What is Ambisonic?

AMBISONIC is a specific method for creating, capturing and playing back spatial audio. It is radically different from other surround techniques as the technology is capable of reproducing a spherical representation of sound where the directional information of a source is located in a 3D soundfield.

Ambisonic is also both a recording and a spatial synthesis technique, where one can capture the full environment in 3D sound through the use of so called A or B-format microphones such as the: Soundfield SPS200, Røde NT-SF1, Sennheiser Ambeo, Coresound TetraMic and more. Alternatively, a sound field can be synthesised from any mono, stereo and multichannel sources to Ambisonic, constructing a virtual 3D sound environment by placing the sources at locations in a virtual 3 dimensional field.

Ambisonic in its simplest form, the 1st order ambisonic (also called B-format) only 4 channels is needed to represent a full 3D sound. The 4 channels or spherical components W, X, Y and Z resembles the pressure patterns found in an omni microphone (W) and three figure-of-8 microphones for left/right (Y), front/back (X) and up/down (Z) as depicted in Fig.1:

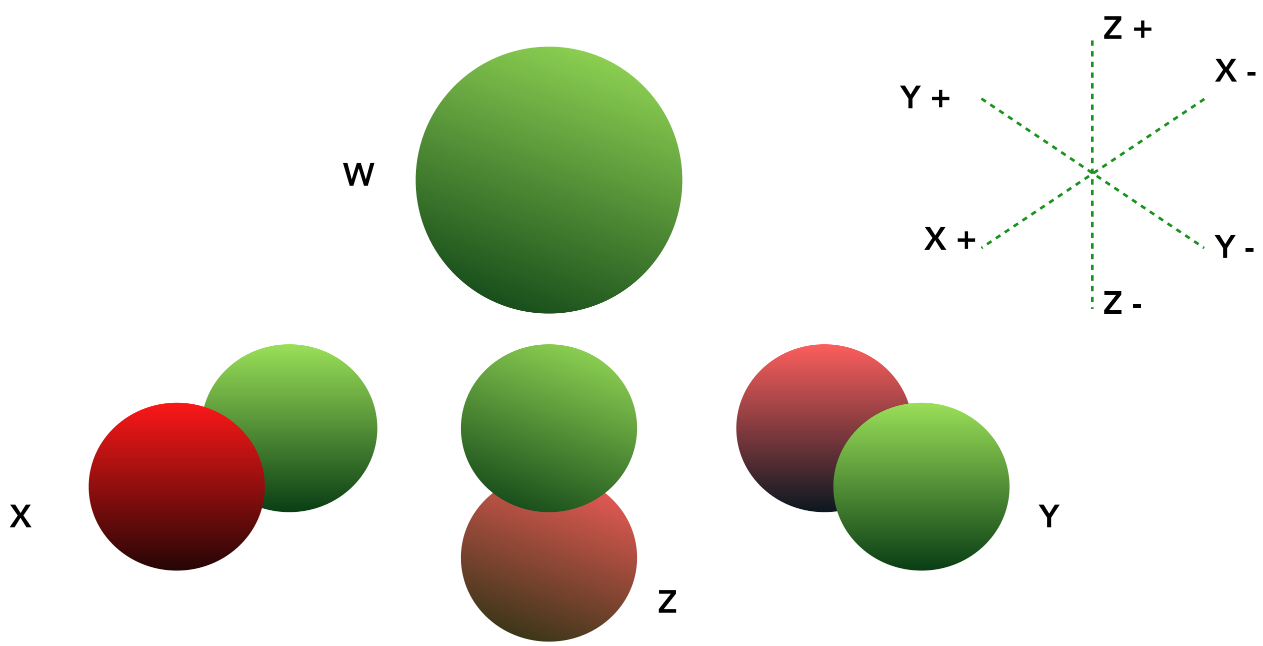


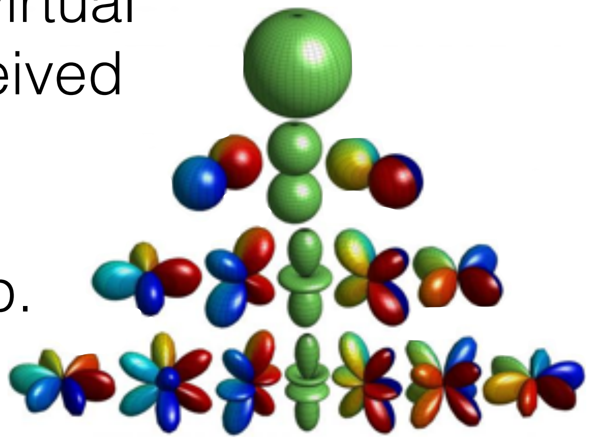
Fig.1. Ambisonic 1st. order WXYZ spherical components. Pressure and gradient polar patterns

Ambisonic as opposed to other surround and spatial techniques and methods does not carry a speaker signal it is an encoded signal that has to be decoded to the speaker signals. This encoding / decoding scheme has the advantage of being very portable and flexible since one is not bound to a specific speaker setup. I.e you can have your ambisonic mix played on a number of speaker setups, for instance Quad, headphones (binaural), 5.1, 6, 8, 7 speaker etc. based on the decoder. When ambisonic is played back on speakers all the speakers contribute to the directional content, what one is hearing is not the sound coming from a specific speaker but from a specific direction.
Ambisonic was originally developed by the late British mathematician and sound engineer Michael Gerzon and others in the 1970s, although it was a commercial failure at the time this very powerful spatial technique albeit not widespread has since been used by a number of composers, sound designers and researchers. However with the introduction of Virtual reality and related technology ambisonic is given a new renaissance being a perfect format for such applications.

Ambisonic

Ambisonic has several advantages:

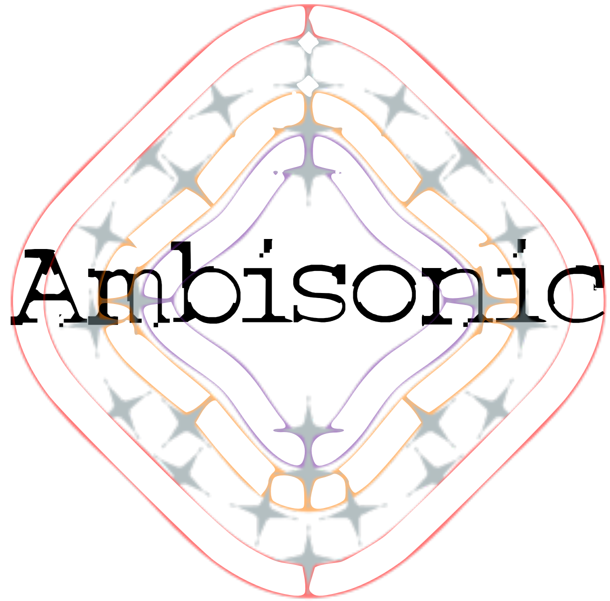
- It supports perifony (height)
- It can be combined with the distance clues of the virtual sound source, resulting to sounds, which are perceived as being closer or more distant to the listener.
- It stable (when done right)
- Its very portable! can be decoded nearly any setup. (speaker independence)



Michael Gerzon from the University of Oxford introduced First-Order Ambisonic in form of the so-called B-Format, which encodes the directional information of a given three-dimensional soundfield to four channels called W, X, Y, Z:

W= input signal * 0.707107 i.e 1/sqrt(2)
X= input signal * cos(Φ)cos(Θ)
Y= input signal * sin(Φ)cos(Θ)
Z= input signal * sin(Θ)

1st order

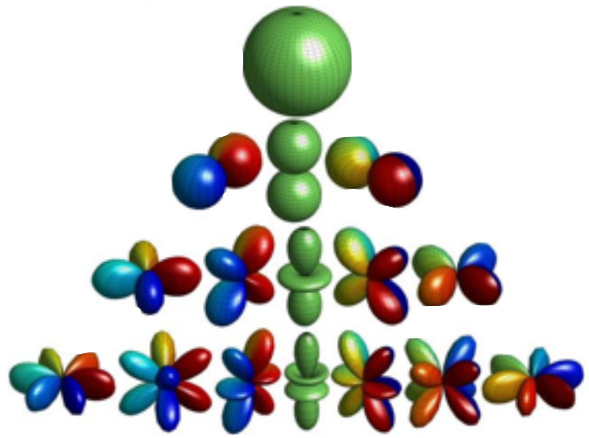


R= input signal * 1.5sin(Θ)sin(Θ)-0.5
S= input signal * cos(Φ)sin(2 Θ)
T= input signal * sin(Φ)sin(2 Θ)
U= input signal * cos(2 Φ)cos(Θ)cos(Θ)
V= input signal * sin(2 Φ)cos(Θ)cos(Θ)

2nd order

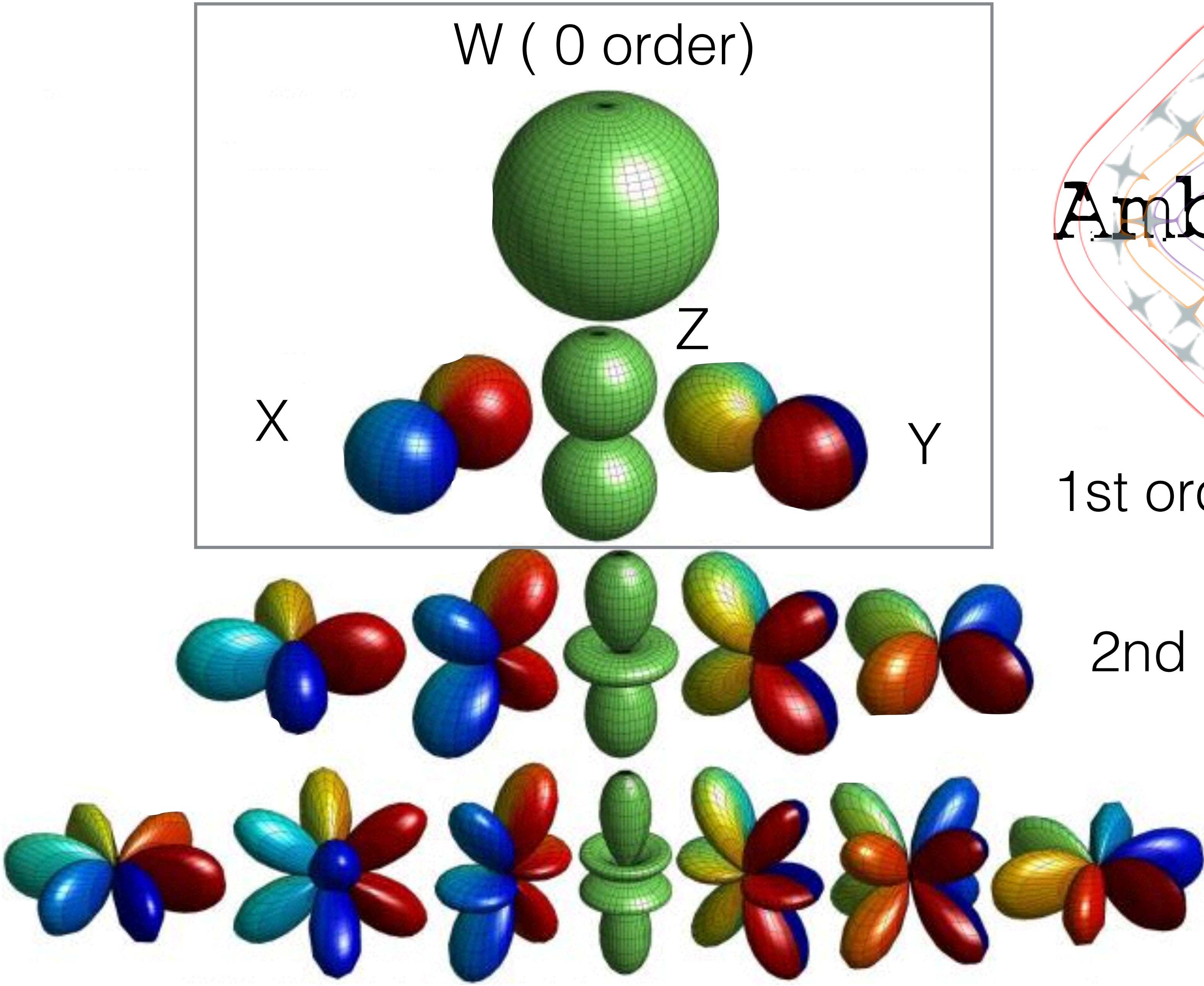
Φ = Phi Θ = Theta

Note, that Φ is used for azimuth, and the Θ for elevation, which is vice versa to the standard American notation of spherical coordinate systems….



Spherical harmonics
Ambisonic = pressure patterns

Ambisonic



1st order

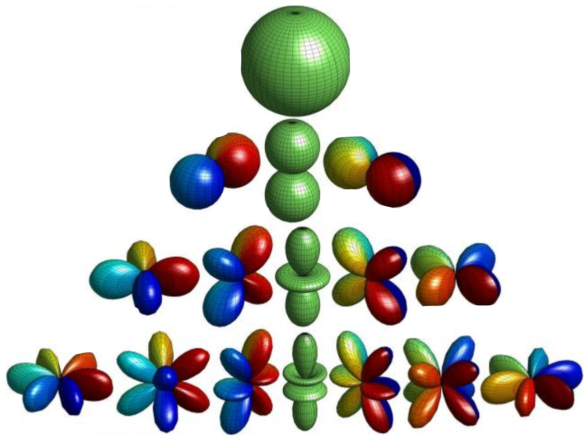
2nd order

3rd order

Ambisonic encoding->decoding

A very basic Ambisonic decoder:
Each speaker receives its own weighted sum of all Ambisonic channels. For each speaker, the weight of an Ambisonic channel equals the value of the according spherical harmonic for the position of that speaker. i.e a sampling.

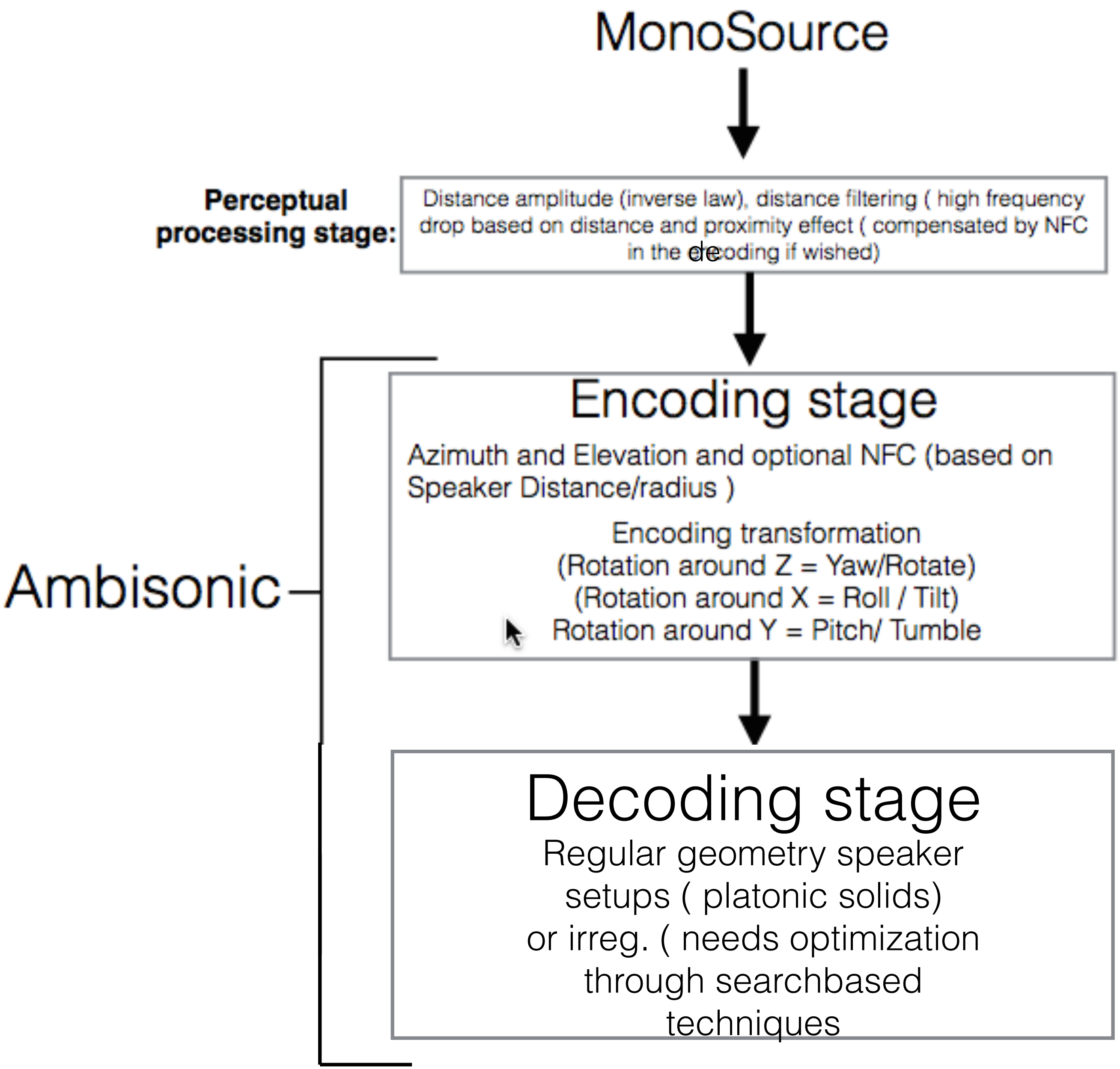
The least amount of speakers needed for an full Ambisonic (3d) reproduction (decoded):
(N+1) ^ 2
N = order
Examples: 1st order 4 speakers or more, 2nd 9 speakers or more, 3 order 16 speakers or more. 4th order 25 or more, 5th order 36 or more. 6th order 49 or more



Ambisonic reproduction - Realisations in concert

Pros: Portable, speaker-independent, flexible to number of speakers encoding-decoding scheme (decoupled from playback), Creates a soundfield : All speakers contribute to any sound in any direction, as opposed to conventional panning, Compose spatially in 3D. Immersive

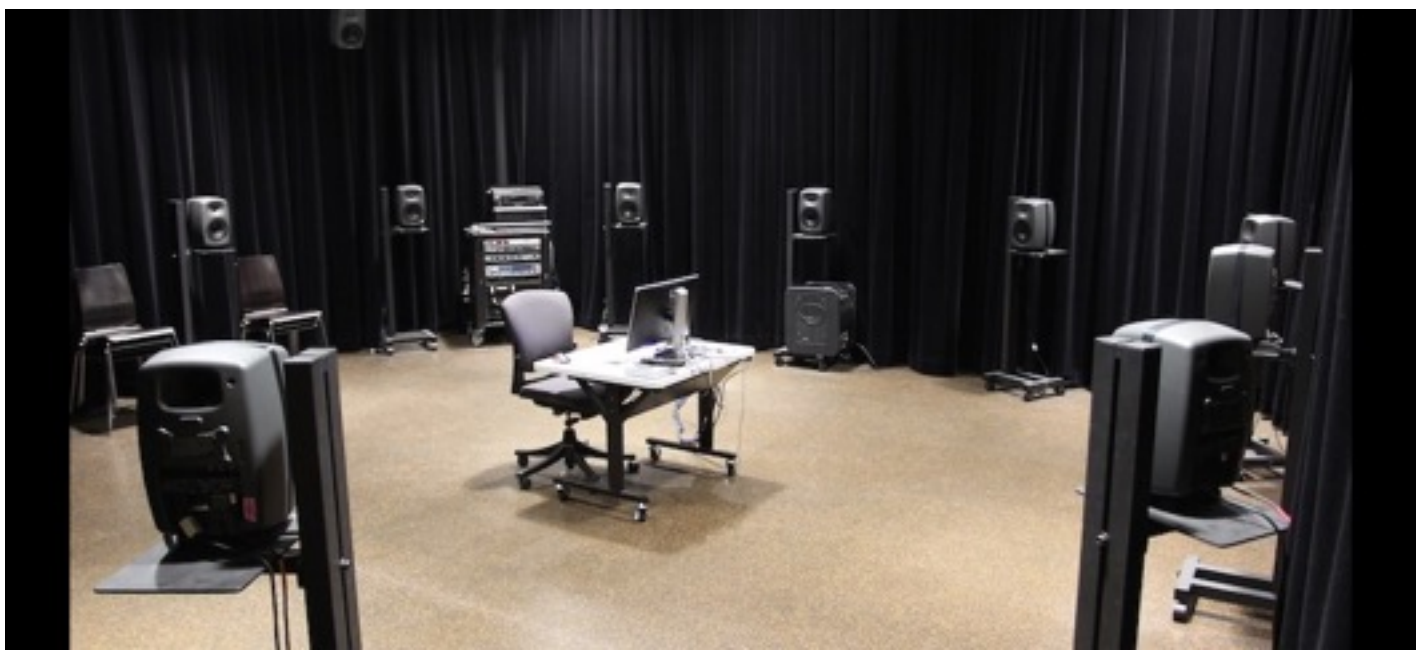
Cons: conceptual, different conventions and schemes, literature is often from a engineering/mathematical perspective, sweet spot (order dependant),

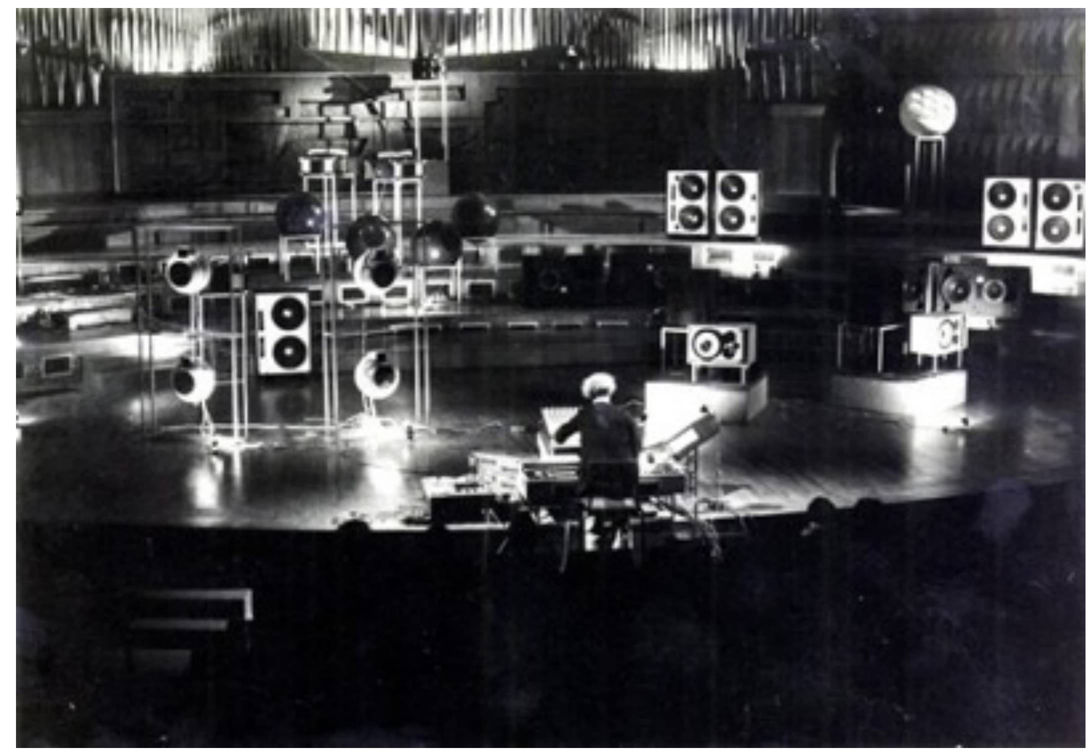

MonoSource
Perceptual processing stage:
Distance amplitude (inverse law), distance filtering (high frequency drop based on distance and proximity effect (compensated by NFC in the decoding if wished)
Ambisonic
Encoding stage
Azimuth and Elevation and optional NFC (based on Speaker Distance/radius)
Encoding transformation
(Rotation around Z = Yaw/Rotate)
(Rotation around X = Roll / Tilt)
Rotation around Y = Pitch/ Tumble
Decoding stage
Regular geometry speaker setups (platonic solids)
or irreg. (needs optimization through searchbased techniques

Ambisonic

Ambisonic reproduction - Realisations in concert

The ideal setup quite often not a possibility in real-life concert halls





- studio vs concert hall
- Regular : platonic solids, spherical and regular shapes
- Irregular: 5.1, 7.1, diffusion/loudspeaker orchestra (speakers with different freq.response and gains)
- Room acoustics, audience occlusion, phase.

Ambisonic reproduction - Realisations in concert

Try to make your piece in as High Order that is feasible according to you workflow
HOA = Better angular resolution and larger sweet-spot.
You can always monitor in UHJ /stereo, binaurally or virtualspeakers (Ambix etc.)

Get speaker plans if possible. Measuments (rarely a inquery being met btw.)

Plan before hand, ambisonic is flexible for number of speakers, folding down 3D field to 2D layout still keeps spatial res.(You can also do some tricks to do vice versa)
Decode in layers if there are something that is out-of-place according to your needs. An hybrid approach is to diffuse different decoded layers! see GRM example

If time permits: Bring a lasermeasurement device and a protractor sheet, do a quick measurement.
Do calibrate the loudness (gain adjust) of the speakers (noiseburst test) and time align (delay) speakers. **Use you ears** or an omni Mic.
Make sure init. levels are all equal and flat/no eq on the board/interface.

Use good decoders methods, particulary suited for the task esp. if irregularity is high (AllRAD, energypreserving, custom opt.decoders IDHOA or ADT)

If you have even more time: Render the decoded signal(s) and eq them slightly to fit the room/Speakers. must be Multichannel linearphase! (hard to find > 8 channels) option to eq the speakers.

Composing with ambisonics

- Working with musical/sound objects in space and how they relate to each other spatially. Creating spaces is strongly connected to the experience of our surroundings, spatial mimicry can be a useful approach. Or the idea of allusion. Building up an impression of space. Connected to Reverbration in ambisonic (a room in a room) constructing different sizes. Perceptual processing as a part of constructing the space within ambisonic.

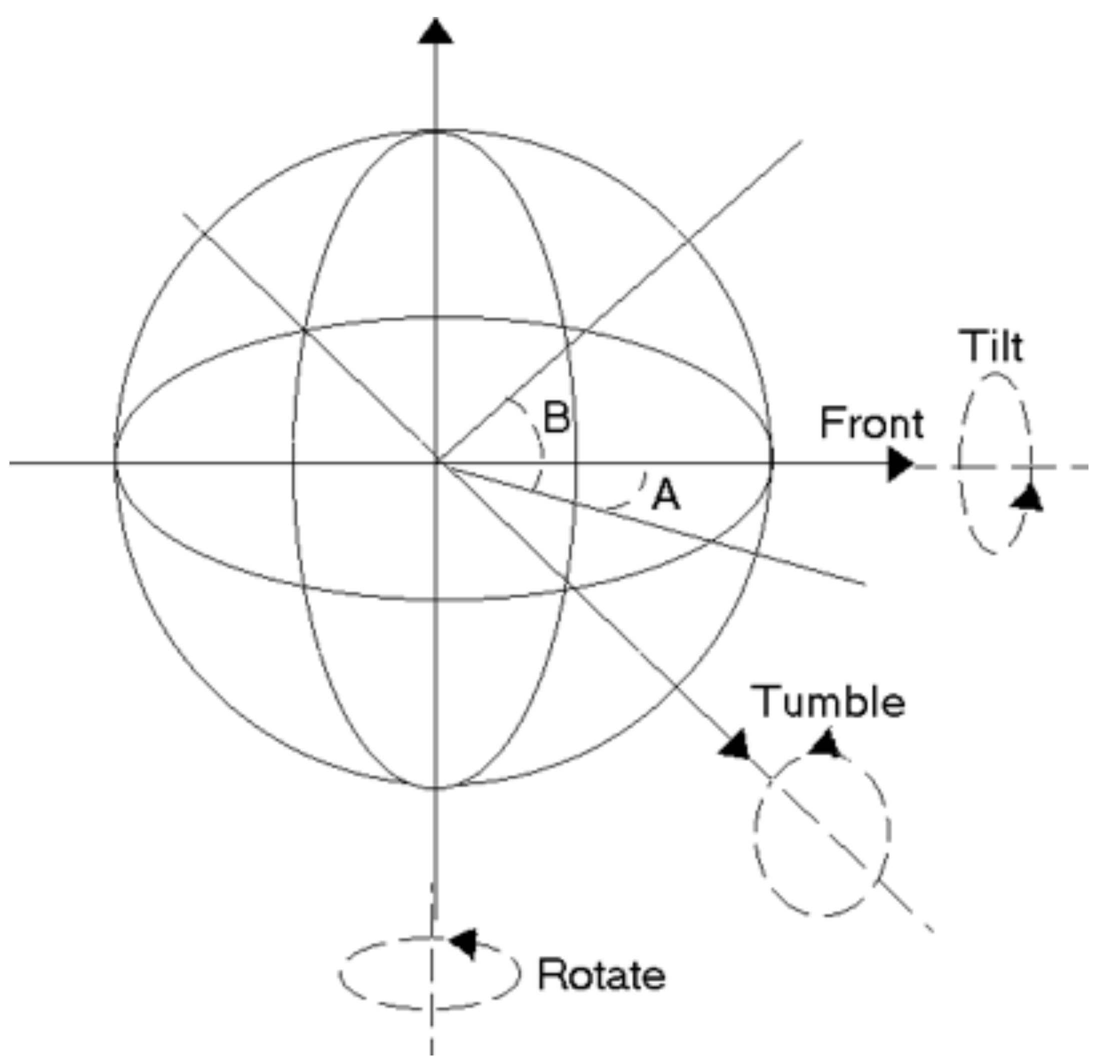
- Take care of elevation, explore more boundaries at the horizontal, as our ears are more sensitive on the horizontal plane. Just because its 3D does not mean everything as to be jumping up and down!

- Establish a good workflow practice (DAW or enviroment) that faciltates what you want to accomplish.

- Keep in mind what is the intended performance space or medium (sound installation or concert music). Pragmatic approaches to decoding. Decode in layers.

Ambisonic transformation

Simple (but effective!) rotations in 3D - yaw, pitch,roll (or rotate, tumble tilt) around Z axis, X axis and Y axis



Ambisonic transformation

encoding

processsing

decoding