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# Kosmoscope – A Seismic Observatory

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## ABSTRACT

Earth tremors are a constant, intrinsic part of our planet's nature and a visceral experience when first encountered.

Kosmoscope, a telematic art installation by Tim Redfern, marries two venerable technologies, the kaleidoscope and the seismograph, in order to immerse viewers within an abstract audiovisual representation of earth tremors. Kosmoscope uses state of the art seismic monitoring to render live scientific data impressionistically, making the worldwide network of ultra-sensitive seismic microphones audible and creating an imposing, visually fractured narrative that evokes the frailty of humanity in the face of geological forces. This paper describes the Kosmoscope's influences, aims, design and realisation.

## Categories and Subject Descriptors

H.5.1 [Information Interfaces]: Multimedia Information Systems – Audio input/output

J.5 [Computer Applications]: Arts and Humanities – Fine arts

## General Terms

Algorithms, Design, Theory.

## Keywords

Installation, Telematic, Seismic, Art

## 1 INTRODUCTION

Kosmoscope (Greek; *kosmos*: people/universe/world; *scopio*: shape/form) is a telematic art installation utilising live computer-generated visuals and immersive sound. Kosmoscope was constructed in June 2008 and first shown at the Sebastian Guinness Gallery in Dublin, Ireland. Designed to fit the dimensions of the Georgian stairwell in which it was shown, Kosmoscope is a 5.2m high aluminium structure that contains five 2.4m long mirrors and a vinyl rear-projection screen, displaying live computer-generated imagery from an LCD projector. Altering the symmetry of the classical 'box' kaleidoscope, Kosmoscope creates an illusion that is fragmented and chaotic, questioning the constancy and longevity of our environment and

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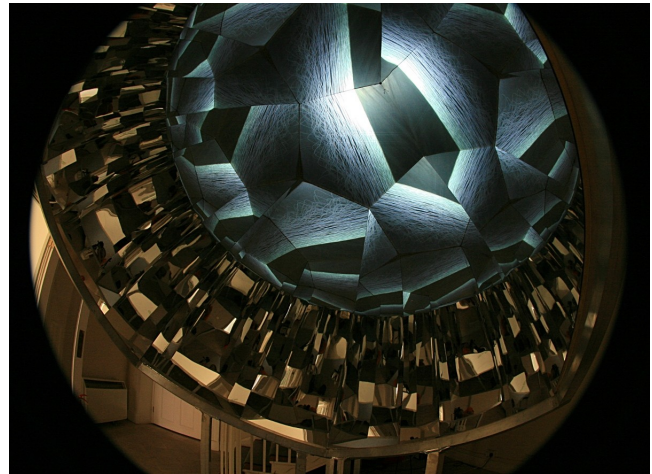


Fig. 1: Kosmoscope interior

evoking the balance of dynamic forces within the earth. The installation presents an aluminium portal through which may be glimpsed a hint of chaotic reflections inside. On entering, audience members find themselves within an illusory space appearing far larger than the structure that produces it, which presents a multiplicity of jumbled, fragmented reflections of the audience themselves and their surroundings stretching upwards to a dark, faceted sphere above their heads. As time passes, patterns of fractured lines course across the huge overhead globe, resonant rumblings, percussive crashes and groaning sounds surround the audience. These sounds and drawings translate into the visible and audible domain seismic readings which are gathered from around the world via the internet, connecting the audience with the unseen world of earth tremors. (see figure 1.)

Kosmoscope is an artwork that uses scientific research data in a metaphorical way. Such art-science crossovers has become an increasingly prevalent in interactive art and an effective way of disseminating and discussing scientific theories. According to Candy & Edmonds' taxonomy of interactive artworks[1], Kosmoscope may be classified as a 'Dynamic-Passive' interactive artwork, in that it uses a computer to create an experience which is dynamic and unpredictable, but where the audience act as spectators rather than actors. In this case, the interaction is between the earth itself (mediated by sensors, various software layers, the internet) and the installation. It thus acts as a telematic artwork, affording the viewers insight into natural forces affecting the world beyond our control.

“In the posthuman era, it has gradually become evident that our senses can be expanded by technology” (Domingues and Reategui, 2007)

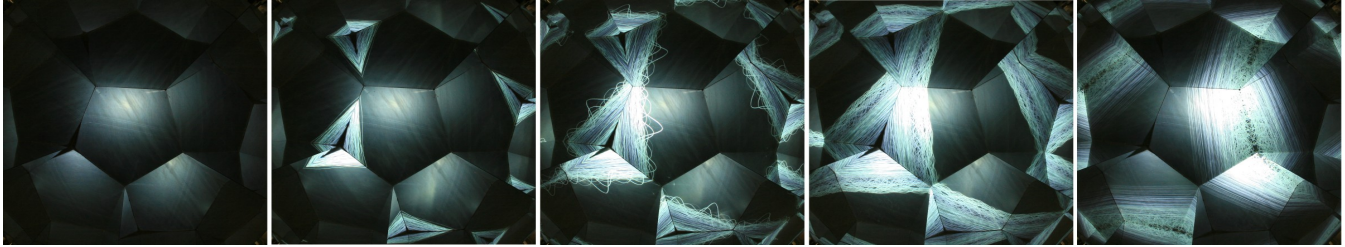


Fig 2: Sequence of Kosmoscope imagery

## 11.1 Aims

### 1.1.1 A telematic experience of seismic movements

When translated into audible frequencies, seismic readings have a surprising range of timbres, from distant resonant whistlings to cataclysmic, percussive crashing noises. Access to a global network of seismic sensors via the internet is a recent development, which as well as facilitating seismic research is enabling a menagerie of artworks. Kosmoscope aims to act as an observatory allowing the audience to experience seismic events as audible sound and diagrammatic visual representation of movement.

### 1.1.2 Revisiting two historical inventions

Kosmoscope is the result of research into technological history and the relationship between art and science in the past. Reinventing and combining two classic technological devices as a single contemporary interactive artwork conjures an alternative history of interactive artwork stretching back to the Victorian era.

### 1.1.3 A visceral, immersive experience

Kosmoscope's design aims to create a profound experience for its audience. The scale and positioning of the illusory imagery, the control of light while minimising any barrier to entry, and the use of spatialised sound combine to immerse the audience, evoking a sense of powerful geological forces and allowing the range of earth movements to be experienced on a human level.

## 2. SEISMOMETRY

Before the discovery of 'deep time'- the model that earth scientists use to describe the planet's long history - phenomena such as mountains, volcanoes and earthquakes were philosophical mysteries. It is believed that the first seismoscope was the 'Houfeng Didong Yi', which was invented during China's Han Dynasty in the 2nd century AD. Literally translating as 'instrument for measuring the seasonal winds and the movements of the Earth', the device featured eight dragon's heads holding bronze balls which would fall indicating the direction of the tremor. With the invention of the seismograph in the 19th century, a more sensitive device that could depict earth movements as a drawn line, it became possible to compare seismic recordings and imagine how these waves move through the earth. As readings of natural and artificial seismic events became important in geological surveying for discovery of oil deposits, seismometry increased in sophistication allowing investigation of hitherto unseen structures within the earth. Kosmoscope uses the Global Seismographic Network (GSN), a coordinated network of seismographic instruments accessible via the Internet for monitoring, research and education.

## 3.1 Seismometry in interactive art

There have been several prominent seismic themed interactive artworks in the last decade.

Mori (1999), an "internet based earthwork" by Ken Goldberg, Randall Packer, Gregory Kuhn and Wojciech Matusik. In Mori, the movements of California's Hayward fault are amplified as vibrations and abstract visuals within a resonating cavity.

Sonusphere (Mark Bain, 2004) takes the form of a 6-metre diameter inflatable sphere, acting as a loudspeaker that transduces seismic recordings. Installed in a restricted gallery space, the audience have to press themselves into the yielding, pulsating sphere in order to move through the room. Bain has also created several works which use resonant vibrations to play the structures of buildings, following the ideas of maverick engineer Nikolai Tesla. [3]

'PIEQF' (Parkfield Interventional EQ Framework, 2004). Working with the USGS, artist D.V. Rogers has created a large scale kinetic earthwork based at Parkfield on the San Andreas fault, between San Francisco and Los Angeles in California. PIEQF takes the form of a hydraulic motorised table which produces artificial earthquakes in response to seismic events, and audience interaction via geophones (seismic recording devices) scattered around the location. [4]

Icelandic locative/ net artist Pall Thayer's 'Nude Studies in Aleatoric Environments' (2008) uses the same internet datafeeds as Kosmoscope. Custom software draws abstract, organic shapes in response to seismic data. [5]

While several of these works render local seismic activity, and one even uses global data for abstract purposes, Kosmoscope is unique in attempting to create a rendition of worldwide seismic activity. In displaying nearly-live seismic data as an abstract audiovisual experience, Kosmoscope attempts to act as a seismic observatory: A channel for emotionally connecting with the sound of the moving planet.

## 4. KALEIDOSCOPES

Kaleidoscopes (from Greek, literally: beautiful view) were known to the ancient Greeks but are held to have been re-invented by Scottish inventor Sir David Brewster (1771-1868) in 1816. Brewster discovered the kaleidoscope while he was experimenting with the action of homogenous fluids upon polarised light. In his writings he gripes about the 'opticians' who were asked to review his patent application stealing his invention before it could be brought to market. Whether or not the kaleidoscope was invented by Brewster, he refined its construction, and had many ideas

about its potential, highlighting for instance the kaleidoscope's use in devising new designs for carpets and textiles.

Brewster also discovered the 'box' kaleidoscope. In "The Kaleidoscope, Its History, Theory and Construction" [6, p 107], Brewster describes prism-shaped kaleidoscopes of 3 and 4 sides, and the properties of their reflections. Brewster considered symmetry to be the ultimate expression of beauty, and would therefore likely be dismayed by the 5-sided geometry employed for the Kosmoscope.

#### 4.1 Video Kaleidoscopes

The use of video for producing moving kaleidoscopic imagery has become popular since the 1980s and has a long history in interactive art. Inventor Nick Moore has been building video kaleidoscopes since the 1980s, such as the permanent one at the London Natural History Museum, which uses a 4-sided configuration of mirrors to reflect moving imagery from large TV sets.

Karl Sims' 'Video kaleidoscope' was shown at Siggraph 1987. Before his well-known work on artificial life, Sims built this rotating, three-sided box kaleidoscope, described as "A human sized real kaleidoscope which creates colorized feedback patterns from faces".

'Iamascope' (Fels, Reiners, Mase, 1997), uses a video camera as input, allowing viewers to interact with their depiction within the kaleidoscope, and a gestural music engine. Here, the kaleidoscopic geometry is created using software rather than by actual mirrors. While physically simpler and more portable, this creates a kaleidoscope that is less immersive and creates a flat rather than spherical illusion. [7]

Ara Peterson and Jim Drain's "Large Video Kaleidoscope" (2003-06) is similarly a mirror-based box-kaleidoscope that projects a computer-generated moving image. Peterson and Drain's artwork explores psychedelic abstraction - a 21st century reappraisal of the 1960s aesthetic separate from any new-age philosophical claims.

Kosmoscope differs from other interactive and video-based kaleidoscope installations in that its focus is not the kaleidoscopic effect itself, but to use the effect as metaphorical expression. The spherical 'box' kaleidoscope illusion creates an abstracted, spherical illusion of the world of seismic activity, while the impossible size of the illusory space it creates, unexpectedly opening out within the gallery, combining with the spatialised audio system, creates an isolated, virtual space where the qualities of elapsing seismic recordings may be appreciated.

#### 5. PHYSICAL STRUCTURE

Kosmoscope is a large, vertical, free-standing installation that the audience may walk straight into (see figure 3.) The lower half of the structure comprises mirrored panels, whereas the open top half positions another mirror which bounces the beam from the projector back onto the black vinyl screen which separates the two halves of the installation. This configuration positions the illusory sphere directly above the audience, emphasising the fragile position of humanity beneath forces on this cosmic scale. Kosmoscope differs from most box kaleidoscopes in that it uses pentagonal symmetry and also in that it uses acrylic mirrors rather than glass. Acrylic mirrors, although over 90% reflective, which

is comparable with glass, are less consistently flat and also exhibit a more pronounced colour filtering than glass or metal mirrors.

The distortions and colour shifts introduced by the acrylic mirrors are multiplied by the bouncing path that light takes through the installation, breaking the imagery down into abstraction more noticeably. Whereas rectangular and triangular arrangements of mirrors can create perfect symmetry, (i.e. the images of the mirrors thus reflected fall directly on top of one another, creating a 'sensible' illusion of a larger symmetrical object), Kosmoscope's 5-sided geometry is deliberately imperfect: in effect, every reflected break between two mirrors reveals two different versions of the entire illusion.

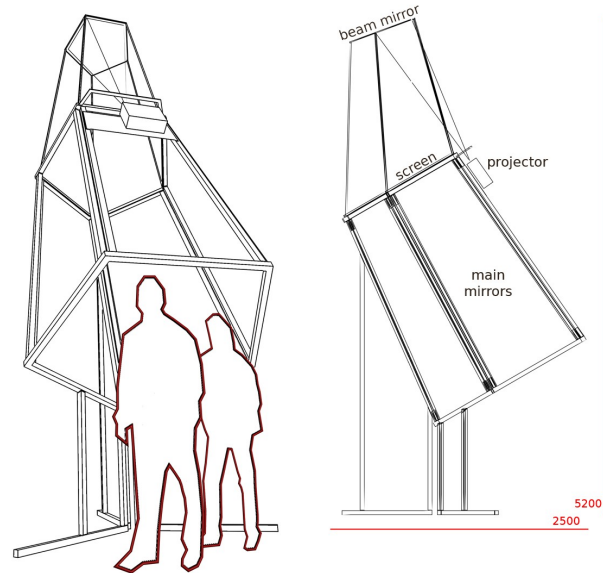


Fig 3: CAD drawing of Kosmoscope

Kosmoscope was realised through an iterative process of design prototyping and visualisation using ray-tracing software to simulate the kaleidoscope effect. The final solution is a compromise between the sizes of materials used, the size of the stairway space it was constructed for, the optical capabilities of the projector, and the qualities of the illusion created.

#### 6. AUDIOVISUAL REPRESENTATION

Kosmoscope retrieves seismic data from the internet and renders an impressionistic audiovisual experience. It uses a custom Java 'external' module for Cycling 74's 'Max/MSP' software, which encapsulates a FISSURES client. The "Framework for Integration of Scientific Software for University Research in Earth Sciences" is an open-source tool for accessing seismic waveforms from the Incorporated Research Institutions for Seismology (IRIS) network, which aggregates seismic data feeds from thousands of monitoring stations worldwide, using their data handling interface (DHI). The IRIS DHI uses the Common Object Request Broker Architecture (CORBA) to offer a language-neutral software interface via the internet. Due to the level of availability of the (near-realtime) IRIS 'Buffer of Uniform Data' (BUD) datacentre using the gallery internet connection, the data-gathering strategy is thus: every hour the client software queries the datacentre for any new recordings made within the last hour. These recordings will be available if the seismic activity was above a certain



threshold. In practice there are approximately 20-100 new recordings available each hour. These recordings are fetched and cached for playback by the A/V engine.

This A/V engine is designed to play back continually. Even though most of the recordings are actually an hour long, they are played at 200x normal speed in order to make them audible. As a 1-hour recording will last only 18 seconds, the database of recordings is looped continually with new recordings replacing old ones as they appear. Kosmoscope visualises these waveforms as line drawings with trails. Thus, the drawings that would have appeared on the original seismographs appear as dynamically evolving fractures in the illusory overhead globe.

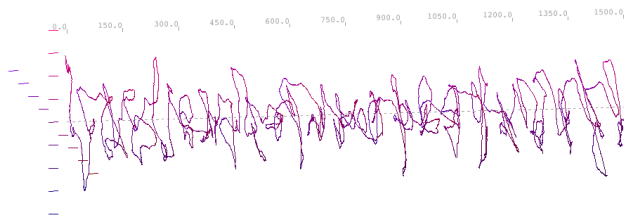
## 6.1 Audio spatialisation

Modern seismographs are instruments which can detect earth movements in 3 dimensions and transmit these readings in near-realtime for comparison and extrapolation. Thus many seismic recordings are actually 3D records of vibration- completely dissimilar to normal '3D audio' which concerns the placement of sounds in space.



**Fig 4: The sensor vault at MACI station, Morro de la Arena, Canary Islands ( Photo courtesy of Neil Ziegelman, Albuquerque Seismological Laboratory). (right) – Interior of a seismometer showing E/W and N/S sensors.**

Kosmoscope uses *ambisonics* to express these 3D waveforms as spatialised sound. Ambisonics[8] is a format for encoding spatial audio as channels of spherical harmonics: i.e. there will commonly be a one-channel omnidirectional signal and three further channels for the “figure of 8 pressure responses” along the three cartesian axes. Ambisonic recording is commonly used for 'soundfield recordings' where a periphonic spatial image is generated through the use of a four-capsule microphone. This then may be used to recreate the spatial image – the direct sound plus the ambience of the space around it - through any arrangement of speakers. Kosmoscope uses these directional seismic recordings to create a synthetic soundfield representing the harmonics of the earth tremor around the audience, also positioning this soundfield based on its geographical position (as reported by the



**Fig 5: A seismic recording from MACI station, April 16th 2009. Plot shows NS/EW movement vs. time (seconds).**

seismographic recording station). This approach allows the 3D nature of the recordings to be perceived directly by the audience.

## 7. CONCLUSION AND FUTURE WORK

The aim of Kosmoscope is to create a place to experience earth movements, translated into a range appreciable by human senses. Using a publicly accessible network of seismic research instruments, it gathers data and presents it within a sculptural installation, creating an illusory sphere of seismic fractures, surrounded by a 3D rendition of these movements as sound. Kosmoscope is a marriage of two Victorian technological instruments- the kaleidoscope and the seismograph. The aesthetic decision to combine them in a way suggests an alternative version of Victorian scientific history which Sir David Brewster may have been involved with.

As noted in this paper, there have been several recent artworks use the IRIS datastreams to represent dynamic seismic activity. There has clearly never been such a powerful and convenient way to access seismic data directly from around the world, and this should lead to future creative applications for seismic data. Chris Laughon of the IRIS DMC is presently working on a real-time waveform interface to the BUD datacentre. Once ready, this may enable viewing applications like Kosmoscope to access seismic data in real-time.

## 8. ACKNOWLEDGEMENTS

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