AI & Soc (2012) 27:307–309
DOI 10.1007/s00146-011-0353-3

OPEN FORUM

Cosmic ray sonification: the COSMOPHONE

Richard Kronland-Martinet · Thierry Voinier · David Calvet · Claude Vallée

Received: 2 September 2010 / Accepted: 9 August 2011 / Published online: 31 August 2011

Abstract The Cosmophone is an attempt to show the close connections existing between the infinitely small and the infinitely large in sensory terms by detecting and imaging the continuous flow of elementary particles (cosmic rays) originating from our entire galaxy.

Keywords Sonification · Moving sounds · Cosmic rays · Sound immersion

1 Introduction

Art and science are both driven by a quest for truth. The approaches used in each case are different; however, art plays on the strength of emotions, whereas science usually involves comparing theoretical concepts objectively with experimental data. But the two approaches can meet together when emotion is elicited by a direct contact with an unexpected invisible physical phenomenon. Sound immersion is an interesting way of perceiving events that are not visible: among the many differences between sound and vision is the fact that sounds produced by invisible or hidden sources can be heard and both the motion and the location of the sources can be detected by our hearing system. The Cosmophone (Official Web Site: http://cosmophone.in2p3.fr) is a 3-D sound immersion installation in which invisible cosmic particles can be perceived by listeners in terms of synthetic sounds inducing physically related sensations.

R. Kronland-Martinet (✉) · T. Voinier
L.M.A., C.N.R.S., 31 Chemin Joseph Aiguier,
13402 Marseille Cedex 20, France
e-mail: kronland@lma.cnrs-mrs.fr

T. Voinier
e-mail: voinier@lma.cnrs-mrs.fr

D. Calvet
Laboratoire de Physique Corpusculaire de Clermont-Ferrand,
24 Avenue des Landais, 63177 Aubiere Cedex, France
e-mail: calvet@in2p.fr

C. Vallée
C.P.P.M, 163 Avenue de Luminy, Case 902,
13288 Marseille Cedex 09, France
e-mail: vallee@cppm.in2pfr

2 The cosmic rays

Interstellar space contains a permanent flux of high-energy elementary particles called cosmic rays. These particles have been created by violent phenomena occurring somewhere in our galaxy, when a massive ancient star explodes into a supernova, for example. The particles are then confined in the galaxy for millions of years by the galactic magnetic fields before reaching our planet. When colliding with the earth's atmosphere, cosmic rays create showers of secondary particles. Although they are partly absorbed by the atmosphere, these showers induce a large range of phenomena, which are measurable at sea level. The main phenomenon is a flux of muons, a kind of heavy electron which is absent from usual matter because of its short lifetime. Muons are produced at a high rate in cosmic showers. Thanks to their outstanding penetration properties, they are able to reach the ground. At sea level, their flux is about hundred muons per second per square meter. High-energy cosmic rays produce bunches of muons, or multi-muons, having the same direction, which are spaced a few meters apart. In addition, muons occasionally interact in the air, producing dense electromagnetic showers of electrons and photons which can reach the ground.

3 The Cosmophone concept

Human beings are insensitive to the cosmic particles crossing their body. The Cosmophone is a device designed to make the flux and properties of cosmic rays directly perceptible within a specially designed three-dimensional space. This is done by connecting a set of elementary particle detectors to an array of loudspeakers via a real-time data acquisition system and a real-time sound synthesis system. In this way, the information transmitted by the detectors triggers the emission of sounds, depending on the parameters of the particles detected. These parameters and the rates of occurrence of the various cosmic phenomena cause a large variety of sound effects to be produced. Many methods of generating sounds in this way from sources of random events can be and are being explored, but for lack of space, we will restrict this account to the description of a science museum installation designed to give listeners the impression of being immersed in a shower of energy particles. For further details about this installation, readers can consult the papers and website listed in the References section.

4 The particle detection system

Two detector arrays are located on the ceiling and the floor of the installation. Each detector is composed of a slat of plastic scintillator combined with a photomultiplier. A particle passing through the scintillator triggers the emission of some of the photons it contains. These photons are then guided along the scintillator until they reach the photomultiplier, which generates an electrical impulse. Parasitic noise from natural terrestrial radioactivity is eliminated because muons travel at a similar speed to that of light, and therefore cross the installation quasi-instantaneously: each muon's signature is produced whenever two sensors are hit on the ceiling and the floor quasi-simultaneously. The positions of the sensors hit give the direction of the muon's trajectory in space. In the case of electromagnetic showers, several contiguous sensors are hit in both detector arrays. The signals corresponding to all the phenomena detected are read by a fast data acquisition system, converted into MIDI format and transmitted almost instantaneously to a real-time sound synthesis system.

5 Sonification strategy and spatialization in the Cosmophone

To simulate a shower of rain particles in which listeners are immersed, loudspeakers are also placed in two arrays, one above the listeners, and the other one below them, under a specially built floor. These arrays are arranged/positioned so that the ears of the listeners (who are assumed to be standing up and moving around inside the installation) are located approximately at an equal distance from the two sets. When the detection system triggers a sound event, i.e., a sound moving from the ceiling to the floor, materializing the trajectory of a particle is simulated. To obtain this effect, the first idea was to use a panpot to distribute the energy between the loudspeakers in the upper and lower arrays. But to improve the illusion of a vertical movement, we had also to use the Doppler effect which occurs when a relative movement takes place between an acoustic source and a listener (Chowning 1971). This effect leads to a change in the pitch of the sound perceived during time, as well as a change in its amplitude. While this greatly improved the illusion of a vertical movement, the points of departure and arrival of the moving sound in space could still not be very clearly perceived by listeners. To improve this aspect, two short sounds (called localization indices) were therefore added as starting and ending cues. The first cue is emitted by the upper loudspeakers at the beginning of the sound event; and the second one by the lower loudspeaker at the end of the event. Since they were chosen so that they could be easily localized, these two cues greatly improve the illusion, giving the impression of a sound crossing the ceiling before hitting the floor (Kronland-Martinet and Voinier 2008).

6 Conclusion

Many methods of generating sounds from a source of random events have been developed. Some of them could even have been translated into musical compositions driven by the random fluctuations of cosmic phenomena. Sound imaging methods make it possible to completely mask the underlying technology so that listeners focus on the original physical phenomenon itself. An ideal Cosmophone would be a place which would make its visitors suddenly aware of a new aspect of the universe (cosmic radiation) as if by magic. The principles which guided the design of the Cosmophone could be applied to many other physical phenomena. We believe that there exist many potential ways of extracting beauty and emotion from the hidden complexity of nature (Vallée 2002; Diennet et al. 2007).

References

Chowning JM (1971) The simulation of moving sound sources. J Audio Eng Soc 19(1):26

Diennet J, Calvet D, Kronland-Martinet R, Voinier T, Vallée C (2007) The COSMOPHONE: playing with PARTICLES, the COSMOS and SOUNDS, MutaMorphosis: challenging arts and sciences 8–10 Nov 2007, Prague, Czech Republic. On-line proceedings: http://www.mutamorphosis.org

Kronland-Martinet R, Voinier T (2008) Real-time perceptual simulation of moving sources: application to the Leslie cabinet and 3D sound immersion. Eurasip J Appl Signal Process. Special issue on spatial sound and virtual acoustics. http://www.hindawi.com/journals/asmp/2008/849696.html

Vallée C (2002) The cosmophone: towards a sensuous insight into hidden reality. Leonardo 35(2):129