Ally Bisshop, for Arachnophilia & Studio Tomás Saraceno

On the occasion of the event, *How to hear the universe in a spider's web?* A New Year's Eve Concert for Invertebrate Rights presented by Tomás Saraceno, with the generous support of the Arachnophilia community, Festa Di Roma and spider/webs around the globe.

Toward a haptic astronomy; or, how else to read the cosmos?

As the Earth nears the end of this lap around the Sun and we begin to burden the coming year with promise and ambition, Tomás Saraceno's *How to hear the universe in a spider's web* is a moment to pause, reflect, and find new possibilities for connection. Where the global COVID-19 pandemic has frustrated opportunities for proximity and intimacy between bodies, this event questions how we might connect differently, through the affective and resonant sensory possibilities of vibration. In its capacity to move across bodies and scales, in its blurring of the boundaries between the visual, the sonic and the haptic, vibration presents as a way of "touching at a distance"[1]; of linking cosmic and terrestrial milieux, human, nonhuman and celestial bodies. Through a transdisciplinary research collaboration involving Stavros Katsanevas at the European Gravitational Observatory and pioneering work in astronomical data sonification by Wanda Diaz-Merced, Tomás Saraceno's How to hear the universe in a spider's web is a resonant meditation on the possibilities for sensing across difference, for sensing otherwise. If a "politics of experience"[2] limits and defines our sensorial rendering of the world, this event reflects on the ecology of sense that opens up when we attempt to think beyond the human as the centre of what is possible. Through this critical reflection, Saraceno proposes a speculative *haptic astronomy* as a provocation to challenge habitual frameworks and praxes for understanding the world; to reflect on the logical and ethical premises that such practices embed, and the possibilities that emerge through embracing the resonant promise of vibration.

[1] —riffing on RM Schafer's (1994) claim that hearing is a way of 'touching at a distance'; in *The Soundscape: Our Sonic Environment and the Tuning of the World.* Rochester, NY: Destiny.
[2] Friedner, M., & Helmreich, S. (2012). Sound Studies Meets Deaf Studies. *Senses & Society,* 7(1), 72–86.

On the limits of the senses: astronomies of the unsound and unseen

Within a Western cultural regime of the senses, the eye dominates the ear. Following this logic, many of its scientific practices privilege and structure themselves upon visual means of knowing and understanding the world. In the dominant account, astronomy began as a visual exercise. Across myriad geographic and cultural lines, astronomical knowledge emerged through a durational process of visual attention to the movements of celestial bodies: of watching the night sky, observing and recording phenomena, charting and measuring patterns and shifts in planetary movements. In turn, as the limits of our human sensorium drew boundaries around which parts of the cosmos we could know (and which parts we could only speculate about), we began to construct devices that better aided both this visual inquiry and parallel efforts to mathematically model the universe of which this terrestrial planet is part.

On another account, our relationship with planetary movements has always drifted between sensory modalities. The very first marker is given in our circadian rhythms: an embodied chronobiological dance that follows a 24-hour solar cycle, entraining our body to the Earth's daily rotation as it makes a slow orbit around the Sun. The second is in our affection for the Sun itself: in the absence of sight, we still feel it's radiant heat as it moves across the sky, a passage that traces a thermal path across our skin; the Sun touches us. Even in some instances of full or near total blindness, photosensitive cells in the eye are still able to detect levels of light, and thus set the body's clock to day or night.[3] And, in the ancient Pythagorean concept of the musica universalis or 'music of the spheres', we are given an account of universal structure as a musical or resonant hum—an idea which also appeared in Chinese cosmology[4]—and which hints at early intuitions of the notion of orbital resonance in celestial mechanics.

As scientific knowledge of the universe began to access more and more distant parts of the cosmos, the data became more abstract, such that the universe is now understood as mostly dark matter;[5] "the unlit and non-radiated dead quarter(s) of the universe"[6] that defines itself by its imperceptibility. If the material substance of the universe is dark and ungraspable, it is perhaps striking that we continue to privilege visual techniques for grasping its structure. *How else, then, might we read the cosmos? What new data might we glean from reading and sensing otherwise?*

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[3] Zaidi, F. H., Hull, J. T., Peirson, S. N., Wulff, K., Aeschbach, D., Gooley, J. J., et al. (2007). Short-wavelength light sensitivity of circadian, pupillary, and visual awareness in humans lacking an outer retina. *Current Biology*, 17, 2122 –2128

[4] Xiaochun, S. (2000). Crossing The Boundaries Between Heaven And Man: Astronomy In Ancient China. In H. Selin (Ed.) *Astronomy across cultures: the history of non-Western astronomy*. Dordrecht: Springer Science+Business Media.

[5] "Planck Mission Brings Universe into Sharp Focus". NASA Mission Pages. 21 March 2013.

[6] Heys T. (2019). Large Hadron Collider: The Ultimate Underground Groove. In S. Goodman, T. Heys, E. Ikoniadou (Eds.) *AUDINT—Unsound:Undead.* Urbanomic.

These questions are core to the practice of astrophysicist Wanda Díaz-Merced. Díaz-Merced had been studying the patterns of light emitted in gamma-ray bursts—some of the universe's most energetic events—when she lost her sight, and thereby her capacity to practice astronomy in the way to which she, and the discipline itself, were accustomed. Gamma ray bursts—like much of the light phenomena that astronomy attends to—are not visible to the naked eye. Human vision can only access that tiny subset of the electromagnetic spectrum that we call 'visible light'. As such, human astronomy uses apparatuses and methods to study light phenomena beyond this threshold of visibility, including 'light curves' that plot changes in light intensity over time, and on which Díaz-Merced's work is grounded. Despite themselves being abstractions of *invisible* stellar radiation, the light curves she relied on were *visual* representations, requiring sight to access and scrutinise the numerical data they contained.

For Díaz-Merced, the solution to this impasse was in reconfiguring the representation of that data; pivoting from the visible to the audible. Working collaboratively, she developed a method to translate the data embedded in light curves into sound, a process of data sonification that used pitch, volume and rhythm to signal qualities like brightness or frequency of electromagnetic radiation.[7] In turn, the ability to *listen* to these light curves brought something new to her ears: qualities and patterns in the data not accessible by looking alone. Sensitive to different signals, listening allowed her to "detect patterns in stellar radio data that could potentially be obscured in visual and graphical representation". In other words, listening to the universe was no longer a poor companion to *looking* at it; rather, sonic methods could transform visual interpretations of celestial events in new and surprising ways.

Unsounds: energetic hauntologies and vibrational ontologies

In its efforts to render audible the imperceptible and the not-yet or no-longer audible, sonic astronomy is an opening onto what sound theorist Steve Goodman calls unsounds—the broader vibrational continuum of which perceptible sound is only a subset; a "sonic virtuality" which includes both the inaudible and the "non-cognitive, inhuman phenomena connected to the unknown".[8]

Since Thomas Edison's attempts to invent a valve technology to amplify the vibrations of the departed[9], a hauntology of sound has speculated about the possibility of sonic perseverance, beyond its audible perishing. This hauntology reasoned that—if the first law of

[7] Diaz-Merced, WL. (2013). *Sound for the exploration of space physics data.* PhD thesis, University of Glasgow.
[8] Goodman, S. Heys, T. & E. Ikoniadou (Eds.) (2019). *AUDINT. Unsound: Undead.* Falmouth: Urbanomic.
[9] Trower, S. (2012). *Senses of Vibration: A History of the Pleasure and Pain of Sound.* New York: Continuum Books.

thermodynamics gives us that energy does not disappear, but is only ever transformed—perhaps this was also true of sound, such that it could simply continue reverberating, albeit beyond audible thresholds. For the philosophical mathematician Charles Babbage, this idea rendered "the air itself [as] one vast library, on whose pages are forever written all that man has ever said or woman whispered". And, if an atmospheric library exists in which sonic vibrations imprint themselves onto atoms of air, perhaps—Edison and others had reasoned—these could be retrieved by sufficiently sensitive instruments capable of bringing these sounds within the thresholds of hearing. In a sense, we might also think of astronomy as a *hauntology of cosmic energy*, insofar as it seeks to invent techniques and apparatuses to access the energetic patternings of events long-past, of dead or dying celestial bodies. As with the "spiritual vibrations" that Edison had attempted to revivify, much of astronomy is an attempt to render sensible phenomena that are neither *visible, audible* or even contemporaneous: the unsound, the unseen, the unknown.

The notion of *unsound* alerts us to the limits of thinking sound purely in terms of that which is *hear/here*. Sound is merely a thin slice of the vibrational whole, naming only those vibrations that fall within the spectrum of frequencies audible to (some) humans, between 20 and 20000 Hertz. In turn, our tendency is to partition this slice even further, making qualitative differentiations between sound and its negative facsimile, *noise*. For pioneering scholar of acoustic ecology R. Murray Schafer, "noises are the sounds we have learned to ignore".[10] The 'we' of his statement implies a particular subset of 'we humans' who have become adept at filtering and backgrounding urban and industrial anthropogenic noise. At the same time, historical examples of the weaponization of noise[11] alerts us to its potential violence. The violence of anthropogenic noise is one that many nonhuman species are already familiar with, as bioacoustic studies increasingly reveal the deleterious impact of noise pollution on different plant and animal populations.[12] In turn, anthropogenic noise does not limit itself to audible sound spectrums. It also writes itself, materially, on this planetary body that we call Earth—as evidenced in the global quieting in high-frequency seismic activity during COVID-19 lockdown.[13]

As anthropologist Stefan Helmreich writes, "sound can provide a way of wobbling a prognosticating common sense that usually operates in the domains of the visual, the graphic, or

[10] Schafer, RM (1973) *The Music of the Environment*. Vienna: Universal Edition.
[11] Goodman, S. (2010). *Sonic Warfare: Sound, Affect and the Ecology of F*. Cambridge, London: The MIT Press.
[12] Gill S, Job J, Myers K et al. (2015) Toward a broader characterization of anthropogenic noise and its effects. *Behavioral Ecology* 26(2): 328–333.
[13] Lecocq, T. *et al.* (2020). Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures. *Science* 369, 1338–1343.

the calculational".[14] In turn, with Michelle Friedner, Helmreich stresses that to only think of sense in idealised and categorical terms ('hearing', 'seeing', etc.) is to erase or gloss over the continuities between different sensory modalities, and the multiple ways in which sensation is made manifest.[15] A categorical thinking of sense sets up a politics of experience—a "politics of frequency"—that also obscures the points of contact or "zones of possible articulation"[16] between different sensory modalities. They argue that a critical strategy for establishing this zone of sensory articulation is given in practices of tuning into low frequency vibrations: sounds that "edge from hearing into tactility".[17] This is because vibrations are *mediations*, rather than entities as such; intercessors that are able to "cross distances between things, between people, between self and environment, between the senses and society, promising (or threatening) to shrink or break down such distances".[18] Vibrations offer the possibilities to blur sensory boundaries, and find new ways to articulate different sensing bodies.

A "vibrational ontology" describes an attempt to think sound otherwise; to move beyond "a philosophy of sound and the physics of acoustics toward the basic processes of entities affecting other entities".[19] It attends to infra- and ultra-sonic zones at "the fuzzy periphery of auditory perception, where sound is inaudible but still produces neuro effects or physiological resonances";[20] hovering between the realm of sound and the *unsound* of the not-yet-articulated. In turn, a vibrational ontology offers alluring propositions for thinking through a synaesthetic sensory dynamics of astronomy that extends beyond the limits of perception, and which is capable of articulating human and nonhuman bodies alike.

Nonhuman astronomers: a haptics of tremor

The idea of nonhuman or animal astronomy is a playful way of thinking about other capacities for sensing the cosmic order. An alterity of nonhuman astronomical sense includes magnetoreception, which allows certain organisms to detect and orient themselves according to the Earth's magnetic field,[21] or the astrotaxis possessed by some invertebrates (such as spiders),

[14] Helmreich, S. Melt. In Cultural Anthropology: *Lexicon for an Anthropocene Yet Unseen*. Retrieved from: https://culanth.org/fieldsights/melt
[15] Friedner, M., & Helmreich, S. (2015). Sound Studies Meets Deaf Studies. In Helmreich, S., Roosth, S., & Friedner, M. *Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond*. Princeton and Oxford: Princeton University Press.
[16] *Ibid.*
[17] *Ibid.*
[18] Trower, S. (2008). Vibratory movements. *Senses & Society* 3(2): 133-136.
[19] Goodman, S. (2010). *Sonic Warfare: Sound, Affect and the Ecology of Fear*. Cambridge, London: The MIT Press.
[20] *Ibid.*
[21] —while humans are thought *not* to possess magnetoreception, a recent study has troubled this idea: Wang, C. X. *et al.* (2019). Transduction of the Geomagnetic Field as Evidenced from alpha-Band Activity in the Human Brain. *ENeuro*, 6(2).

and which allows them to orient themselves using celestial bodies like the sun and moon. Indeed, spiders and cosmology are already linked in myriad ways—from the material metaphor of a three dimensional 'cosmic web' to describe the structure of the universe,[22] to the development of the first astronomical micrometer in the fifteenth century, an event that was sparked by a spider building its web in the lens of an astronomer's telescope.[23]

Following the promise of vibrational ontologies for linking earthly and cosmic phenomena across modalities of sense, web-building spiders give us a starting model for our speculative *haptic astronomy* through their vibrational capacity for reading the world. Where jumping or non web-building spiders possess telescopic vision that can even allow them to visually resolve the moon in the sky,[24] their web-building cousins are virtually blind, building their picture of the world and cosmos primarily through their acute vibrational sense. For these spiders, their web is an instrument for vibrational communication —a vibrant and organic network of silk threads, whose architecture is acutely attuned to the vibrational tremors that pass through it: the signals the spider sends through the web to gauge its tension and structural properties, the signals sent by other spiders (potential mates, or predators), the vibrations produced by the spider's prey, or even the low frequency tremors produced by the wind. The sensory capacities of the spider are thus extended through the material threads of its web, which acts as a network for conducting the vibrational semiotics through which the spider's cosmology takes its shape. And, the spider senses these vibrations not as sound—possessing no ears as such—but through specialised organs for sensing airborne and substrate-borne vibrations: trichobothria (hair-like extensions that cover the spider's legs), and slit sensilla; sense organs for which we humans possess no recognisable cognates.

This vibrational signalling capacity and sensitivity is described in the nascent sub-field of bioacoustics known as *biotremology*.[25] Vibrational sense has been described for numerous animals: alligators, elephants, frogs, moles, whales, insects —using vibrational signals that range from near-infrasound (0.1 Hz to 20 Hz) to ultrasound (above 20,000 Hz). In mapping the range of frequencies to which particular animals are sensitive, biotremology studies illuminate the realm of *unsounds* to reveal the rich vibrational sensitivities and vocabularies of different entities that lie

[22] —note that this comparison by Volker Springel between spider and cosmic webs first inspired Saraceno to build a novel apparatus and method for creating precise 3-D models of complex spider webs, and then of realising them as large-scale analogue sculptures. See: Saraceno, T. & S.Arrhenius (eds). (2010). 14 *Billions (Working Title)* Milan: Skira; see also: V .Springel *et al.*, 'Simulations of the Formation, Evolution and Clustering of Galaxies and Quasars', *Nature*, 435(7042), 2005, pp. 629–36.
[23] Bedini, S. A. (2005). Along came a spider: Spinning Silk For Cross-Hairs. *The American Surveyor*, March/April.
[24] Yong, E. (2017). Tiny Jumping Spiders Can See the Moon. *The Atlantic*, accessed at: https://www.theatlantic.com/science/archive/2017/06/jumping-spiders-can-see-the-moon/529329/
[25] —see: Hill, P. *et al.* (Eds.). (2019). *Biotremology: Studying Vibrational Behavior.* Cham, Switzerland: Springer.

outside of a human sensory grasp. And, while 'we humans' possess no vibrational sense as the spiders do, we can nonetheless *feel vibrations*: the sub-bass line in a club that quivers our organs, the low-frequency sounds that edge toward the haptic. Low-frequency or sub-sonic vibrations as mediating an invisible politics of touch across species thresholds.

How to hear the universe in a spider's web: a haptic reading of the cosmos

The universe is dynamic, holding endless uncertainty. To render this uncertainty in sonic terms creates what Diaz-Merced calls "a beautiful symphony" that reveals more than is possible from looking alone. However, to focus on the distinctions between sighted and unsighted astronomy is to reproduce the same kind of categorical logic on which a hierarchy of sense was first constructed. Perhaps, we argue, we might think in terms of a *haptic astronomy* that edges between the visual and the audible, between what is heard and what is felt; tracing the passage of tremors that underscore this universal symphony. A speculative haptic astronomy is a way to think sense differently—not as something constrained and defined by different bodies, but as a way of receiving, of *parsing* the world as vibrational force. It emerges from an attempt to think of sense as something that is not limited to a single body, but which is distributed across bodies, instruments and phenomena. As a movement toward a *haptic astronomy*, the *How to hear the universe in a spider's web* concert folds together multiple vibrational possibilities for illuminating a relationship with the stars: *visual* (through high-powered light beams), *sonic* (through a multispecies jam session enrolling spiderly, earthly and cosmic sounds) and *haptic* (through subsonic or VLF waves). In so doing, it attempts to unfold the possibilities for a synaesthetic sensory grasping of the cosmos, mediated by vibration.

The concert, *How to hear the universe in a spider's web,* also plays with the possibilities for creating a shared, vibrational resonant sympathy that links bodies and phenomena across scales. The physical phenomenon of resonance finds expression in molecular particles, in the tissues of our organs, in musical instruments, electronic technologies, as much as resonance has become a way to think of the structure of a vibrating universe. Deriving from the Latin 'echo' (*resonatia*), resonance also becomes a way to think of resounding the *unsounds* of a distant cosmos, as well as finding correspondences between microcosms and macrocosms, between us and the stars, between distant lands, between *you* and *me*.