Art and Astrophysics in Conversation with KM3NeT
Deep in the Mediterranean Sea

Donald Fortescue,\textsuperscript{a} Gwenhaël de Wasseige,\textsuperscript{b} Jonathan Mauro,\textsuperscript{b,∗} Paschal Coyle\textsuperscript{c}
and Alin Ilioni\textsuperscript{d} on behalf of the KM3NeT Collaboration

\textsuperscript{a}California College of the Arts, San Francisco California
\textsuperscript{b}Centre for Cosmology, Particle Physics and Phenomenology - CP3,
Unversité Catholique de Louvain, B-1348 Louvain-la-Neuve, Belgium
\textsuperscript{c}Aix-Marseille Université, CNRS/IN2P3, CPPM,
163 Avenue de Luminy, Case 902, 13288 Marseille Cedex 09, France
\textsuperscript{d}Université de Paris, CNRS, Astroparticule et Cosmologie, F-75013 Paris, France
E-mail: dfortescue@cca.edu, gwenhael.dewasseige@uclouvain.be,
jonathan.mauro@uclouvain.be

We present the result of a cross-disciplinary collaboration between the California College of the Arts, San Francisco and the KM3NeT Collaboration.

The project involved creating an analog sound producing instrument which was installed within a standard KM3NeT pressure resistant glass sphere housing along with sound and video recording equipment. The instrument, titled “Bathysphere”, was deployed in the sea for the first time adjacent to the ORCA array of KM3NeT off the coast of Toulon, France on September 23, 2021.

One outcome of this project is the video work “Below the Surface”. It incorporates sound and video recorded from within the “Bathysphere” as it floated on the surface of the Mediterranean and then as it dived down to 300 m depth. As the “Bathysphere” dived, the analog instrument it contained quietened. The sound in the dive portion of the video is created from the sonification of data from the KM3NeT array that was recorded during the deployment of the “Bathysphere”.

“Below the Surface” highlights the extraordinary environment in which the KM3NeT array is being created and operates. The data sonification illustrates the potential of this method of data representation to connect with viewers in a deeply physical way and offers new perspectives on the data collected by KM3NeT.

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∗Speaker

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1. Introduction

We present here the result of a cross-disciplinary collaboration between the California College of the Arts, San Francisco and the KM3NeT Collaboration, which builds on the success of a previous art/science work [1] that was carried out in collaboration with the IceCube Neutrino Observatory [2].

KM3NeT is a European particle astrophysics research infrastructure located deep in the Mediterranean Sea [3]. It is being constructed to search for neutrinos from distant astrophysical sources, and it consists of two discrete detector arrays: ORCA situated off the coast of Toulon, France, and ARCA situated off the coast of Sicily, Italy.

The current project involved one of us (Fortescue) creating an analog instrument which was installed within a standard KM3NeT pressure resistant glass sphere housing along with sound and video recording equipment. This instrument, titled “Bathysphere”\(^1\), was deployed for the first time, adjacent to the ORCA array of KM3NeT, off the coast of Toulon, on September 23, 2021.

One outcome of this project is the video work “Below the Surface”. The work incorporates sound and video recorded from within the “Bathysphere” as it floated on the surface and as it dived down to 300 m depth. As the “Bathysphere” dived, the analog instrument it contained quietened. The sound in the dive portion of the video was created from the sonification of data from the ORCA array. “Below the Surface” is publicly available at https://vimeo.com/844369324

2. The Bathysphere

The “Bathysphere” is an idiophonic instrument that operates on the surface and at depth to transduce water oscillations into sound. It consists of seven stainless steel hemispheric bells activated by six hammers as shown in Fig. 1. Sounds are produced by the hammers hitting the bells and by them running around the rim of the bells. A standard GoPro Hero 8 and Sony Digital Audio Recorder are attached to the “Bathysphere” to record video and sound.

Deployment involved lowering the “Bathysphere” with its attached ballast and connected flotation buoy to the sea surface (Fig. 2). The “Bathysphere” was allowed to float on the surface some 50 m from the deployment vessel for about 15 minutes, then the flotation buoy was released and retrieved back to the ship. With the release of the buoy, the ballast sank and towed the “Bathysphere” along with it. Once the “Bathysphere” reached approximately 300 m depth, it was hauled back to the surface and retrieved.

Recordings from the dive were edited and used to create the video work “Below the Surface”, which incorporates both recorded “Bathysphere” sounds and sonified data from the ORCA array.

\(^1\)Named in honor of the Bathysphere developed by Otis Barton and deployed by Barton and William Beebe during the first deep-water dives in Bermuda in the early 1930’s.
3. Sonification

Sonification is the transduction of non-audio data into audible sound. “Below the Surface” incorporates the sonification of digital signals derived from the detection of photons by the ORCA array.

The way in which data is transduced into sound is selected to reflect the underlying physics and to satisfy aesthetic considerations. To play the sounds from “Below the Surface” sonification, we use a digital instrument based on the glockenspiel as it is a close analog to the sounds produced by the “Bathysphere”.

During the “Bathysphere” deployment, six Detection Units (DU) were active in the ORCA array (18 currently active). Each DU holds 18 Digital Optical Modules (DOMs) and each DOM houses 31 Photomultiplier Tubes (PMTs) [4].

The sonification process we developed involved assigning four discrete notes to each DOM. In a manner similar to tuning a musical instrument, each DOM has been assigned a unique sound given by the choice of the four notes that it covers, avoiding strong dissonances.

Lower octaves are mapped to the bottom of the detector, while higher octaves are found at the top. This allows us to reproduce the dimensionality of the detector and of the sonified signal. A filter was used on the data to get rid of most of the incoherent noise. The sonified signals are expected to be produced by the decay of sea salt ($^{40}$K), and from bioluminescent species, as well as Cherenkov photons from the interaction of atmospheric muons and neutrinos. The detected charge is used to modulate the volume of the notes.

4. Objective approaches to art making

The underwater audio for “Below the Surface” was obtained by establishing an objective set of constraints on the data set selected and the way this data was then transduced into sound. This approach has a strong precedent in contemporary art. In fact, an objective methodology was first established by the minimalist and conceptual artists of the 1960’s and 70’s who were striving to reduce artistic agency in reaction to the dominant paradigm of Abstract Expressionism. The renowned conceptual artist Sol LeWitt explained in his Paragraphs on Conceptual Art: "To work with a plan that is preset is one way of avoiding subjectivity. It also obviates the necessity of designing each work in turn. The plan would design the work... the artist would select the basic form and rules that would govern the solution of the problem. After that the fewer decisions made in the course of completing the work, the better. This eliminates the arbitrary, the capricious, and the subjective as much as possible" [5].

The objective approach provides a strong link between the methodological practices of science and art and can help delineate the required conditions for effective art/science collaborations, that is, the common ground where the two methodologies may coalesce.
5. Value of sonification

Sonification is a methodology that is generating wide interest in contemporary data science. We readily discern sound as occurring in three dimensions, so it would seem that ‘listening’ to data that derives from interactions across three-dimensional space could be more intuitively informative than ‘looking’ at graphic analysis or animated renderings on a 2D screen. Also, sonification permits access to data sets by researchers for whom vision might not be their primary sense, thus enabling a broader diversity of scientific researchers. And finally, more general audiences have a direct visceral connection to sound which can facilitate a deeper direct connection with the phenomena being studied by leading research institutions.

6. Collaboration

Artists are rarely considered key components of collaborative science research teams. They are often seen as addenda to the core science, as illustrators or designers who can help with posters or presentations for public outreach. The durable art/science collaboration developed by the authors over many years provides a model for imbedding artists within science teams to facilitate new perspectives and audiences. The current collaboration provides the potential for ongoing art/science projects as the one described in these proceedings (Fig. 3).

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References
