonics and wave-field synthesis and in transformation into 3-D sound sculptures. From 2009 to 2015 he was curator of the Signale Graz concert series for electroacoustic music, algorithmic composition, radio art, and performance at the MUMUTH Graz. His works were presented at the SPARK Festival of Electronic Music and Art, Minneapolis, 2006; the New York City Electroacoustic Music Festival 2009 and 2016; the DAFx-10 International Conference, Graz, 2010; the International Conference for Spatial Audio (ICSA), Detmold, 2011; the International Conference on New Interfaces for Musical Expression (NIME), Oslo, 2011; the ELIA-Art Schools NEU/NOW Festival, Vilnius, 2009 and 2011; the Darmstadt International Summer Course for New Music 2014; the Music Biennale Zagreb 2015; and the Sound and Music Conference (SMC) 2016. He received numerous awards and grants. He was scholarship holder of the

German Academic Exchange Service (DAAD) in 2007 and 2009. In 2008 he was awarded the German Sound Art Award. In 2007 and 2010 he was Artist in Residence at Pact Zollverein Essen, working on his concept of sculptural sound projection and formation. During his 2011–2013 residency at the Institute of Musicology in Wuerzburg, Germany, he conceived and established the Atelier for Sound Research. In spring 2014 he was composer in residence at ZKM Karlsruhe. Currently, he is senior researcher and composer within the three-year artistic research project "Orchestrating Space by Icosahedral Loudspeaker" (OSIL) funded by the Austrian Science Fund (FWF).