SPATIAL LISTENING AS AESTHETIC PRACTICE AND METHOD: PHENOMENOLOGICAL APPROACHES TO IMMERSIVE SOUND ENVIRONMENTS

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1 INTRODUCTION

The development of immersive, spatialised 3D-audio listening environments has had a significant impact on the modalities of auditory perception and the aesthetic experience of soundspace. At the core of such environments lies a dual construct: the embodied soundspace, in which the listener's physical and perceptual presence in space becomes central to the sonic experience; and the mediated soundspace, which is technologically structured through electroacoustic diffusion systems, software architectures and spatialisation interfaces. The analysis of these dimensions through a methodological lens and its context enables a more profound understanding of how sound might be perceived as an auditory phenomenon that co-emerges with the listener's orientation, movement and sensory engagement.

2 PHENOMENOLOGICAL APPROACHES TO IMMERSIVE SOUND ENVIRONMENTS

2.1 Embodied spatial listening: Sound as situated experience

In embodied soundspaces, spatial listening might be defined as a multisensory and corporeal activity. The listener is able to inhabit the soundfield as a mobile and affective agent whose perception is conditioned by several factors including body awareness, orientation and kinaesthetic awareness. The concept of acousmatic listening, as initially defined by Pierre Schaeffer, [1] is recontextualised within contemporary immersive environments. In such contexts, the source of sound may be hidden or abstracted, yet the spatial behaviour of the sound – the manner in which it envelops, locates and interacts with the listener – becomes the primary aspect.

François Bayle's Acousmonium, developed at INA-GRM in the 1970s, is regarded as a pioneering work in the field of embodied soundspaces, despite its utilisation of acousmatic principles. This instrument is composed of a system of loudspeakers, each possessing distinct geometrical forms and acoustic properties. It facilitates the projection of sound in a three-dimensional manner across an array, thereby enabling performers to manipulate sonic material in real time. [2] The MOTUS Acousmonium, a more recent and mobile evolution of Bayle's concept, similarly prioritises diffusion artistry over static reproduction, inviting listeners to experience a field of sound in continuous flow. [3] The Audium, developed by Stan Shaff in San Francisco, was among the first fixed-location theatres dedicated solely to spatialised sound. The architectural integration of speakers, distributed across walls, floors and ceilings, creates a unique embodiment of soundspace with a theatrical character. In this embodiment, composers themselves spatialise their own works. [4]

The concept of embodiment is further emphasised in the BEAST (Birmingham ElectroAcoustic Sound Theatre) system, which was founded by Jonty Harrison. The BEAST platform has been developed as a pedagogical, performative and creative tool, with the objective of encouraging interaction between composers and performers working in the field of spatial audio. The platform fosters an ecology of listening that incorporates subtle gestural and spatial nuances. These environments illustrate how

spatial sound composition becomes a choreographed encounter between the creative work, the technological system and the listener's sensory agency. [5]

A significant illustration of this performative embodiment can be identified in the oeuvre of Annette Vande Gorne, whose practice with acousmatic spatialisation is characterised by both gestural and dramaturgical elements. In her diffusion performances, particularly those which utilise the Musique & Recherches Acousmonium in Belgium, Vande Gorne develops a language of spatial phrasing and energetic contour, thereby transforming spatialisation into a form of physical articulation. Her approach treats space as a narrative and expressive dimension and not merely as a technical domain. [6]

The bodily gestures of the performer, whether visible or implied, serve as a medium for the transmission of sonic energy across the speaker array, thereby engaging listeners in a dynamic process of embodied listening. In this context, space and sound become inseparable agents of meaning.

2.2 Mediated soundspaces: Technological infrastructures of perception

The mediated aspect of soundspace refers to the ways in which technological infrastructures shape and articulate auditory experience. Here, the sonic field is not naturally occurring but engineered—through speaker arrays, digital signal processing, spatialisation algorithms and interfaces. These systems act as mediators in the aesthetic encounter, thereby extending the composer's palette to encompass not only timbre and rhythm, but also topology, depth and motion.

The Spherical Concert Hall, or *Kugelauditorium*, was designed for Karlheinz Stockhausen at the 1970 Osaka EXPO and is an exemplar of the early ambition to fully mediate sound in three dimensions. Utilising a spherical speaker array to project electronic sounds omnidirectionally, Stockhausen sought to create a space in which sound could literally orbit the listener, anticipating by decades the principles of 3D audio and object-based spatialisation.

New halls for listening must be built to meet with demands of spatial music. My idea would be to have a spherical chamber, a platform, transparent to both light and sound, would [sic] *be hung for the listeners. They could hear music coming from above, from below and from all directions*.

Stockhausen's statement from 1959 has been cited as a source of inspiration for the imagination with regard to its conceptualisation of new spaces and configurations of sound. This has been particularly influential on sound artists, architects and composers. Furthermore, his notion of an intermediate spherical chamber has been identified as a key element in the conception of three-dimensional sound paths in space. [7][8]

A pioneering precedent for these systems can be found in the *Philips Pavilion*, a design by Le Corbusier and Iannis Xenakis for the 1958 World's Fair in Brussels. The performance of two compositions of a pioneering nature within the domain of spatialised electronic music was set against a backdrop of a multimedia architectural environment. The pieces in question were Edgard Varèse's *Poème électronique* and Iannis Xenakis's *Concrete PH*. [9][10]

The pavilion's hyperbolic paraboloid geometry, conceived by Xenakis, functioned as a radical visual structure but also as a sonic amplifier and sculptural resonator. The implementation of hundreds of loudspeakers within the structure facilitated a dynamic spatial projection of sound, synchronised with both projected visuals and architectural lighting. The audience's physical movement through the space resulted in an engagement with a shifting audio-visual environment, thereby challenging conventional notions of performance and immersion. This early integration of architecture,

composition and spatial sound foreshadowed many principles of today's embodied immersive environments. [11] At the time, Corbusier's concept of *synthèse des arts* was for architecture, colour, music and image to melt together as a unity. Kees Tazelaar has authored an article [12] in which he elucidates the challenges encountered during the conception and construction of the Philips Pavilion in achieving these objectives in a satisfactory manner for Corbusier, within specified limitations.

In a more recent context, the Sound Dome at the ZKM | *Zentrum für Kunst und Medien* in Karlsruhe represents a sophisticated environment for immersive audio production. The Sound Dome has been equipped with a hemispherical speaker array consisting of up to 47 full-range loudspeakers and four subwoofers (43.4 CH). It utilises Higher-Order Ambisonics (HOA), among other technologies. This enables composers and researchers to articulate sound in three-dimensional space with exceptional spatial resolution and precision. [13]

This infrastructure transcends conventional stereo or multichannel diffusion formats by enabling the continuous and smooth transmission of sound throughout a three-dimensional space that surrounds the listener, including the vertical dimensions. In this sense, the Sound Dome enables real-time spatial composition and performance, allowing sound trajectories and spatial textures to be sculpted as live, dynamic phenomena. It can therefore be argued that the space in question evolves into a responsive, performative medium in its own right, rather than merely serving as a vessel for playback.

Artists working within the ZKM Sound Dome, including figures such as Natasha Barrett, Hans Tutschku, Luc Ferrari or Beatriz Ferreyra, have delved into the exploration of these spatial affordances as a constituent element of their compositional practices. In their artistic pursuits, these creators have approached space as an active and malleable dimension that plays a pivotal role in shaping the form and perception of their artistic endeavours. In Barrett's oeuvre, for instance, environmental recordings and synthetic materials are mapped onto three-dimensional trajectories, thereby creating immersive soundscapes that transform the listener's perceptual orientation. Ferrari's artistic oeuvre frequently engages with concepts of language, memory, gesture and spatial location, giving rise to the unfolding of sound narratives that are characterised by a dual reliance on both spatial dramaturgy and spectral development. [14] [15] [16] [17]

This shift towards spatial thinking in composition is congruent with overarching trends in sound art and electroacoustic practice wherein space is regarded as an expressive terrain — a locale of aesthetic, perceptual and even political engagement. The immersive quality of the Sound Dome facilitates the evocation of virtual architectures, the simulation of acoustic environments, and even the challenge of the listener's sense of bodily presence and orientation.

By facilitating compositions that engage distributed auditory surfaces, sonic topologies and spatialised dramaturgies, the Sound Dome and analogous immersive systems (e.g. the *Hexadome* in Berlin, the *Satosphere* in Montreal, the *CNMAT's spherical loudspeaker*, or the *AlloSphere* at UCSB among others) are redefining the very notion of the auditorium. These infrastructures shift the focus away from fixed-point listening toward relational, embodied and spatially enacted experiences, positioning the listener as an active participant in a field of dynamic sonic forces. These spaces serve not only as a medium for the presentation of sound; they are also inherently spaces that are created by sound. This serves to illustrate the remarkable possibility of generating spatial dimensions through the utilisation of sound and, conversely, the generation of sound within a spatial context.

The *Hexadome*, [18] a collaborative initiative by the Institute for Sound and Music (ISM) and ZKM | Zentrum für Kunst und Medien, is an innovative development that explores the potential of spatialised media. It achieves this by integrating 360° panoramic video projection with a spatial audio system powered by Klangdom technology. This hybrid environment fuses visual and sonic elements into a multisensory architectural structure, thereby redefining how audiences perceive and experience immersive environments. The *Hexadome* represents a convergence of audiovisual composition, media installation and spatial architecture, resulting in the creation of a mediated soundspace. This is defined as an experiential territory in which technological mediation is not a limitation, but rather a fundamental aesthetic strategy.

In contradistinction to customary concert settings, where sound and image are arranged in a hierarchical manner or segregated, the *Hexadome* presents an intermodal continuum in which sound and image coexist within a shared spatial dramaturgy. The perceptual logic of the space encourages not only immersion but also distributed attention, where the audience must navigate shifting sonic and visual trajectories that are orchestrated in a complementary manner. In this sense, mediated immersion becomes both an aesthetic condition – a mode of presentation – and a perceptual modality, conditioning how one listens, sees and orients oneself within the compositional field.

A number of artists have utilised the *Hexadome* platform to explore spatial and audiovisual synergies, including Ben Frost, Holly Herndon & Mat Dryhurst, Tarik Barri & Thom Yorke, and Peter Van Hoesen. Frequently, these artists design works that treat space itself as a compositional dimension. In such contexts, listening becomes an auditory process but also a situated, embodied and performative one. This is defined as a process of navigating acoustic topographies and visual flows that collectively articulate the work's form and affective charge. [19] [20] [21] [22]

In this manner, Holly Herndon and Mat Dryhurst addressed concerns regarding data collection and artificial intelligence in their dual performance and subsequent installation *Spawn Training Ceremony I: Deep Belief* in 2018. The training of their AI algorithm is based on Herndon's voice audio files, recordings and contributions made by participants in the designated space. In addition to this, the AI algorithm listens to the audience's responses and attempts to recreate them by using Herndon's voice. The production process gives rise to a number of ethical questions, primarily concerning the use of audience recordings. However, these issues are deliberately addressed by the artists and characterised as grey areas, thereby highlighting the necessity to comprehend the subject matter and the potential for exploring and implementing novel methods of creating fully immersive experiences. According to the artists themselves, these experiences are intended to facilitate the realisation of their own fantasies and futures.[1]

The *Hexadome* serves as a prime example of how contemporary media environments can function as compositional instruments, perceptual laboratories and discursive spaces. The demonstration shows how spatial sound, when integrated with immersive visuality and spatial design, can reconfigure listening as a site-specific, embodied, critically engaged act. This advancement results in new aesthetic languages, framing new ways of thinking, experiencing and composing space through sound.

The ZIMMT | *Zentrum für immersive Medienkunst und Technologie* in Leipzig continues this lineage by offering a modular, artist-driven environment for spatial sound creation and research. Its emphasis on artistic experimentation over fixed technological paradigms reflects a broader shift toward flexible, intuitive tools that enable composers to foreground expressive content over technical complexity. [23]

Concurrent with these developments, the ICST | *Institute for Computer Music and Sound Technology* at the ZHdK | *Zurich University of the Arts* is a leading research centre for spatial audio composition and technology. The ICST provides a unique infrastructure for experimentation with high-resolution spatial sound through both Ambisonics arrays and Wave Field Synthesis (WFS) environments. This enables artists to sculpt three-dimensional auditory experiences with an exceptional degree of control. These spatial audio systems do not merely reproduce sound, but rather generate soundfields, i.e. dense, immersive auditory environments in which the location, motion, diffusion and morphology of sound can be designed with perceptual precision and aesthetic intention. [24]

Ambisonics, with its spherical encoding of sound sources and environmental acoustics, offers a flexible paradigm for immersive spatialisation that adapts to different playback contexts. In contrast, WFS – rooted in Huygens's principle of wavefront reconstruction – permits the projection of virtual sound sources with striking realism and acoustic tangibility, even simulating movement through and around physical space without losing spatial coherence. These technologies enable sound to behave

[1] Hoh, M. (2018)

less like a sequence of events and more like material substance, capable of forming auditory architectures with presence and dimensionality.

At the ICST, artists such as Daniel Bisig, Savannah Agger and Rama Gottfried have expanded the practice of spatial sound composition beyond technical reproduction, moving towards a media-specific aesthetic that foregrounds spatiality as a core compositional material. Daniel Bisig's generative installations are characterised by the integration of spatial sound with complex systems and computational processes, thereby treating spatial diffusion not as an afterthought but as a foundational compositional parameter.

Savannah Agger, a Swedish composer and performer currently based in Berlin, works across acousmatic composition, live diffusion, 3D spatialisation and electroacoustic practices that combine traditional instruments with electronic media. Her approach emphasises immersive spatial dramaturgy and perceptual clarity.

Our perception of space and place is shaped by our sensory experiences over time. Our perception of sound localisation relies on several factors, one of which is the sound's spectrum. Spectral spatialisation allows you to work more consciously with this sensation; however, this should not be mistaken for absolute control over perceptual localisation. In several of my compositions, I explore the idea that sound is a multidimensional object containing space within itself, defined by its spectral components. One technique I have used extensively is to explore spectral space by allowing the spectral content of a sound to control movements in physical space. These compositions become journeys through spectral spaces and places, creating aural landscapes. [25]

The composer and researcher Rama Gottfried, affiliated with ICST, brings an especially nuanced perspective to the potential of these systems. Influenced by phenomenology, somatic practice and Media Art, Gottfried's works treat spatial sound not only as an extension of musical material but as a bodily field of interaction. His concept of architectural design imagines sound as a pliable substance capable of shaping movement, attention and affect – a notion realised through spatial systems that respond to bodily gesture and orientation.

I was composer-in-residence with Ircam's Acoustic and Cognitive Spaces team, exploring the aesthetic nuances of Wave Field Synthesis (WFS) and Higher Order Ambisonics (HOA). After a period of experimentation, I developed an [sic] *working method where spatial rendering signal processing is considered as a type of spatial-instrumental timbre which can then be orchestrated with other instrumental textures. For the 2012 inauguration of Ircam's WFS/HOA system, I composed Fluoresce, for cellist Séverine Ballon and WFS/HOA, which was the first piece at Ircam to integrate these two systems into one.*

In his works, Gottfried employs the ICST's spatial audio systems, as well as WFS, to craft spatial counterpoints and immersive sound environments in which the listening body becomes a participant in the formation of space. Utilising the sensory immediacy of spatial diffusion, his compositions explore the manner in which sound texture and motion generate perceptual architecture – spaces that unfold not solely acoustically but also viscerally, kinaesthetically and relationally. For Gottfried, immersive sound is not merely spatialised. It is inhabited, structured through dynamic relationships between soundfield, listener and environmental topology that blur the boundaries between architecture, choreography and musical structure.

Building upon these explorations, IRCAM | *Institut de Recherche et Coordination Acoustique/Musique* in Paris represents another major centre where spatial audio has been cultivated not only as a technological frontier but as an aesthetic and compositional paradigm. IRCAM's sustained integration of WFS | *Wave Field Synthesis* and HOA *Higher Order Ambisonics*, as exemplified by the ESPRO and Spatialisateur projects, has established the institution as a major contributor to the advancement of sophisticated spatialisation techniques. These technologies facilitate an unparalleled degree of

spatial precision and immersion, thereby expanding the boundaries of sound design, live performance, and electroacoustic composition.

The WFS (Wide/Frequency Stereophonic) system, which has been implemented in *IRCAM's Espace de Projection* and other venues, allows composers to construct spatially explicit soundfields in which virtual sources are perceived as stable and externally located within the room, independent of the listener's position. This capacity for holographic realism engenders a scenario in which sound can appear to move behind, above or around the audience, intervening in architectural space as if materially present. In contradistinction to panning-based systems as VBAP | *Vector Base Amplitude Panning*, WFS simulates the actual propagation of wavefronts, rendering it especially well-suited for dynamic spatial trajectories, sonic object choreography and immersive spatial dramaturgy.

Furthermore, IRCAM's endorsement of HOA furnishes artists with instruments to encode soundfields that can be decoded flexibly across a range of playback arrays, thereby facilitating portability and rendering composition independent of specific systems. The Spat library, developed at IRCAM, facilitates these spatial renderings in both real-time and fixed media contexts, thereby affording composers access to room simulation, source trajectory control and perceptual spatial modelling.

The technologies under discussion have been central to the work of a number of composers. Each of these composers has engaged with spatialisation as a technical extension and as a compositional voice.

Natascha Barrett, for example, had a residency in 2012 at IRCAM involving the evaluation of perception of spatialisation in the context of high order Ambisonics. In Natascha Barrett's oeuvre, spatial trajectories emerge as the primary musical parameters. These energetic shapes intersect with architectural affordances and the listener's position, creating a dynamic and immersive auditory experience. Her employment of HOA facilitates a dynamic interplay between gesture and field, between localised sound events and distributed immersive textures. *Using this method [HOA] I propose that we can draw attention to interesting features captured in the recordings, and with a science-art approach to information and composition, entice and provoke a new awareness of what is present yet hidden from everyday listening. I have tested this hypothesis in five artistic case studies with the following workflow: 3D site-specific recording; 3D sound analysis; Composition to draw into the perceptual present features we many* [sic] *find interesting; Layering this composed 3D soundfield into the site from which the source was taken.* [26]

In her approach, which is connected with materials previously discovered in situ, the spatial information commences with the recording of three-dimensional data. Following a thorough analysis of the material, the piece is revealed to be a 3D sonic intervention. In her piece entitled "*PRESENCE | NÆRVÆR*", the artist employs sonic experiments to intervene in the space itself, thereby transforming the sound and imbuing it with a new meaning. In this project, Barrett conducted experiments with the MH-Acoustics EM32 microphone for the purpose of recording in three dimensions.

Sounds were recorded from various positions within the courtyard area over a 6-month period using the MH-Acoustics EM32 microphone. Some recordings were made in February, while the majority were captured from March to June 2022. Extended durations of sound were recorded to capture the temporal variation of the soundscape, including intermittent sounds, repeating sounds, keynote sounds (familiar sounds heard above the background), and the continuously varying background hum of the city and harbour.

The recording of spatial dimensions over extended periods of time can yield more intriguing results. The space-time continuum is subject to change over time, resulting in the reconfiguration and extension of materiality from one place to many creative ends.

IRCAM's spatial systems also intersect with live performance, enabling hybrid practices in real-time, spatial processing and instrumental interaction. One example is the piece *Llum i matèria. Pour Kaija* (2023) for ensemble in space and electronics by the Spanish composer Nuria Giménez Comas, commissioned by Ensemble Itinéraire for their 50th Anniversary and premièred at ESPRO (IRCAM).

The title Llum i matèria (Light and Matter) is a reference to the dual nature of light, which can be regarded as both a wave and a particle. It served as the conceptual foundation for the composition and coincides with the title of a work by Kaija Saariaho, *Light and Matter* (2014). The composer dedicated this piece to Saariaho after her recent death.

Beginning with this duality of light, other sources of inspiration informed Llum i matèria, particularly the work of Franco-Danish visual artist Eva Nielsen, who merges painting and screen-printing. Through this medium, Nielsen deceives the eye using effects that elevate both natural and architectural elements, while questioning temporality in our era of instantaneity and image saturation. Her ongoing series Lucite (initiated in 2015), takes its title from a UV allergy—thus referencing light itself. Her canvases feature deliberately veiled horizons, compelling the viewer to search for an obscured subject (often an architectural fragment) behind screen-like patterns.

As Virginie Huet writes in Connaissance des Arts, "Her suburban odysseys form, by sedimentation, spectro-geographies—fleeting perspectives of non-places." Nielsen's technique, initially involving masked screen-printing beneath layers of tape prior to painting, has since evolved. Source imagery—personal or borrowed—is directly printed on canvas or materials such as organza or leather, and is then overlaid with oil, acrylic, watercolor, or Indian ink. This results in a visual ambiguity where the gaze wanders between surface and depth, disoriented by the absence of focal clarity.

Superimposed on these elusive images are personal recollections of a transformative summer marked by ephemeral yet powerful visions of the ocean. The piece unfolds in two contrasting parts: the first, centered on the spectral quality of light, and the second, invoking the absence—or pursuit—of light, drawing on its granular nature. The electronic elements evoke metaphoric textures of potent natural forces: sea, clouds, wind.

As the work progresses, a spatial dialogue emerges between instrumental sound phenomena and their electronic counterparts. The musical discourse, punctuated by citations from Schubert's *Unfinished Symphony*, traces a trajectory from the most rarefied to the densest sonic materials, both temporally and spectrally, traversing all intermediate gradations. The conclusion of the piece draws inspiration from Yves Bonnefoy's *Psyché devant le château d'Amour*, itself derived from the eponymous painting by Claude Lorrain, who is widely regarded as the quintessential painter of light. In this study, Nuria Giménez employs a metaphorical reconstruction of the landscape of Bonnefoy's poem through the medium of sound, utilising synthetic textures to achieve this reconstruction.

Spatialization of both, instruments and electronics plays a fundamental dramaturgical role. In the first, more "spectral" part, the spatial distribution of instruments creates overlapping textures and spatial gestures exchanged among players. Real-time electronics act as an increasingly dense spatial orchestration of the instruments, eventually surpassing them sonically. In the second part, it is the electronics that fill the space, while the instruments articulate transitions using rhythmic fragments and re-orchestrated Schubertian harmonies. Granular electronics – designed using José Miguel Fernández's antescollider software – generate immersive 3D textures. At GRAME, Nuria Giménez collaborated with Max Bruckert to configure a tailored concert patch. At IRCAM, using Studios 1 and 2 with the 24-speaker dome, I developed the spatial structure, refining textures and performing detailed spatial mixing. Two intensive days at the ESPRO space enabled deeper exploration of spatial resonance and richness.

The piece concludes with an ambisonics-based spatial design that contrasts the vast 100-speaker environment with the focused resonance of a single speaker facing a wall. This spatial "détournement" culminates in an acoustic flute solo, whose physical presence stands in stark contrast to the preceding electronic soundscape.

This convergence of compositional vision, technological precision, and architectural awareness at IRCAM reinforces the idea that spatial listening is a medium of conceptual and formal construction. In such environments, the auditory field becomes sculptural, responsive and experiential, functioning as an aesthetic topology – a malleable terrain of flows, densities, and resonances. Moreover, the integration of machine learning, motion tracking and augmented acoustics at IRCAM increasingly allows for interactive and adaptive sound spaces, in which listener movement or environmental data can actively modulate the spatial behaviour of sound. This blurs traditional boundaries between composition, installation and performance, enabling soundspaces that are alive, co-constructed and affectively potent.

More recently, the Satosphere at Montreal's Société des Arts Technologiques and the Allosphere at UC Santa Barbara, conceived by JoAnn Kuchera-Morin, exemplify large-scale domed environments that combine immersive sound, data visualisation and real-time interaction, bridging scientific and artistic domains.

The Satosphere at Montreal's Société des Arts Technologiques (SAT) is one of the most advanced venues for immersive audiovisual experimentation in North America. As a 360° hemispherical dome equipped with a spatialised multi-channel loudspeaker array and panoramic video projection, the Satosphere facilitates a deeply embodied experience of sound and image, where audiences are enveloped in synaesthetic environments that challenge traditional modes of listening, viewing and spatial perception. This infrastructure has become a fertile ground for artists exploring the aesthetic potential of spatial audio, particularly through the lens of embodiment, materiality and performative listening.

Among the notable artists working within the Satosphere, Myriam Boucher, a composer and video artist based in Montreal, has created immersive works that blend acousmatic composition, granular synthesis and visual landscapes to evoke atmospheric, emotionally charged environments. Her piece *Phases* (2018), for instance, transforms the Satosphere into a luminous and sonic cosmos. In its audiovisual performance, *Phases* uses the three phases of water (solid, liquid, and gas) to relate music and image. Through live manipulations, the performer composes a musical and visual scene that reveals our relationship with the natural world surrounding us and engaging listeners through dynamic spatial gestures and finely sculpted electroacoustic textures.

Among the many innovative works presented within the SAT | *Satosphere at Montreal's Société des Arts Technologiques*, I was able to compose, realise and perform my own piece *Cosmic Polarizations* within the framework of an artistic residency at SAT. This piece is an audiovisual generative work and stands out as a compelling example of immersive, intermedial composition. Bridging scientific imagery, real-time synthesis and spatialised audiovisuality, the piece interrogates the perceptual dynamics of cosmic energy, polarity and motion through an integrated media approach. Drawing on my own photographic studies – resonant with Paul Klee's investigations into abstraction, energetic form, and chromatic structure – the piece transforms still images of astronomical phenomena into dynamic visual textures. These textures are generated and modulated in real time using Jitter, responding to sonic behaviours crafted in *Max/MSP*.

The performance system is distributed across two interconnected computers, communicating via OSC, Open Sound Control protocol. The first computer is dedicated to sound generation, employing wavetable synthesis and stochastic modulations to produce evolving sonic materials. Previously defined auditory data streams are sent to the second computer, which receives and interprets the data as control parameters for the visual domain, thereby generating reactive textures and shifting visual fields. This intermedial architecture creates a material unity in which sound and image are not simply synchronised but co-constitutive, shaping one another through mutual feedback. The resulting audiovisual textures are spatialised using third-order Ambisonics, rendered through the Satosphere's hemispherical array of 93 full-range speakers and 5 channels for low-frequency transmitter, immersing the listener in a dynamic field of multidirectional movement and envelopment.

Crucially, this piece is never performed in the same way twice: elements of randomness are woven into both sonic and visual processes, influencing timbre, form, spatiality, and temporal development. Each instantiation of *Cosmic Polarizations* becomes a unique perceptual event, shaped by generative variables and environmental conditions. My own compositional strategy reflects a commitment to aesthetic emergence, where form is not pre-fixed but continuously re-shaped through system behaviour, sensory interaction, and spatial perception.

In doing so, the piece contributes to a growing field of audiovisual spatial composition in which technological systems are active agents in aesthetic formation.

Cosmic Polarizations exemplifies how immersive architecture, spatialised sound and visual abstraction can converge to produce a holistic and embodied sensory experience – one that is perceived not as two modalities in parallel, but as a singular, integrated material: a sonic-visual topology woven into the very fabric of space.

Closing this exploration of advanced immersive soundspaces, the *AlloSphere* at the University of California, Santa Barbara, stands as a landmark in the convergence of scientific research, spatial sound composition and media arts. Conceived and directed by JoAnn Kuchera-Morin, the *AlloSphere* is a three-story spherical chamber within a cube, equipped with a high-density loudspeaker array, 360-degree stereoscopic projection and interactive real-time computing systems. Unlike conventional concert spaces, the AlloSphere is a fully responsive instrument-environment in which spatialised sound, dynamic visuals and data interaction coalesce in real time. Here, sound does not merely occupy space—it generates, modulates and transforms it. [27]

AlloSphere's works exemplify how scientific phenomena – gravitational waves, quantum fields – are translated into immersive sonic and visual experiences, allowing both researchers and the public to perceive the imperceptible. The AlloSphere supports a wide range of interdisciplinary artists and researchers, including Curtis Roads, whose microsound-based compositions take on new spatial dimensions within this environment.

From a technological standpoint, the AlloSphere employs a method of audio signal decorrelation, with the purpose of supplementing spatialisation. Furthermore, it introduces other developments in the field of spatial audio, including Ryan McGee's Spatial Modulation Synthesis, which simultaneously explores the synthesis of space and timbre.

The AlloSphere exemplifies the paradigm shift from spatial sound as an extension of composition to spatiality itself as compositional matter. It also addresses the challenging issue of interactive up-mixing through the utilisation of the Sound Element Spatializer and the Zirkonium Chords project. The application of geometric spatial chords as a high-level means of spatial up-mixing in performance is a notable feature here. In this context, JoAnn Kuchera-Morin's work is vital: she reframes spatial listening not as a secondary experience, but as a primary aesthetic mode, where perception, presence and sound architecture converge to produce new forms of embodied cognition and poetic understanding.

Further approaches that develop spatial dimensions and architectures in specific ways within an immersive spatial concept include the immersive modular and multimedia concert space Sound Dome at the Royal College of Music in Stockholm; the IRCAM Espace De Projection; the Sound Dome in New Zealand (2019); The Sonic Laboratory at the Sonic Arts Research Centre (SARC) at Queen's University in Belfast; The Deep Space and The cubo negro, developed by the team at the Ars Electronica Center in Linz (2020). In this context, the role of these and other institutions shifts towards becoming laboratories for not only the technical development of spatial systems, but also the conceptual reinvention of listening. In this paradigm, space is recognised not only as a frame, but also as a core compositional material that shapes the fundamental conditions of both aesthetic and perceptual experience.

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