

Introducing... the Ambisonic Toolkit

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Introduction

The Ambisonic Toolkit (ATK) brings together a number of tools for working with Ambisonic surround sound, and introduces a variety of innovative transforms and approaches. The intention is to be both ergonomic and comprehensive, providing algorithms to creatively manipulate and synthesise Ambisonic soundfields.

Tools are framed for the user to 'think Ambisonically'. By addressing the problem of creatively controlling a soundfield holistically, the ATK allows and encourages the artist to think beyond the placement of sounds in a sound-space. Instead the user is encouraged toward attending to the impression and image of a soundfield, taking advantage of the idiom the Ambisonic technique presents.

Imaging

Central to the idea of 'thinking Ambisonically', the ATK provides a number of transforms to creatively re-image naturally recorded and artificially created soundfields. The 'axial transforms' favour part of an image or direct the whole of an image along a particular axis.

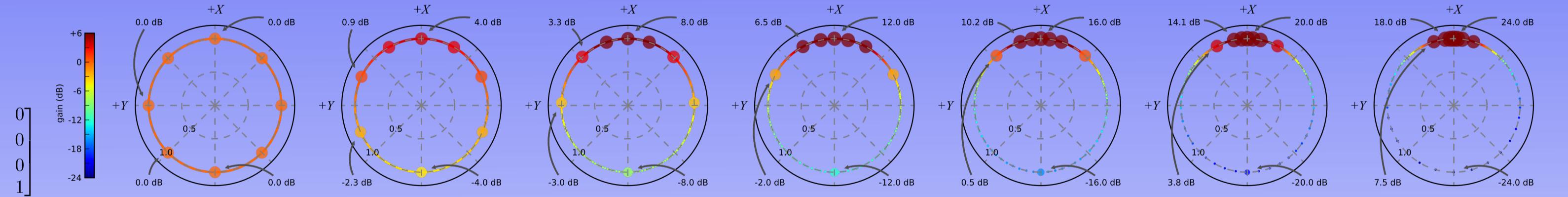
With these tools, a diffuse synthetic image may be 'directed' and a naturally recorded image may be 'focused'.

The ATK provides 'directive' transforms at any azimuth, elevation, giving control over directional incidence, focus and immersion.

'Dual axes' transforms are also available.

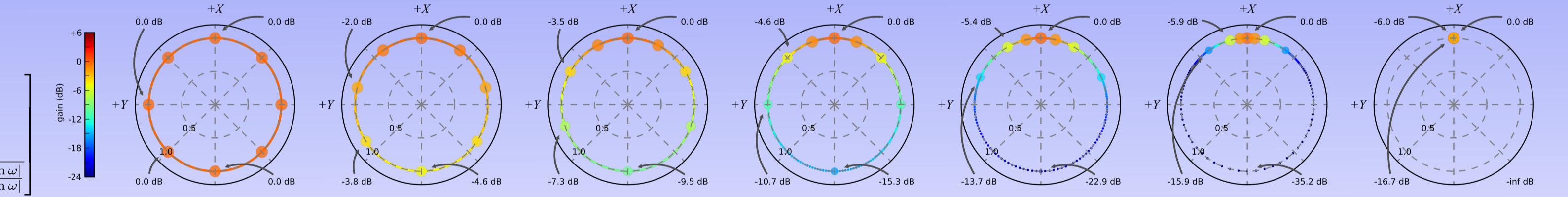
Dominance

$$\begin{bmatrix} \frac{1}{2}(\lambda + \frac{1}{\lambda}) & \frac{\sqrt{3}}{2}(\lambda - \frac{1}{\lambda}) & 0 & 0 \\ \frac{1}{\sqrt{2}}(\lambda - \frac{1}{\lambda}) & \frac{1}{2}(\lambda + \frac{1}{\lambda}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



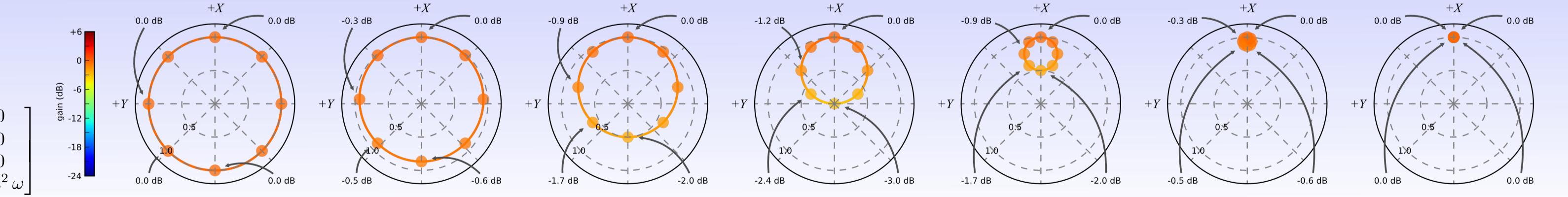
Focus

$$\begin{bmatrix} \frac{1}{\sqrt{1+|\sin \omega|}} & \frac{1}{\sqrt{2}} \left(\frac{\sin \omega}{1+|\sin \omega|} \right) & 0 & 0 \\ \frac{1}{\sqrt{2}} \left(\frac{1}{1+|\sin \omega|} \right) & \frac{1}{\sqrt{1+|\sin \omega|}} & 0 & 0 \\ 0 & 0 & \sqrt{\frac{1-|\sin \omega|}{1+|\sin \omega|}} & 0 \\ 0 & 0 & 0 & \sqrt{\frac{1+|\sin \omega|}{1-|\sin \omega|}} \end{bmatrix}$$



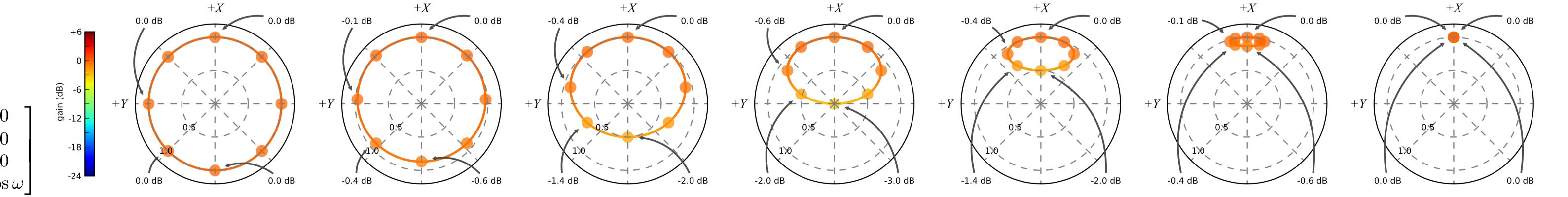
Push

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ \sqrt{2}|\sin \omega| \sin \omega & \cos^2 \omega & 0 & 0 \\ 0 & 0 & \cos^2 \omega & 0 \\ 0 & 0 & 0 & \cos^2 \omega \end{bmatrix}$$



Press

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ \sqrt{2}|\sin \omega| \sin \omega & \cos^2 \omega & 0 & 0 \\ 0 & 0 & \cos \omega & 0 \\ 0 & 0 & 0 & \cos \omega \end{bmatrix}$$



A-format

A-format is the 'directional domain' of an Ambisonic soundfield, and for 1st-order, A-format represents space as a tetrahedron. The ATK provides A-format encoding and decoding (A-B, B-A) in a variety of convenient orientations and W-gains.

Variant A-format orientations support alternative microphone array options for 'creative' recording of natural soundfields, and synthetic soundfields can easily be generated with a choice of A-format orientations. Additionally, A-format is the domain where certain kinds of signal processing are best performed to preserve spatial impression.

Varying W-gains suit a variety of encodings, from normalised to in-phase.

Front Left Up

$$\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

Front Left-Right

$$\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & 0 & 0 \\ \frac{1}{2} & -\frac{1}{2} & 0 & 0 \\ 0 & 0 & \frac{1}{2} & -\frac{1}{2} \end{bmatrix}$$

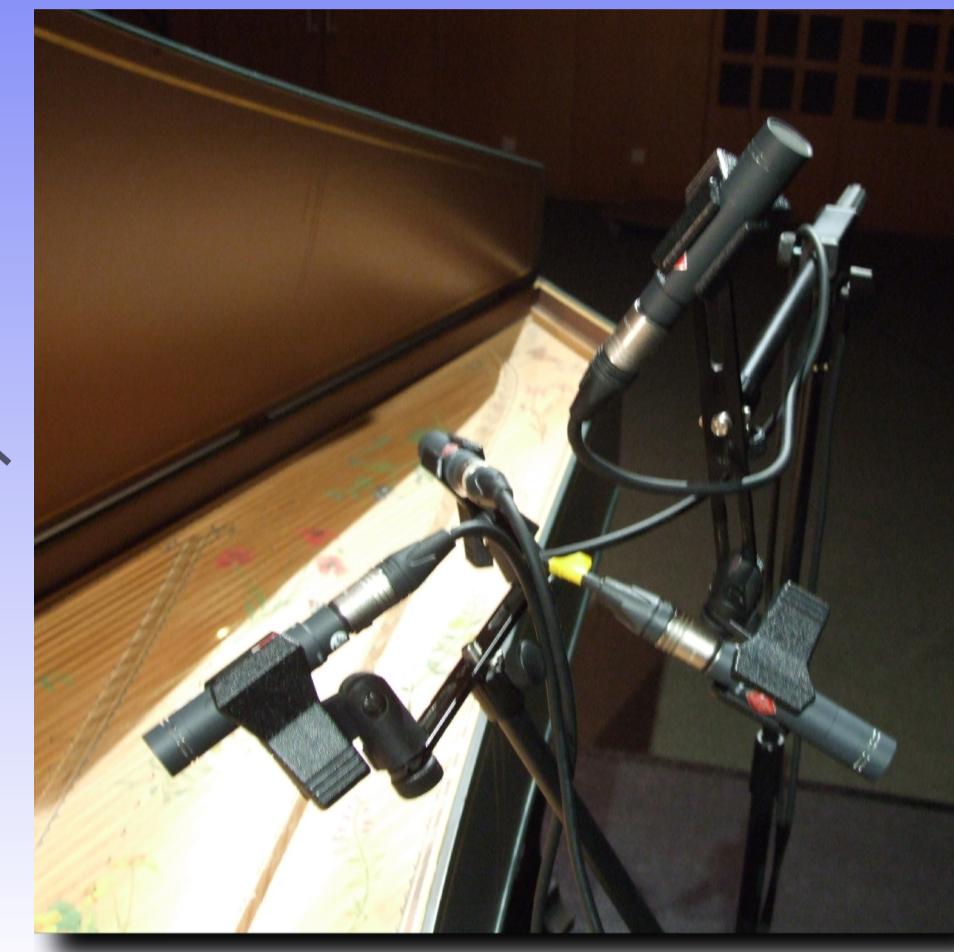


Photo: Gavin Murdoch

Front Back-Down

$$\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{6} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ 0 & -\frac{\sqrt{6}}{3} & \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} \end{bmatrix}$$

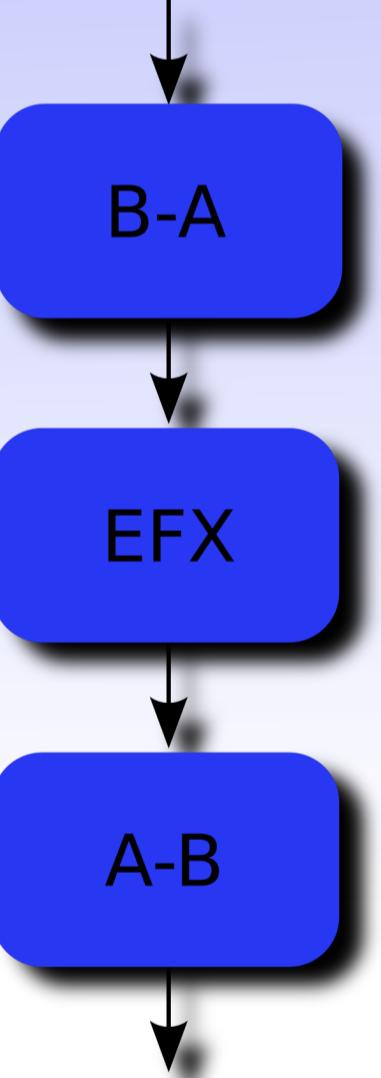
W-gains

Kind	g_w
normalised	$\frac{1}{\sqrt{3}}$
canonical	$\frac{1}{\sqrt{2}}$
unscaled	1
in-phase	$\sqrt{3}$

Signal Processing

In B-format, certain kinds of signal processing techniques are likely to disrupt the spatial information in the soundfield. Interventions which modify phase and/or gain relations between B-format channels will do so to a greater or lesser extent.

Acting independently across multiple channels, effects such as Chorus, Phasing, Granulation, Delay and Distortion are best implemented in the A-format domain.



References

J. Anderson, Epiphanie Sequence, Sargasso SCD28056, 2008. Audio CD.

P. S. Cottrell, "On the Theory of the Second-Order Soundfield Microphone", Ph. D. Thesis, University of Reading, Feb. 2002

M.A. Gerzon, "Panpot and Soundfield Controls", NRDC Ambisonic Technology Report No. 3, Aug. 1975.

M.A. Gerzon, "Ambisonics in Multichannel Broadcasting and Video", J. Audio Eng. Soc., 3 (11), Nov. 1985, 859-871

