21A.505 / STS.065
Anthropology of Sound
Spring 2022 MIT

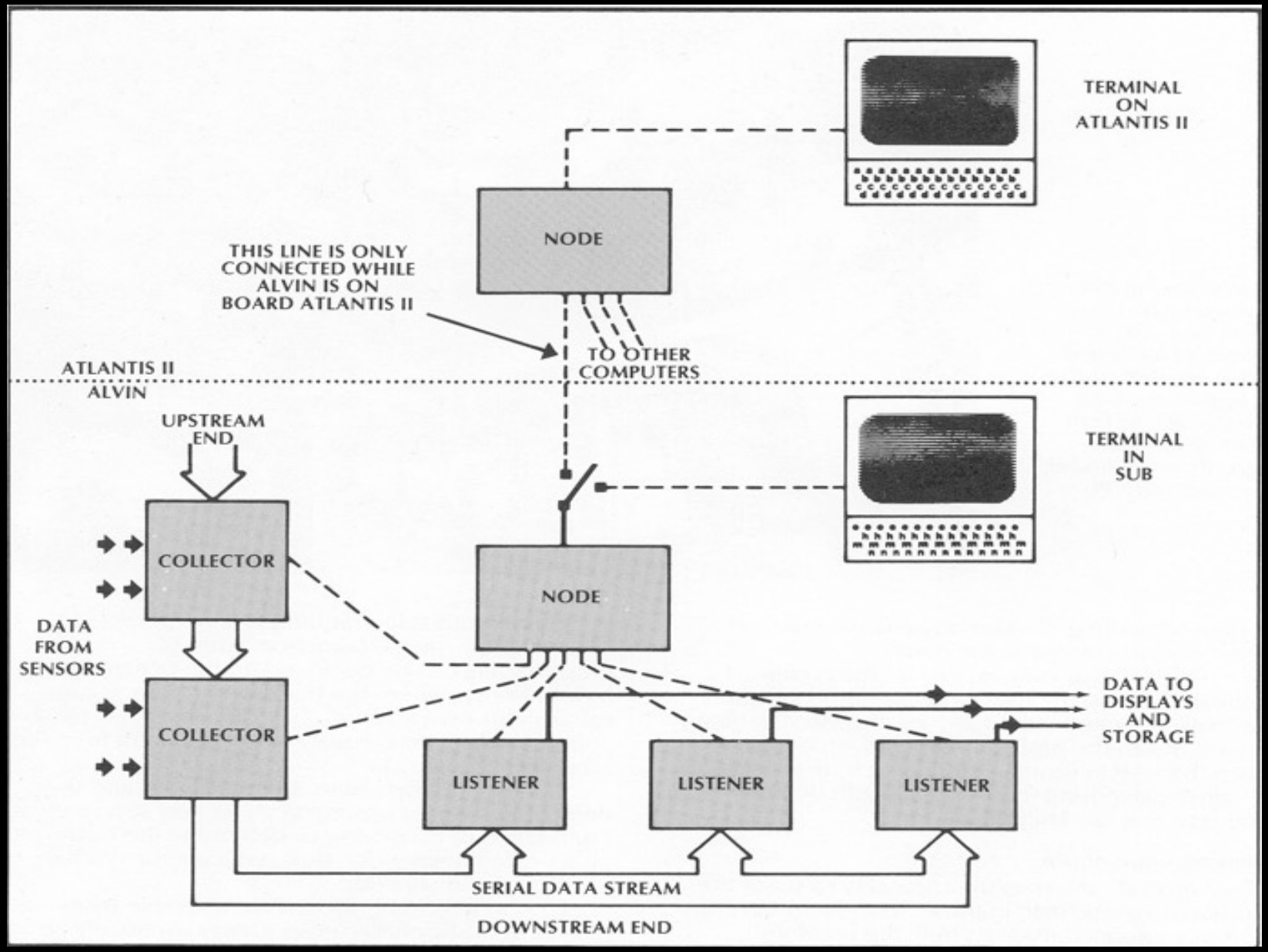
12. Apr 28 HELMREICH
The Sounds of Science

can we classify the different ways that sound is used in science?

- ambient sound or unwanted interference
- audification
- evidence or data
- sonification

transduction, *n.*

Alteration of the physical nature or medium of a signal; conversion of variations in a medium into corresponding variations in another medium.



GRAVITY'S REVERB
LISTENING TO GRAVITATIONAL WAVES

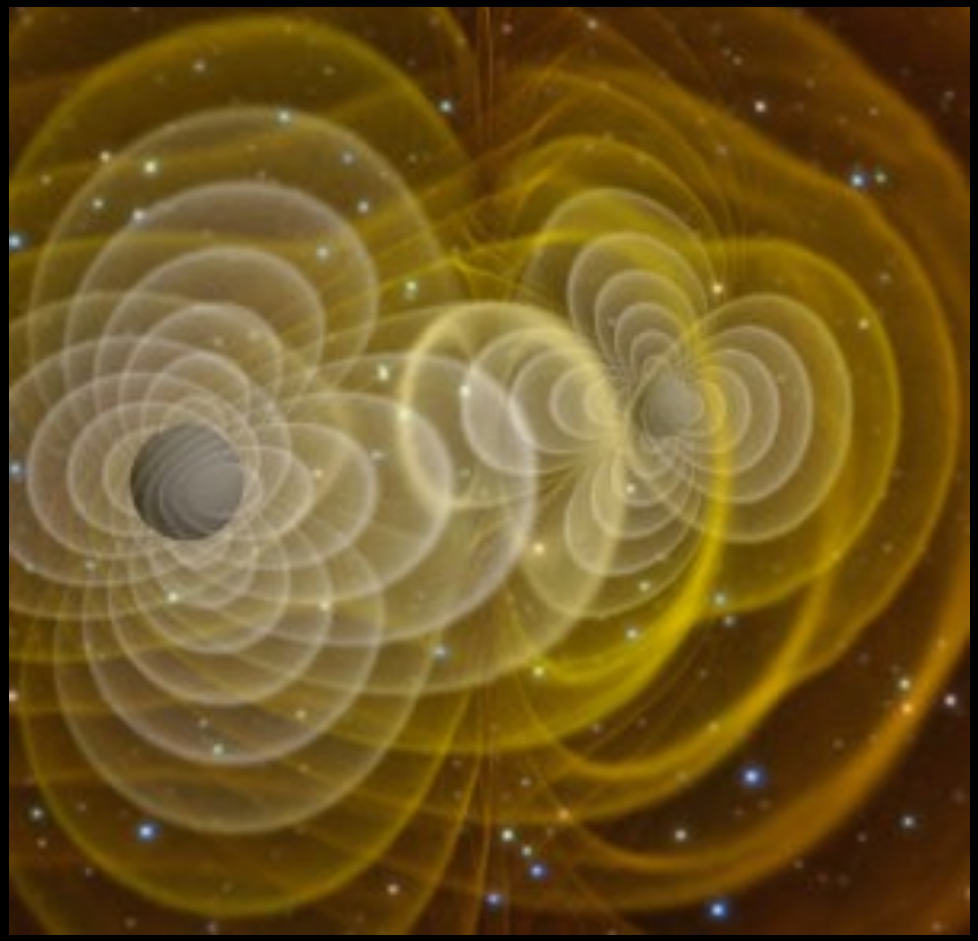
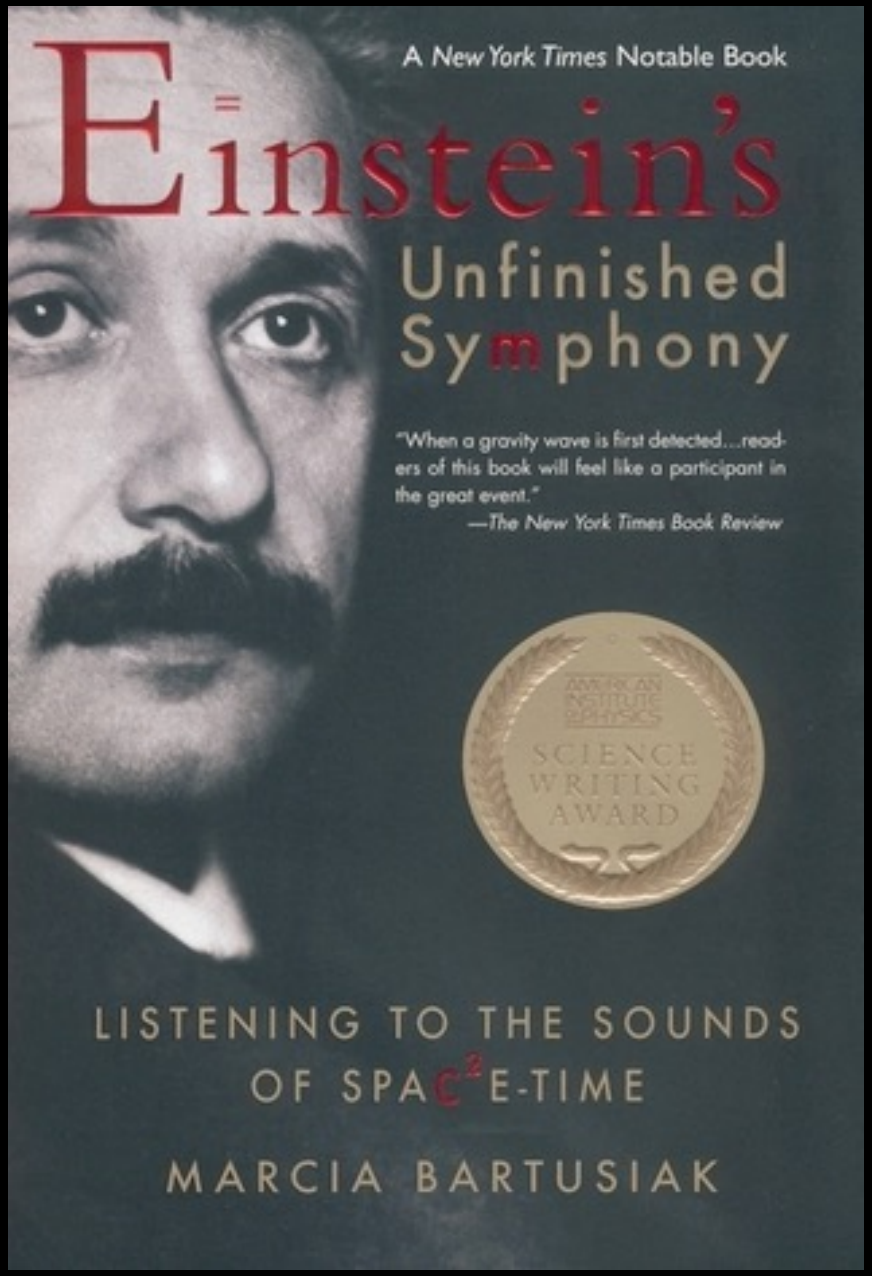


Image by Christopher Henze of NASA. This image is in the public domain. Source: Wikimedia Commons.

2D image of a 3D visualization of gravitational waves produced by two black holes orbiting around one another

Research:
NASA/Goddard numerical relativity group

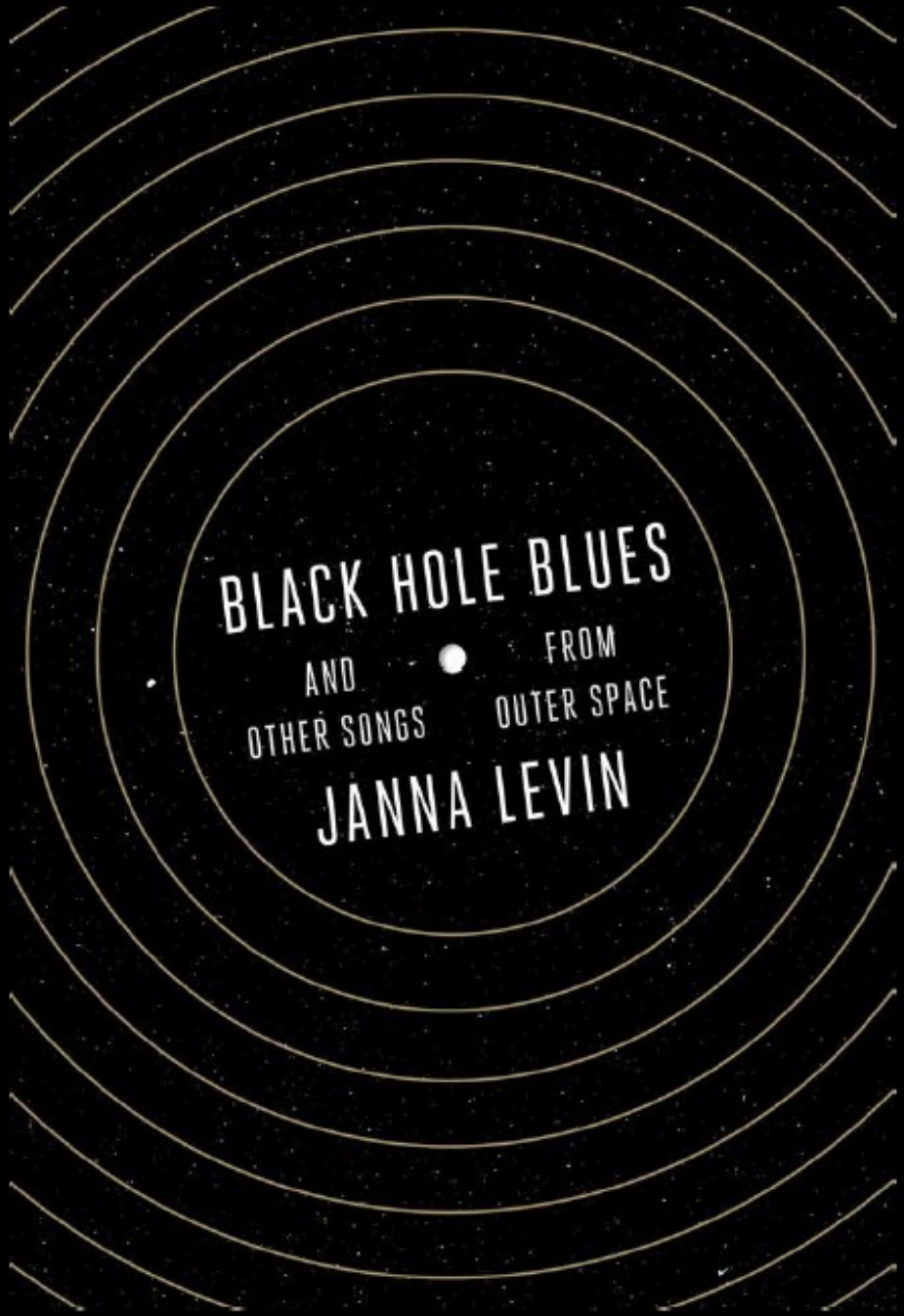
Image: Christopher Henze, Animator, NASA Ames Research Center, 2012

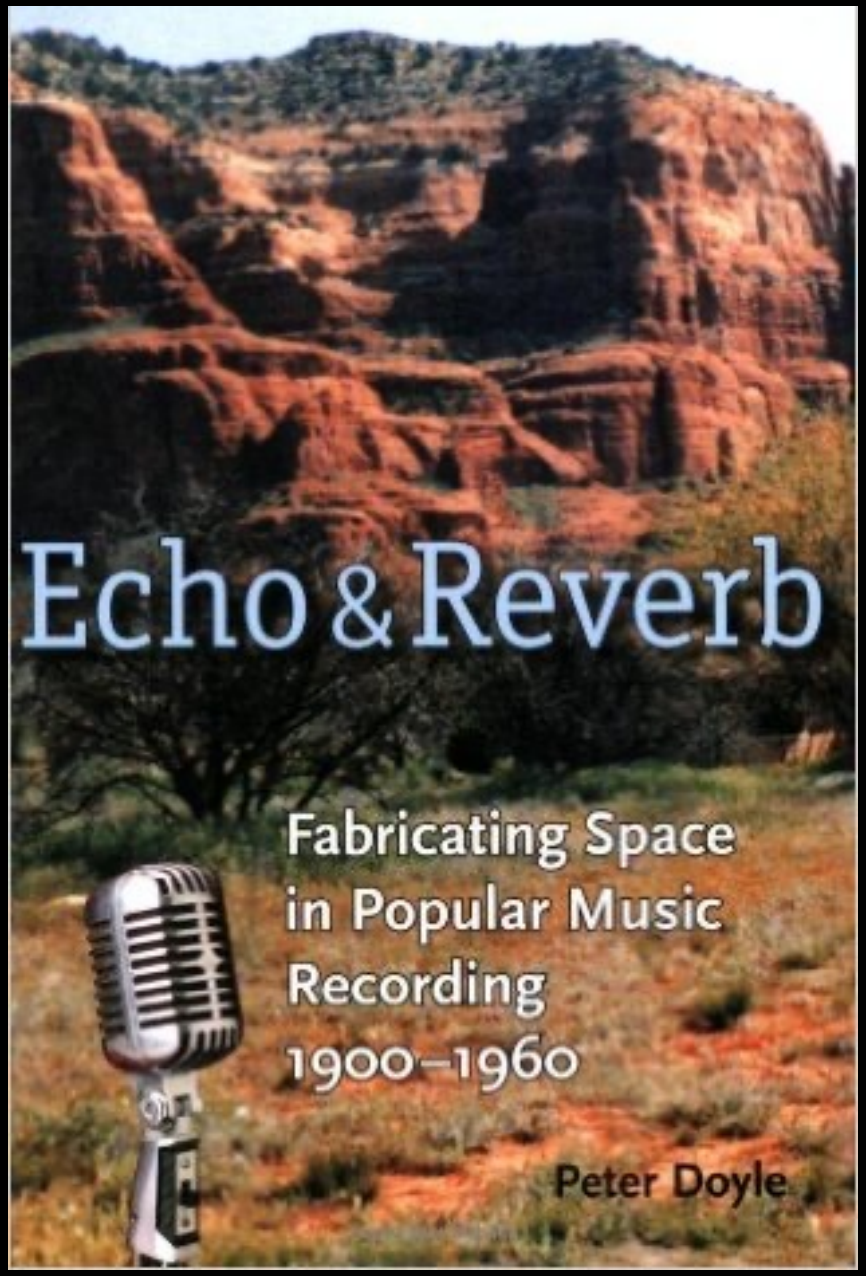


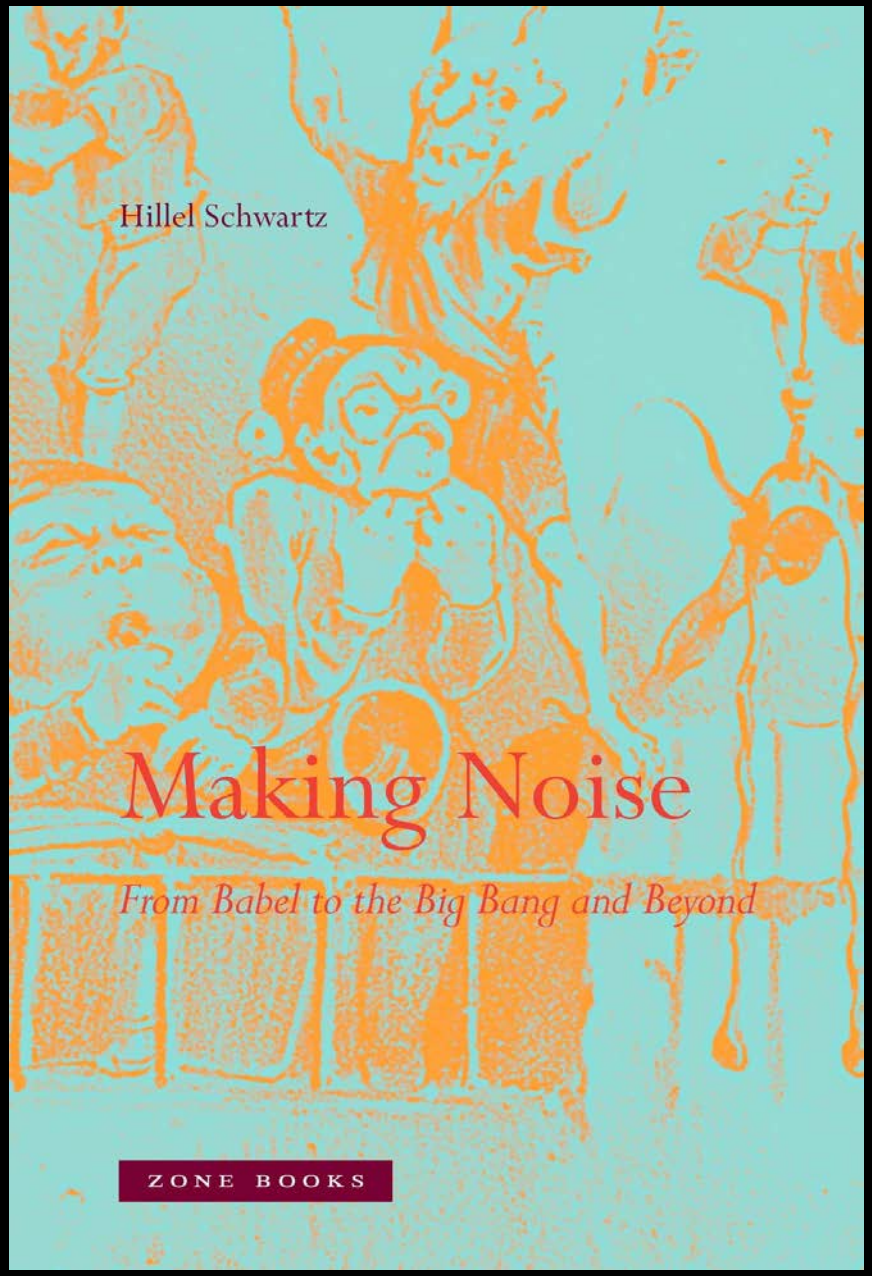
since gravitational waves have a "frequency that happens to fall in the audio range," their detection "will at last be adding sound to our cosmic senses, turning the silent universe into a 'talkie,' one in which we might 'hear' the thunder of colliding black holes or the whoosh of a collapsing star" (Bartusiak 2000: 9).

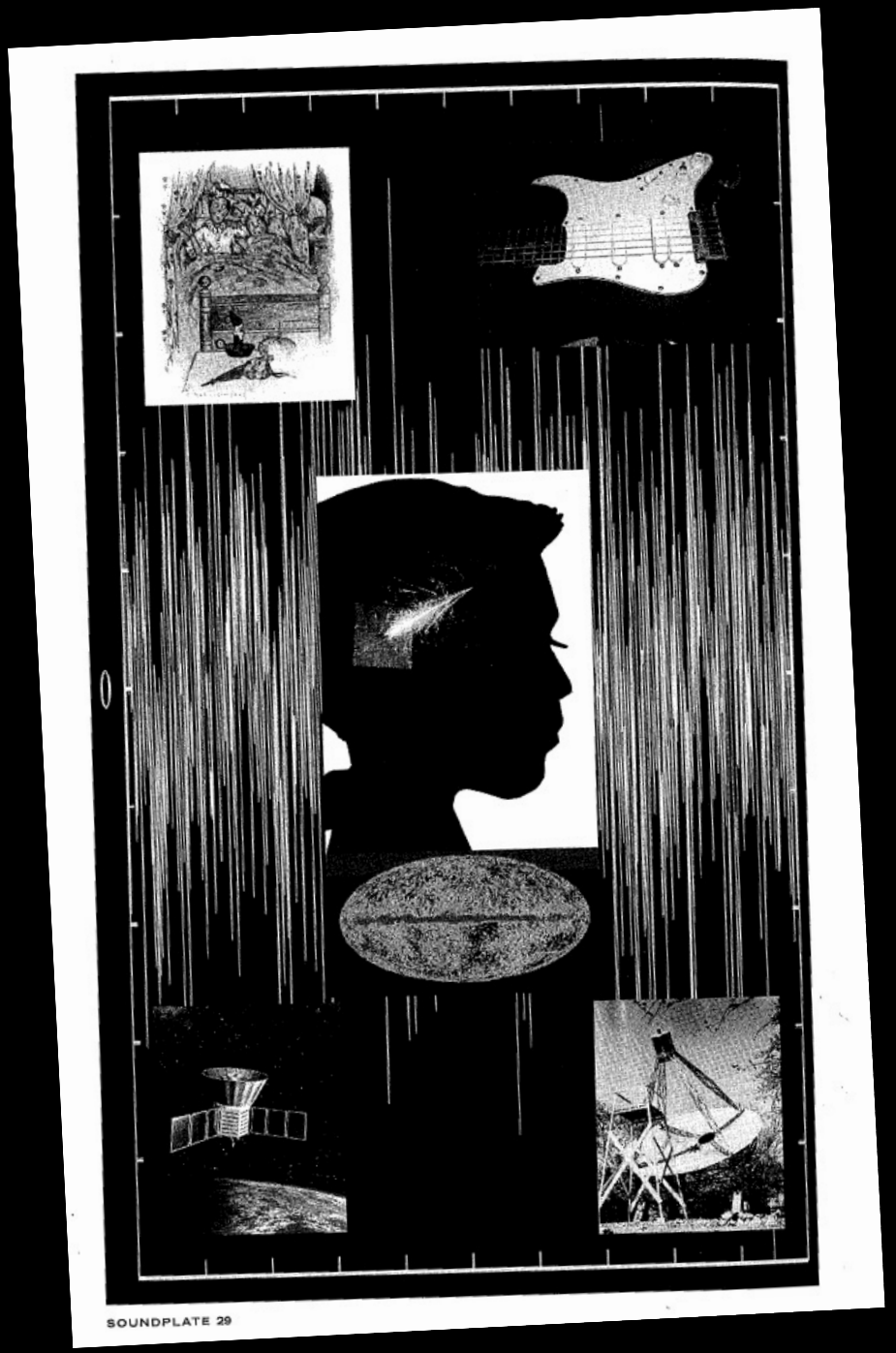
"the universe has a soundtrack and that soundtrack is played on space itself, because space can wobble like a drum"

Janna Levin, "The Sound the Universe Makes," TED Talk, March, 2011









Qafu_prx* Fgjjcj, *K_igle Lmqqc8 Dpmk @_`cjrmrfc@ge@_le $ @cwmlb*, Xmlc@mmiq* 0.//, è Xmlc@mmiq, ?jj pgefrq pcqcptcb, Rfgq amlrclrgq cvajsbcb dpmk msp Apc_rgtc Amk kmlq jgaclqc, Dmp kmpc gldmpk_rgml* qcc frrnq8--mau,kgr,cbs-fcjn-d_o+d_gp+sqc-,

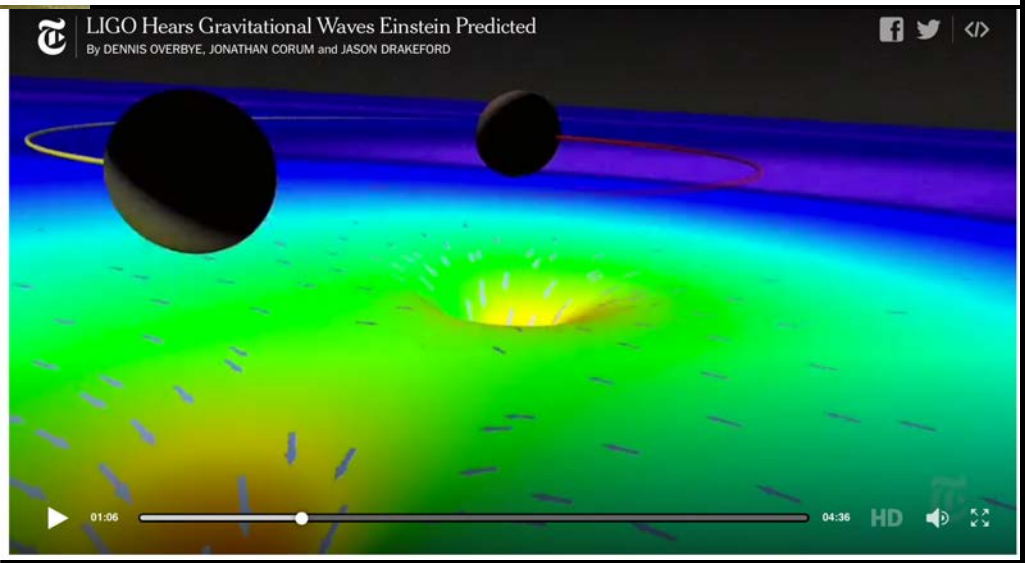
LIGO Hanford

LIGO Livingston

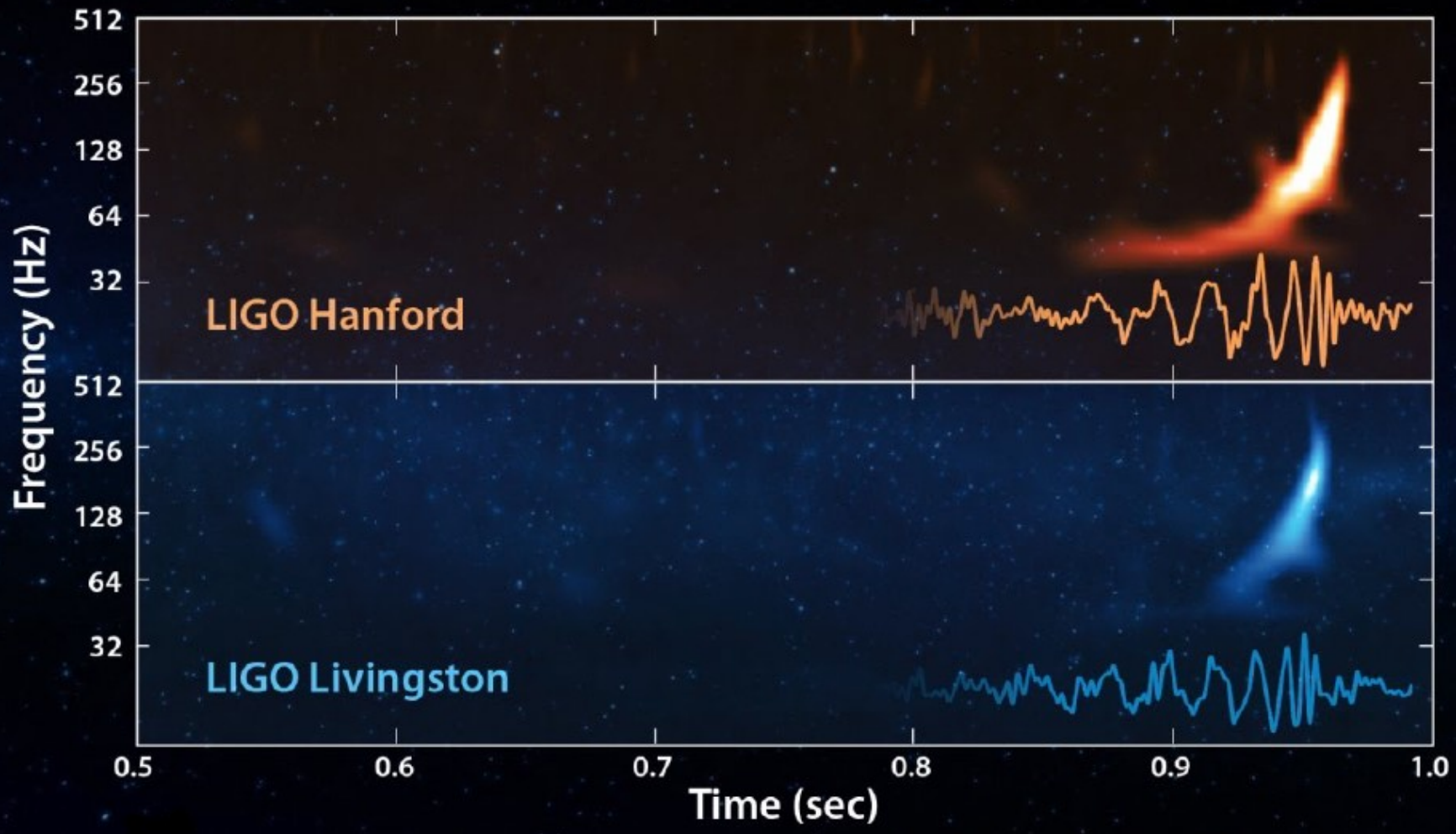
SCIENCE

Gravitational Waves Detected, Confirming Einstein's Theory

Dennis Overbye
OUT THERE FEB. 11, 2016



LIGO
Laser Interferometer Gravitational-Wave Observatory
Supported by the National Science Foundation
Operated by Caltech and MIT



Astrophysical general relativity @ MIT

Research in the group of Professor Scott A. Hughes

The "sound" of spacetime: Overview

The character of gravitational waves generated by a source is quite different from that of electromagnetic waves a source might generate. In many circumstances, electromagnetic waves — be they light, x-rays, radio waves — have a wavelength much smaller than the size of their emitter. For example, visible light has a far smaller wavelength (a few hundreds of nanometers) than the sun (hundreds of thousands of

Home
Research and projects
People
Publications
Sounds
EMRIs
Binaries

kilometers in size) separated by a few hundred kilometers. The waves that they generate will have wavelengths of thousands or tens of thousands of kilometers. We cannot even in principle use this radiation to form an image of its source; thinking about what GWs can help us "see" is just not a well-posed analogy.

A more fruitful analogy can be formed based on sound. The sounds that our ears are sensitive to have wavelengths that can be many meters or tens of meters, far too long to form images of the sources that generate them, such as a person talking. That's fine — you would never imagine using the sound of a

build an image of the emitter, you use your knowledge of the language that is being spoken to understand the information that the emitter is transmitting. (There are some species, such as bats, that use sound for imaging, at least in a crude way; and, humans have developed techniques for making internal images based on sound. Key to these "audio images" is making the sound waves have very short wavelengths; ultrasound wavelengths are typically millimeters or smaller.)

The information content of GWs is analogous to that of sound. GWs have two distinct polarizations, so they carry "stereophonic" information about their source. Each polarization carries the imprints of the source's dynamics and evolution, telling a story about what that source is doing. We use the tools of general relativity to try to speak the language in which that story is told. Also, GW detectors probe the entire sky much as human ears can hear sounds from essentially all directions.

There are differences, of course: Rather than pressure waves moving in an atmosphere, the waves are ripples of spacetime curvature. And, GWs don't act upon membranes in our ear, but rather as oscillating tidal forces upon widely separated masses. As such, it should of course be understood that the analogy to sound waves is really just an analogy. But, it has proven to be a very useful one for communicating the information that GWs carry, and clarifying how GWs can be used for astronomy.

Astrophysical general relativity @ MIT

Research in the group of Professor Scott A. Hughes

Extreme mass ratio inspiral

Extreme mass ratio inspiral (or EMRI) events are the GW-driven inspiral of a "small" (1 – 100 solar mass) compact body into a massive (roughly 10^5 to 10^7 solar mass) black hole. The small body spends on the order of a year or so spiraling through the deep strong field of the large black hole; the waves that they generate in this year are particularly ornate, carrying (in principle) a detailed map of the characteristics of the strong-field spacetime of the large black hole. (Note that regular non-compact stars in this mass range don't work as well since they exhibit very strong tidal interactions with the big black hole, including full tidal disruption. Regular stars falling into black holes are really interesting and important for certain problems in astronomy, but aren't what we focus on here.)

Members of the Hughes group have spent many hours working on techniques for modeling EMRI systems, including the development of some nice audio representations of their waves. Our results are organized by the character of the orbit, and by the spin of the larger black hole. According to general relativity, a black hole of mass M can have a spin angular momentum no larger than GM^2/c; for each orbit class, we have results for a few particular values of the black hole spin.

Circular inspiral

These sounds correspond to an EMRI which initially has zero eccentricity. If an orbit starts out circular, it stays circular, which makes computing its GWs relatively simple. This is a somewhat idealized limit, but nicely illustrates the dynamics of these binaries, and the character of their waves. (And, there are some astrophysical scenarios which make very small eccentricity plausible. Because such waves are relatively simple to model, they may be easier to measure, even if rare, as compared to the generic case.)

Spin 99.8% of maximum

Spin 35.94% of maximum

Generic inspiral

It is generally thought that EMRI events will have significant eccentricity and inclination. Modeling these waves is in relative infancy right now. The best sound files that we have available are produced from so-called "kludge" waves, in which a fairly crude approximation to the wave emission is used to evolve a binary's characteristics. (And, to be perfectly forthright, the kludge has itself been improved over time; the wave models we have at present are particularly kludgy kludges.) This will be updated as our work progresses!

Kludged generic inspiral

"If the two black holes are non-spinning you get a very simple chirp: *whoop*! If the two bodies are spinning very rapidly, I have that same chirp, but with a modulation on top of it so it kinda goes *wooooo woooo wooo woo re ri*! It's sort of the vocabulary of spin, imprinted on this waveform." — Scott Hughes in *The Atlantic*, February 2016

SOUND STUDIES, 2016
VOL. 2, NO. 1, 69–80
http://dx.doi.org/10.1080/20551940.2016.1214446

Routledge
Taylor & Francis Group

OPEN ACCESS

Lobbying for the ear, listening with the whole body: the (anti-)visual culture of sonification

Alexandra Supper

Department of Technology & Society Studies, Maastricht University, Maastricht, The Netherlands

ABSTRACT

Sonification, the transformation of data into sound, is often argued to challenge the "visual culture" of science. Based on an analysis of rhetorical discourses as well as bodily practices within the sonification community, I show that the relationship between sonification and visual culture is in fact more complex and ambivalent: in publications and interviews, sonification researchers blame visual practices for the marginalisation of sound, but also look up to visualisation as a role model. I argue that this delicate balancing act can be regarded as an expression of what historian of science Thomas Kuhn has referred to as the "essential tension" of science between convention and iconoclasm; here: between questioning a scientific status quo (equated with a "visual bias") and conforming to it. Turning towards the sonic and embodied skills involved in doing sonification work, I show that the different sensory modalities, which seem so neatly bounded in discourses about sonification, are intimately intertwined in practice.

ARTICLE HISTORY
Received 3 September 2015
Accepted 8 July 2016

KEYWORDS
Sonification; sound and vision; visual culture; embodied skills; essential tension

In Douglas Adams' (1988) science-fiction story *Dirk Gently's Holistic Detective Agency*, the protagonist Richard describes the advanced visualisation functionalities of his latest project, a spreadsheet program named Anthem:

> If you want dancing girls jumping out of the pie chart in order to distract attention from the figures the pie chart actually represents, then the program will do that as well. Or you can turn your figures into, for instance, a flock of seagulls, and the formation they fly in and the way in which the wings of each gull beat will be determined by the performance of each division of your company. (Adams 1988, 23)

Anthem's most unusual feature, however, is not its capacity for *visualising* numbers and data, but for "sonifying" them by turning them into sounds of varying pitches and lengths. The corporate world is mesmerised by this musical representation, and Richard becomes fascinated by the idea of applying the same technique to make scientific phenomena, instead of business accounts, audible (24) – much to the chagrin of his boss, who does not find any commercial benefit in "turning the erosion patterns of the Himalayas into a flute quintet" (49).

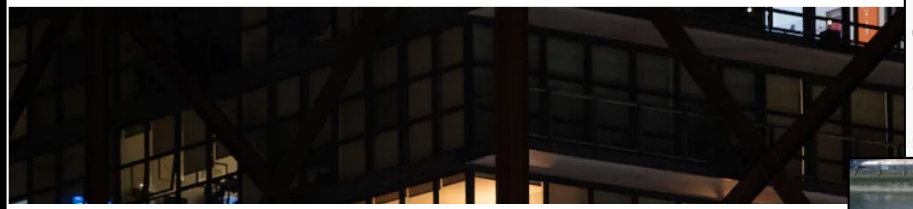
Although written as a piece of fiction almost three decades ago, Douglas Adams' story of Anthem in many ways quite accurately describes the phenomenon of "sonification", the transformation of data into sound. In principle, any kind of data can be made audible – existing

CONTACT Alexandra Supper a.supper@maastrichtuniversity.nl

From Visual Depiction to Sonic Transcription: Some Sounds of the Covid-19 Pandemic

The Washington Post
Democracy Dies in Darkness

What does a pandemic sound like? For many of us at home, it's a heartbreaking silence.



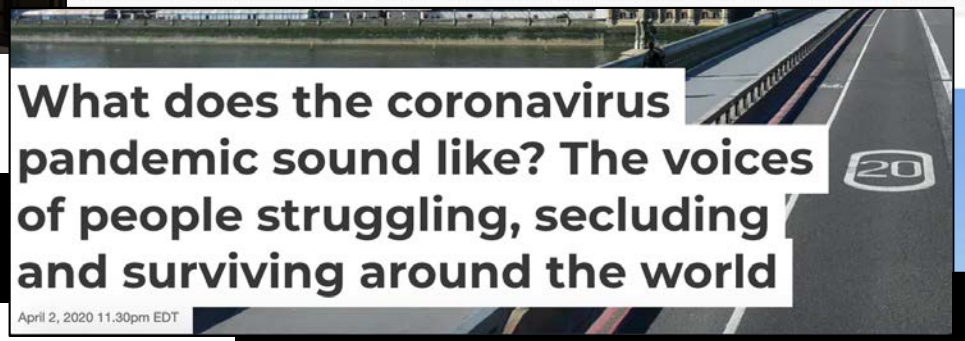
By **Robin Givhan**

April 28, 2020 at 5:00 a.m. EDT

Edition: United States | Donate | Get newsletter | Become an author

THE CONVERSATION
Academic rigor, journalistic flair

COVID-19 | Arts + Culture | Economy + Business | Education | Environment + Energy | Ethics + Religion | Health | Politics/Elec



What does the coronavirus pandemic sound like? The voices of people struggling, secluding and surviving around the world

April 2, 2020 11.30pm EDT

CBC | MENU

COVID-19 | Local updates | Live video | COVID-19 tracker | Subscribe

As It Happens

What does a pandemic sound like? Artist maps audio from people's daily lives

Birds chirping, balcony music and applause for health-care workers among the sounds captured during COVID-19

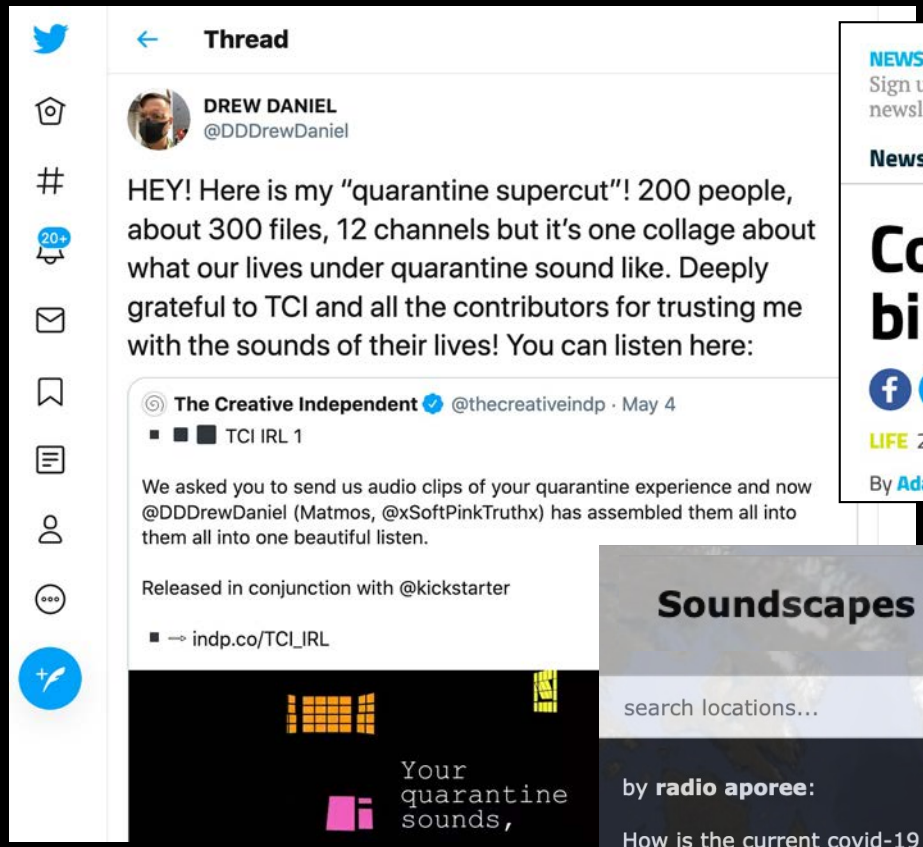
CBC Radio · Posted: Apr 09, 2020 5:33 PM ET | Last Updated: April 9

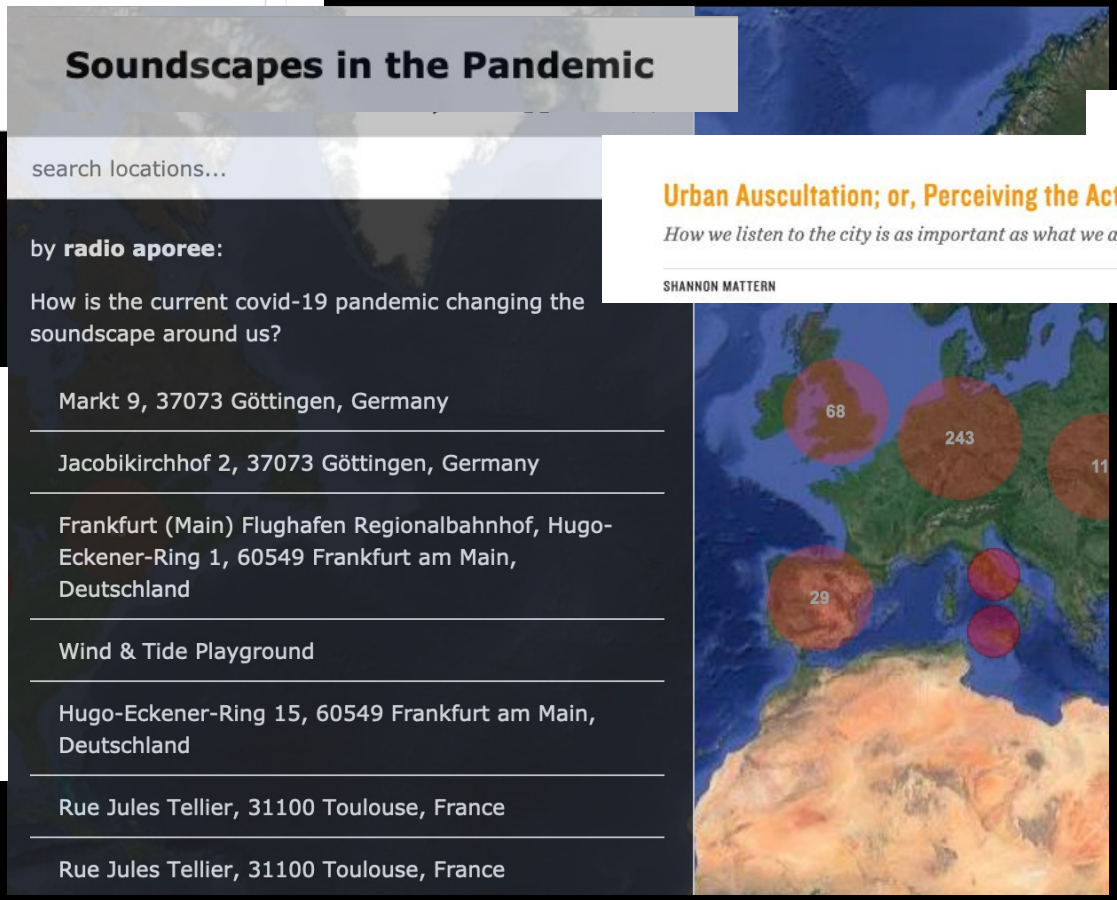
'Sound of the Earth: The Pandemic Chapter'

An online art installation which records the sounds of the COVID-19 Pandemic.

"Over 500 people from around the world have submitted the sounds that they recorded—these include everything from ambulance sirens to waterfalls, as well as events specific to the Pandemic, such as the weekly 'Clap for Carers'."

Credits for these images can be found on page 33.



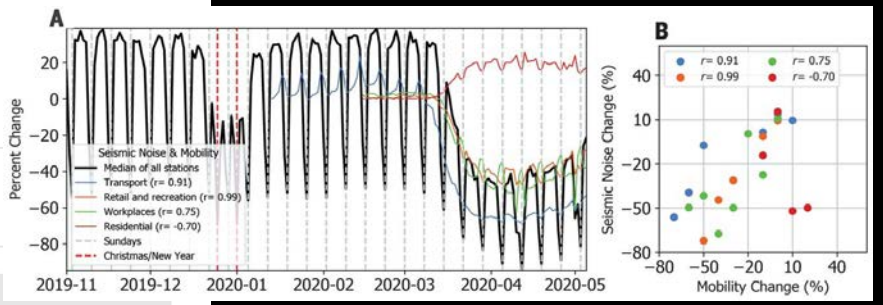


Credits for these images can be found on page 34.

Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures

Thomas Lecocq[1,*], Stephen P. Hicks[2], Koen Van Noten[1], Kasper van Wijk[3], Paula Koelemeijer[4], Ra...
+ See all authors and affiliations

Science 11 Sep 2020:
Vol. 369, Issue 6509, pp. 1338-1343
DOI: 10.1126/science.abd2438



The great seismic quiet period

Noise from trains, airplanes, industrial processes, and other sources is recorded on seismometers worldwide. Disentangling this noise is important for extracting out natural signals, but the noise can also roughly track population movements. Lecocq *et al.* compiled seismic observations around the world and found a substantial decrease in noise resulting from lockdown measures imposed in response to the coronavirus disease 2019 pandemic (see the Perspective by Denolle and Nissen-Meyer). These observations tightly correspond to when the measures went into effect and offer a way to track aggregate behavior. This quiet period also offers the chance to extract anthropogenic sources of noise from those of natural processes.

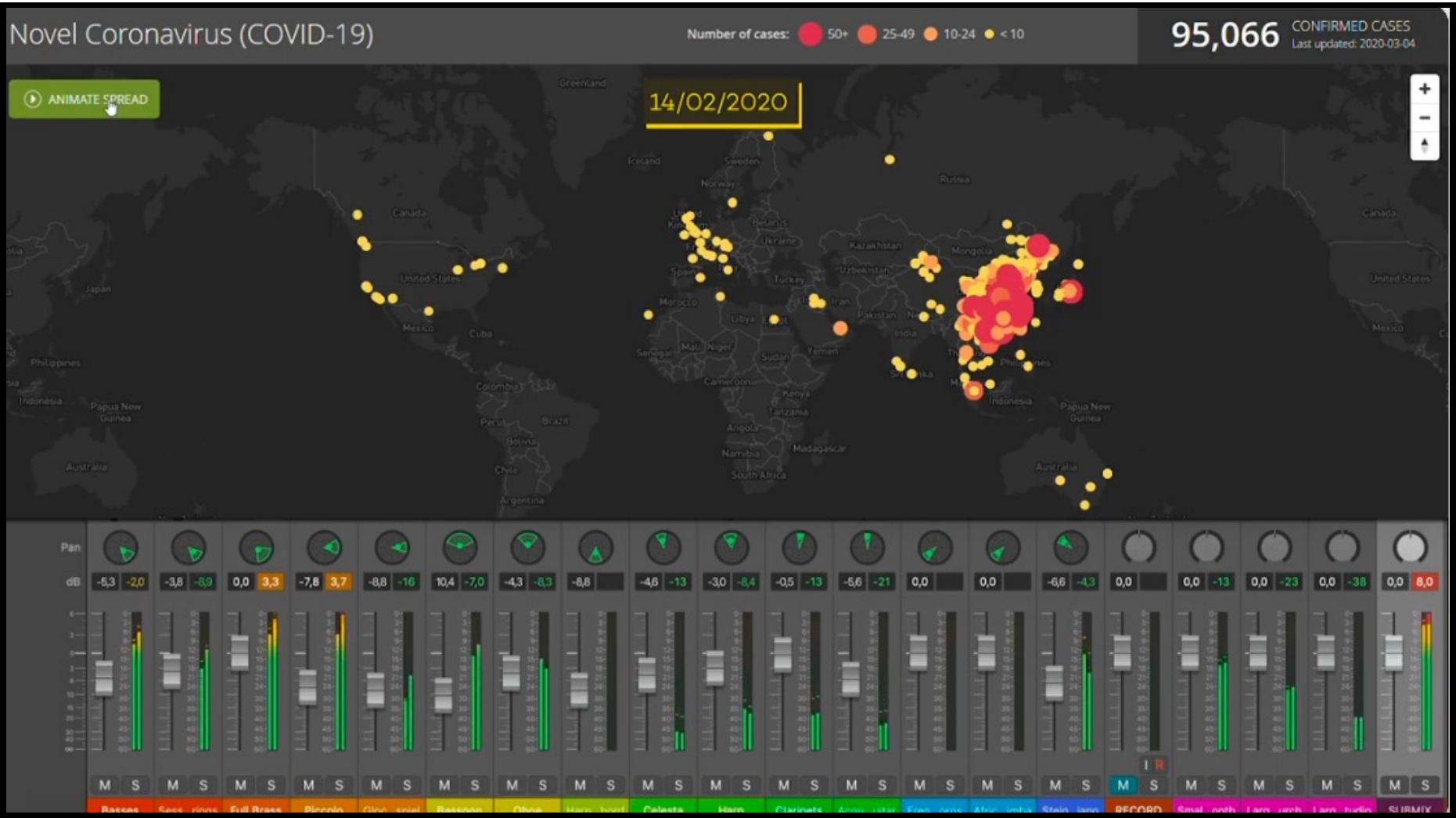
Science, this issue p. **1338**; see also p. **1299**

Sonifying The Coronavirus Pandemic

Mar 9, 2020 • Rayam Soeiro, Paul Koenig, Simon Sandvik, Donho Kwak

Introduction

For this sonification project, our team chose to map the contemporaneous spread of the Coronavirus from China to the rest of the world. This is obviously a phenomenon that is ongoing, so being able to update the sonification as new data came in was an important consideration.



Visually impaired Scots get sonic help with Covid graphs

New website uses musical notes to create an audio map of infection rates or fatalities

- Coronavirus – latest updates
- See all our coronavirus coverage

Scottish COVID-19 Statistics

Summary Dashboard | Regional Insights

Select boundaries:

Health Boards

REGION CASES (last 7 days)
0
1–4
5–9
10–19
20–49
50–99
100–249
250+

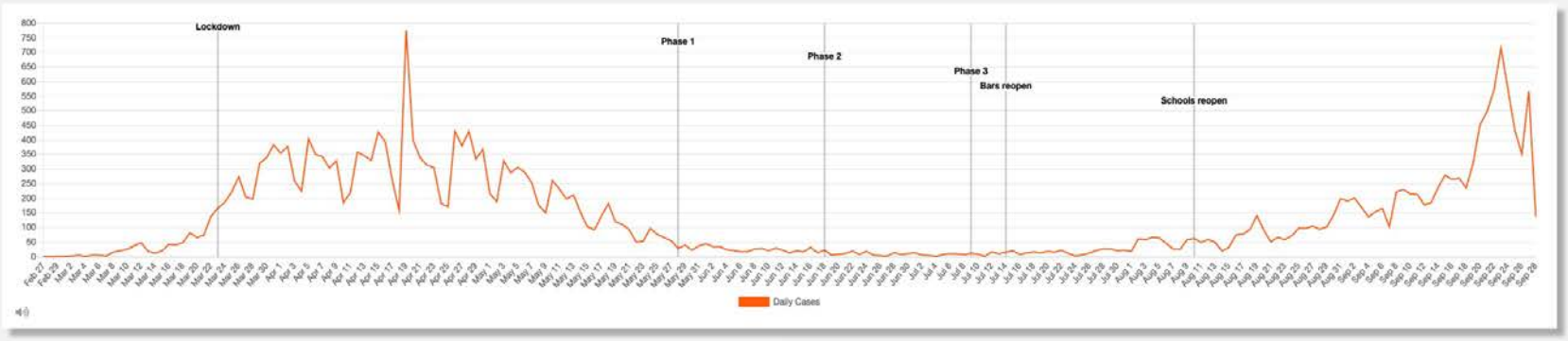
BORDERS
22 Sep - 28 Sep
Cases: 35

Leaflet | © Stadia Maps, © OpenMapTiles © OpenStreetMap contributors

HEALTH BOARDS 14 Boards	
Ayrshire & Arran	
Borders	
Dumfries & Galloway	
Fife	
Forth Valley	
Grampian	
Greater Glasgow & Cly	
Highland	
Lanarkshire	
Lothian	4791
Orkney	23
Shetland	60
Tayside	2515
Western Isles	30

Select Chart:

- Daily Cases
- Total Cases
- Daily Deaths
- Total Deaths
- % Tests Positive



ingenium channel

Français

Home About Browse Boards Content Partners Ingenium Museums

Remembering the sounds of COVID-19

Changing soundscapes

"Listen up: In these disquieting COVID-19 times, hushed cities are making a loud impression on our ears": Reflections on the changing soundscapes of Canada, as impacted by the pandemic.

"The Coronavirus Quieted City Noise. Listen to What's Left": Reflections on the changing soundscape of New York City, as impacted by the pandemic.

"Quiet Oceans: Has the COVID-19 Crisis Reduced Noise in Whale Habitats?": A discussion of how COVID-related quiet is affecting underwater sea sound levels.

Personal reflections

"The Sounds of Covid": Coronavirus lockdown poem written by a nine-year-old child in Cork, Ireland.

"There Is No Noise in a Covid-19 Emergency Room": First-hand account by a front-line doctor in New York City.

"How COVID-19 is unmasking my hearing loss": Personal reflection by an Ottawa resident on the impact of face masks for people with hearing loss.

Recordings and sound maps

"#StayHomeSounds": Collection of audio recordings uploaded by people around the world during coronavirus lockdown.

"Soundscapes in the Pandemic": Another collection of crowdsourced recordings, this one focused on documenting changing local and global soundscapes.

"COVID-19 Pandemic Soundscape": Recordings of residents sounding appreciation for healthcare workers from their condo balconies in Vancouver.

Medical sounds

"Sounds of Coronavirus (COVID-19) - Lung Sounds": Examples of different lung sounds produced by COVID-19.

"COVID-19 Sounds App": An app developed by University of Cambridge researchers to crowdsource sounds of people's voices, breathing, and coughing in order to inform the diagnosis of COVID-19.

"Coughvid": Another initiative to collect the sounds of coughs for research purposes, this one run by the Embedded Systems Laboratory at the Swiss Federal Institute of Technology Lausanne.

Data sonifications

"Viral Counterpoint of the Coronavirus Spike Protein (2019-nCov)": Musical sonification of the amino acid sequence and protein structure of the COVID-19 pathogen.

"The sounds of Covid-19": Another musical sonification of the DNA sequence of COVID-19.

Musical soundtracks and resources

"Golden Sounds of Covid-19": Compilation album of COVID-19-inspired songs, with proceeds donated to charity that provides relief for musicians affected by the virus.

"A Quarantine Playlist For Every Mood": Collection of playlists and live streaming resources for people to access under coronavirus lockdown.

Critical Commentaries

The Future is Unwritten: Listening to the Rhythms of COVID-19

Brian E. Kumm, Joseph A. Pate & Callie S. Schultz

Received 22 Apr 2020, Accepted 13 May 2020, Published online: 26 Jun 2020

ETHNOMUSICOLOGY

Faculty of Music, University of Toronto

Home People Programs News & Events Contact

Listening to COVID 19

Masks curb COVID, but add barrier for deaf community

Mask-wearing makes communication near impossible for those who rely on lipreading to communicate.

Hilary Edwards • June 30, 2020

Informatics in Medicine Unlocked 20 (2020) 100378

Contents lists available at ScienceDirect

Informatics in Medicine Unlocked

journal homepage: http://www.elsevier.com/locate/imu

AI4COVID-19: AI enabled preliminary diagnosis for COVID-19 from cough samples via an app

Ali Imran [a,b], Iryna Posokhova [b,c], Haneya N. Qureshi [a], Usama Masood [a], Muhammad Sajid Riaz [a], Kamran Ali [d], Charles N. John [a], MD Iftikhar Hussain [b,e], Muhammad Nabeel [a,*]

[a] *AI4Networks Research Center, Dept. of Electrical & Computer Engineering, University of Oklahoma, USA*
[b] *AI4Lyf LLC, USA*
[c] *Kharkiv National Medical University, Ukraine*
[d] *Dept. of Computer Science & Engineering, Michigan State University, USA*
[e] *Allergy, Asthma & Immunology Center PC, USA*

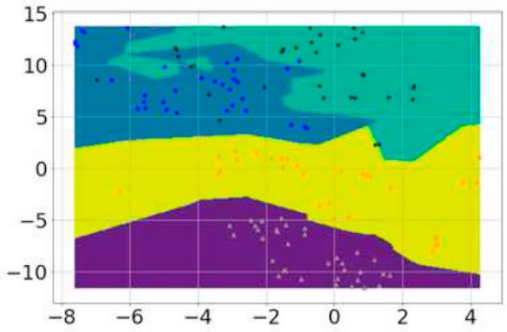


Fig. 1. Visualization of features for the four classes via t-SNE (gray triangles correspond to normal, blue circles correspond to bronchitis, black stars corresis and orange diamonds represent COVID-19 cough. (For the references to colour in this figure legend, the reader is Web version of this article.)

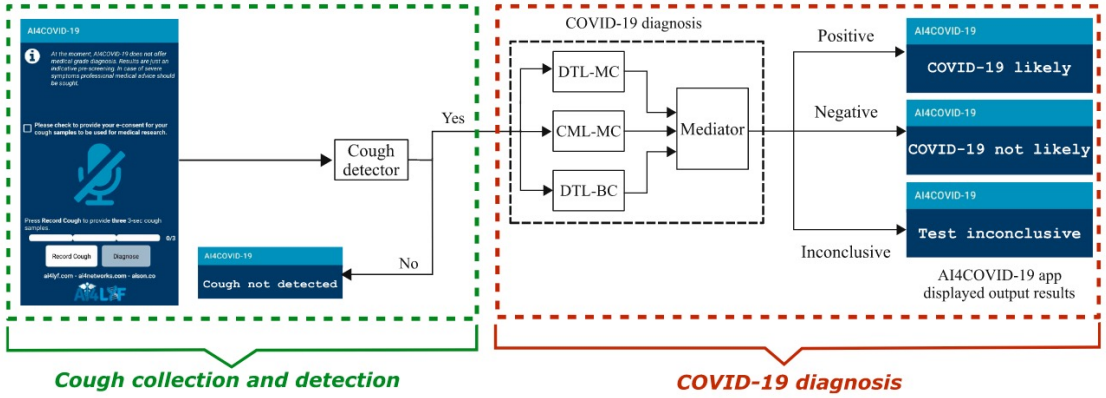


Fig. 2. Proposed system architecture and flow diagram of AI4COVID-19, showing snapshot of Smartphone App at user front-end and back-end cloud AI-engine blocks consisting of Cough Detector block (further elaborated in Fig. 4 and Section 2.3) and COVID-19 diagnosis block containing Deep Transfer Learning-based Multi-Class classifier (DTL-MC), Classical Machine Learning-based Multi-Class classifier (CML-MC) and Deep Transfer Learning-based Binary-Class classifier (DTL-BC) (further elaborated in Fig. 5 and Section 2.3).

Deep learning-based cough recognition model helps detect the location of coughing sounds in real time.

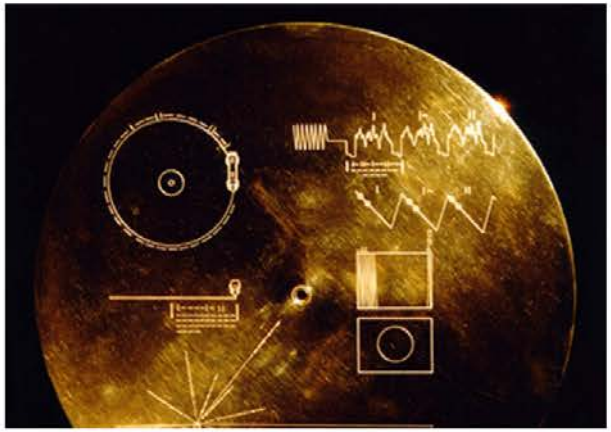
21.08.2020 · #CORONAVIRUS #DEEP LEARNING #INFECTIONS

COVID-19: Deep learning-based cough recognition

The Center for Noise and Vibration Control at KAIST announced that their coughing detection camera recognizes where coughing happens, visualizing the locations. The resulting cough recognition camera can track and record information about the person who coughed, their location, and the number of coughs on a real-time basis.

The Golden Record

Pioneers 10 and 11, which preceded Voyager, both carried small metal plaques identifying their time and place of origin for the benefit of any other spacefarers that might find them in the distant future. With this example before them, NASA placed a more ambitious message aboard Voyager 1 and 2, a kind of time capsule, intended to communicate a story of our world to extraterrestrials. The Voyager message is carried by a phonograph record, a 12-inch gold-plated copper disk containing sounds and images selected to portray the diversity of life and culture on Earth.



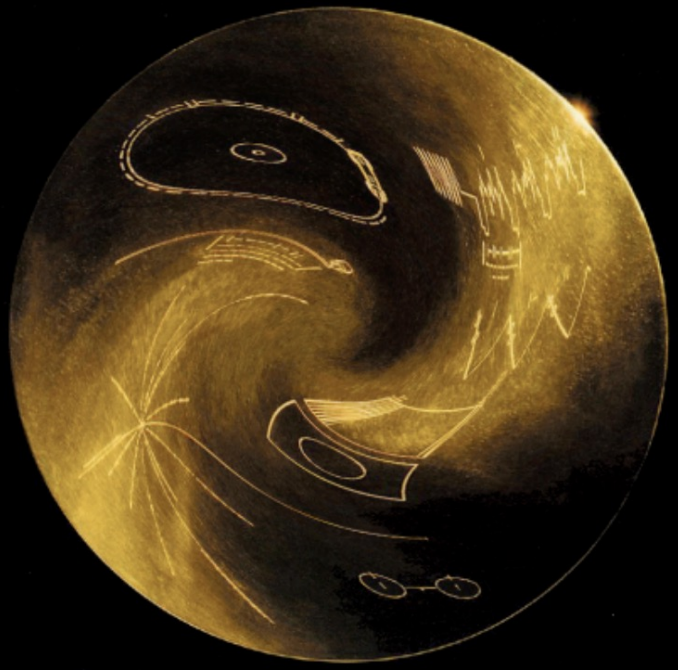
The Golden Record Cover

What's on the Record?

History & Manufacturing

SCRAMBLES OF EARTH

The Voyager Interstellar Record, Remixed by Extraterrestrials



In 1977, NASA launched the Voyager 1 & 2 spacecraft, fastening to each a phonograph album containing sounds and music of Earth. If the best calculations are to be believed, one of these records was intercepted and "remixed" sometime in 2005 by extraterrestrial intelligences on the edge of our solar system. The Search for Extraterrestrial Intelligence in Exile (SETI-X), a dissident offshoot of the better-known Search for Extraterrestrial Intelligence, in 2010 finished decoding signals believed to be transmissions of these "remixes." *Scrambles of Earth*, unauthorized by a skeptical SETI, is SETI-X's document of these audio signs of possible alien intelligence.

object now available from:

SEELAND

TRANSMISSIONS

Hello Uranium Nations
Pulsar Plus
Visit to the Observatory
Gasping in Twelve Languages
Queen's Queens
Psychlo Killer
I Am Getting Married in a Spaceship

TRANSVIEWS

A SCRAMBLES OF EARTH video 13-minute documentary film
AltSounds
Aquarius Records
Daily News, Los Angeles
Popshifter
Radiolab
Santa Fe New Mexican
WIRED
Yale Daily News
Zap Town

TRANSPOSITIONS

3-2-1 Contact

Credits for the images on page 21

Givhan, Robin. "What Does a Pandemic Sound Like?," *Washington Post*, April 28, 2020. © Nash Holdings. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

"What Does a Pandemic Sound Like? Artist Maps Audio from People's Daily Lives." April 9, 2020. CBC. © CBC/Radio-Canada. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

"Sound of the Earth: The Pandemic Chapter." © Yuri Suzuki. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

"What Does the Coronavirus Pandemic Sound Like? The Voices of People Struggling, Secluding and Surviving Around the World." April 2, 2020. The Conversation. © The Conversation US, Inc. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

Credits for the images on page 22

© Twitter, Inc. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

Vaughan, Adam. "Coronavirus Lockdown Changed How Birds Sing in San Francisco." *New Scientist*, September 24, 2020. © New Scientist Ltd. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

Image by Paul Hennessy/SOPA Images/LightRocket via Getty Images. © Getty Images. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

"Soundscapes in the Pandemic." Radio Aporee. © Radio Aporee. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

Mattern, Shannon. "Urban Auscultation; or, Perceiving the Action of the Heart." *Places Journal,* April 2020. © Places Journal. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

21A.505J / STS.065J The Anthropology of Sound
Spring 2022