



GAIA 5.0 — A five-dimensional geometry for the 3D visualization of Earth' climate complexity

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Abstract. The artwork presented here is motivated by the wish to communicate an assumed underlying higher-dimensional space grid for the Universe. It was presented in the digital 3D animated opera named *GALA 5.0. — A Holographic Image Ambience*, a 'big data' visualisation project that proposes a 5-dimensional (suffix 5.0) geometric visualization of the Earth from the Gaia hypothesis standpoint: the Earth as a living, thus complex system. This quasi-crystallography visualisation, situates the Earth in the center of a dynamic 5-dimensional subscendent space configuration and draws parallels between 19th ether concept (cf. Lord Kelvin, V. Bjerknes a.o.) and the newly discovered 3D representation of the *Penrose Kites & Darts* tiling (Epitahedra, E_{\pm}) which allows us to rebuild the presocratic 'living pattern of the world' as 5-dimensional space conforming the Poincaré's dodecahedral space. -- This allows us to regard the Earth not as big data generator but its underlying space which generates symmetries in compounds of multi-dimensional spaces with create particles, matter, fluxes, cycles, metabolism, and meteorological and climate turbulences. Meteorologic and climatic features like the Coriolis effect, Ekman pumping and the Lorenz attractor are discussed in this geometrical framework from an artistic visualization point of view. We conclude that those dynamical physical phenomena on Earth can be related to intrinsic geometrical features of higher dimensional spaces proper to living systems. Finally, a gender perspective and the role of arts as tool for communication in scientific research of complex systems are briefly discussed.

Keywords: Gaia hypothesis; Meteorology; Big Data visualization; Hyper-Euclidean Geometry; 3D representation of the Penrose kites & darts tiling (Epitahedron E_{\pm}); Poincaré Homology Sphere;

1. Introduction

The SciArt program *Resonances* of the Joint Research Center (JRC) in Ispra, as described by the editor Tiziana Lanza in the introduction to this volume (Lanza et al. 2020), is guided by a noble motive, the establishment of a convergence and harmonization of sciences and arts. So, the nowadays almost 70 year old campaign against the 'two cultures' (c.f. Snow, 1959) and pro integrating the resources of disciplines spanning the natural and social sciences, the arts and the humanities, became finally alive in the current societal process triggered by SciArt initi-



atives of the European Commission. In a way, SciArt -- or information art, as it is named sometimes -- nowadays, can be regarded as a restart of Romantic ideas (c.1800–1850) when foremost Diderot & d’Alembert in France, German Idealist philosophers and Romantic poets in England dreamed of knowledge production in a union between the arts and sciences. Georg W.F. Hegel (1770–1831) claimed that “in our age, art invites us to intellectual consideration” (Hegel, [lectures, 1788]1975). Hegel spoke about opening up the possibility of a different kind of art which is „explicitly self-reflexive and exploratory“ (Žižek, 2016).

In this spirit, the British artist John Constable famously (1776–1837) demanded that painting be

“scientific as well as poetic ... a branch of natural philosophy,
of which pictures are but experiments.” (John Constable, 1836, in Beckett, 1970)

The mathematician Ada King, Countess of Lovelace (1815–52) famous for her conception of the first Computer program (1842) praised the importance of imagination (Toole, 2010, 136). It is not the sole preserve of artists or poets, but rather that true imagination only arises when conceptualizing the world using the principles of science and mathematics (Illingworth, 2019).

Lovelace claimed a poetical science while Humphry Davy (1778–1829) and James C. Maxwell (1831–79) were writing sonnets. Foundations for modern arts were laid by Maxwell’s development of a three-color method for photographs resulting from experiments conducted with his wife Katherine Mary Dewar (Maxwell, 1861b).

Contributions to the edifice of knowledge can be hardly allocated either to art or science exclusively: For example, at the beginning of meteorology as modern science, the classifications of clouds goes back to the manufacturing chemist and amateur meteorologist Luke Howard (1772–1864) who painted clouds. He established the terms Latin ‘stratus’- ‘cumulus’ and ‘cirrus’ which are still in use today (Howard, 1803). It seems notable that Howard’s 1802 presentation took place at the Askesian Society, a largely *non-conformist* group dedicated to natural and experimental philosophy. — Progress in science usually does not take place in midst of established convictions and doctrines. Nevertheless the idea of a fusion between art & science remained a futurist project since claimed by the German composer Richard Wagner (1813–1883) in his essay *The future of Art*, when he remarked a strong deficiency of acceptance,

“I’ve brought up the Philistine against me who just want to imagine the artist as silly, but never thinking.” (Wagner, [1849] 2013).

Hence, it seems the separation of the two research cultures increased since the term ‘scientist’ was coined by then most influential British polymath William Whewell (1794–1866). In his review of Mary Somerville’s best selling book *On the Connexion of the Physical Sciences* (1833) he was referring to ‘some ingenious gentlemen who ‘proposed that by analogy to *artist* they might form *scientist*’ due to fact that physical science became endlessly subdivided (Whewell, 1834, 59).

Here we are also addressing the manifold intertwinings between arts and sciences: Art may contribute to scientific research with imagination and visual expertise in order to create complex models. Secondly, art as science communication enables to include emotional aspects which are not allowed in rational objective science which may help to understand the scientific facts better. A third but not easily accepted role of the arts are critical commentaries to science, like f.e. Marcel Duchamps’ works »The Large Glass« (1915–1923) or »3 Standard Stoppages« (1913–14) (see, Henderson, 2005) . While data scientists are mostly calculating, and philosophers ask for causality and ontologic foundations, artists want to know how the system „looks like“. The geometer investigates visual mathematical shapes for the representation of phenomena.



74 2. GAIA 5.0: The Installation



75

76 **Figure. 1.** The earth embedded in the hyper-Euclidean framework of 5-dimensional space. (Image: rendering
 77 F. Grünberger for *GAIA 5.0* video by R. C-Z-Quehenberger, still frame, min 2: 06)

78 The SciArt installation, *GAIA 5.0* a holographic projection and VR-experience of 3D animated film was commis-
 79 sioned by the Joint Research Center (JRC) of the European Commission (EC) in Ispra and shown at the DATAMI
 80 Resonances III festival with exhibitions in Ispra and at the Bozar in Brussels (Dec.2019-- Jan.2020) (datami,
 81 2019). DATAMI is the portmanteau-word created by curator Freddy P. Grunert in order express his Resonances III
 82 theme, addressing artistically societal challenge relating to big data and its reflection -- on a traditional Japanese
 83 tatami mat (Grunert--Fiordimela --Eeckels, 2020-21).

84 *GAIA 5.0* was conceived after vivid discussions with two meteorologists. One was about Earth' intrinsic
 85 dynamics with Louise Arnal, an expert on floods, affiliated at the European Centre for Medium-range Weather
 86 Forecasts (ECMWF) in Reading (UK) and the other was about the aerosol formation process with Frank Raes, a
 87 meteorologist and former head of the Climate Change Unit at the JRC, the inventor of the SciArt program. Hence,
 88 this artwork became a collaboration with meteorology, a branch of the atmospheric sciences which includes
 89 atmospheric chemistry and atmospheric physics, with a major focus on weather forecasting.

90 2.1 Motivation and target

91 There is no general agreement on how to handle higher dimensions in mathematics which remain mainly ab-
 92 stract. This indicates the necessity for contributions from the side of the arts and their expertise in imagination and
 93 in generating images to overcome those shortcomings in science.



94 The voice-over by Lydia Lunch in the video-art work creates the illusion that the Earth herself is narrating in the
95 spirit of the quote »Gaia is a tough bitch« (Margulis, 1995). Quehenberger's text reflects ancient and modern sci-
96 entific concepts spoken by the US-american singer, environmental activist and no-wave-icon Lydia Lunch who
97 also composed the music for it. Her powerful voice should echo the lament of the »World Soul« over the current
98 state of the world, known as »climate crisis«. The dramatic stage of the world, from severe cyclones to desertion,
99 from devastation to pollution and the astronomically high rate of loss of bio-diversity in the Anthropocene is a
100 motivation for the production of art works which create devotion to the glory of nature wonder over the miracle of
101 life in the eyes of the spectator. In this regard the artwork GAIA 5.0 promotes the beauty of symmetries in the
102 higher-dimensional space grid in which we and the stars around us are caught if we abandon the empty flat
103 /curved pseudo-4-dimensional Minkowski-spacetime paradigm.

104 In the title GAIA 5.0, the suffix 5.0 is referring to the 5th spacial dimension by mimicking the usual notion web
105 2.0 for interactive internet or web 3.0 for the semantic web and web 4.0 for the autonomous, content-generating
106 AI agents of the internet of things. *GAIA 5.0* refers to the Earth system functioning as a single living whole which
107 is more than a synthesis of any technological characteristics such as some utopian *web 5.0* currently under
108 development and referred to as the Sensory Web. In the DATAMI artwork the ancient geometry idea of a space
109 grid which is visualized by 5-dimensional geometry is morphing into the satellite grid. The voice-over explains,
110 "This imaginary sparkling space grid was replaced & actually realized
111 by means of technical devices forming the radiance grid of satellites
112 which now provides us continuously with surveillance data of earth' features:
113 both atmospheric and oceanic." (Lydia Lunch as Gaia narrator)

114 Thus in a way the piece is dedicated to a general audience as a meditation on different realities which emerged
115 over time: One of our contemporary high-info-tech existence with Earth sciences and observation technologies
116 and the other, millenia old mathematics, geometry, philosophy and imagination about the divine Earth,-- a living
117 creature embedded in the evidently higher-dimensional living pattern of the world.

118 It seems notable that the satellites used for telecommunication and observations are forming a technical 4-dimen-
119 sional environment, a metal shield around the planet. Global positioning systems (GPS) functions based on
120 Minkowski's pseudo-4-dimensional geometry but as a consequence no comprehensive 4-dimensional model of the
121 Earth exists. But there are 4D weather data models with images of 'data towers' built on the surface of the globe
122 such as the Four-Dimensional Weather (4DWX) system which is well established since the 1990s (2018 RAL An-
123 nual Report). In this regard the GAIA 5.0 video presents the Earth as hypersphere for visualizing space and time
124 as 4-dimensional object in (imaginary) movement (see fig. 1 and 2b).

125 Satellites are creating a technological web around the planet that replaced what was previously considered as
126 'living intelligent Pattern of the world' by Plato (Platon, Timaios 29d–30c).

127 In 2019 the European Union's Earth environmental satellite *Copernicus* was launched. The *Copernicus* observa-
128 tion program provides important data for meteorology and weather forecast, the information obtained is data of
129 the Earth' atmosphere, seismic and oceanic features around the globe. The depiction of satellites in the *GAIA 5.0*
130 video are purely symbolic. The number of actually launched space objects of nearly 10.000 is documented by
131 United Nations Office for Outer Space Affairs (UNOOSA, Online Index, March 31, 2020). Satellites which are
132 used for telecommunication and observations are forming a technical 4-dimensional environment, a metal shield



133 around the planet while no comprehensive 4-dimensional model of the Earth exists. Only a so-called 4D weather
134 data models (4DWX) create images that remind us of “data towers“ built on the surface of the globe (c.f. 2018
135 RAL Annual Report).

136 2.2 The 4-dimensional hypersphere – imagining the biosphere

137 The French philosopher Paul Virilio (1932--2018) attributed the negation of the notion of physical dimensions and
138 a lack of spacial awareness to a fractal perception of reality (Virilio, 1984). The discovery of fractals actually goes
139 back to the British physicist and meteorologist Louis Fry Richardson (1881–1953) who pioneered modern
140 numerical weather forecasting in the 1920s.

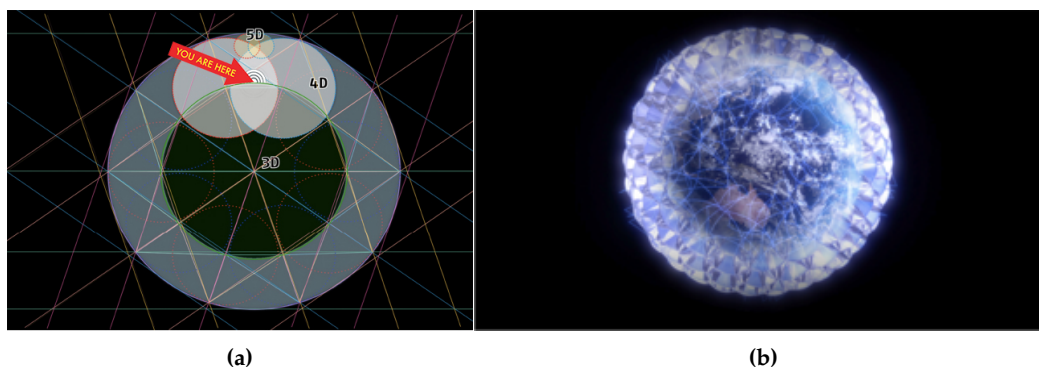


Figure. 2. (a) The 5-dimensional space-grid and the embedding of the planet. image RCZQ; (b) GAIA 5.0, the earth as hyper-sphere. Usually the hypersphere (S3) is not very well depicted and often declared as „unimaginable“. It is described as three-dimensional sphere S3 with the boundary of a disk in 4-dimensional Euclidean space,-- there you find on each point of the 3D sphere the center of a small sphere with the imaginary radius of the horizon. (Still frame, GAIA 5.0)

148 Fry Richardson first recognized fractal patterns in 1926 by studying the turbulence phenomenon at stream current
149 within wind wheels and coast lines (Richardson, 1926). More then 50 years later the notion „fractal“ was coined
150 by the French-American mathematician Benoît Mandelbrot (1924–2010) who produced the first digitally
151 generated mathematical visualisation on an IBM computer, known as Mandelbrot set in 1980. This led to the
152 development of fractal geometry. Mandelbrot wrote a book on the fractal geometry of nature with examples of
153 self-similar fractal features like the branching of rivers, veins and neurons (Mandelbrot, 1977).

154 This lack of the human ontologic position as manifest in the absence of recognition of the 4-dimensional space
155 may well result in the lacking awareness for the biosphere we inhabiting on the surface of our sphere, currently
156 epitomized by the ecologic crisis. Fig. 2a depicts an inclusive position embedded into the higher-dimensional
157 realms where the 4D tangent spaces around the 3D sphere is the space of the biosphere.

158 The four-dimensional sphere is simply analogously to the four-dimensional hypercube constructed, which was



described as “a cube inside another” (Schlegel, 1882). The same mathematician, Victor Schlegel wrote a pamphlet in which he forbids imagining the *4th dimension* to *artists* and *spiritists* and claims to leave it to the mathematicians as a purely abstract meaningless feature. (Schlegel, 1888) Alas, his influence still resounds today: There is no model for the 4-dimensional space and the hypersphere (S3) is declared as „unimaginable“. For the hyper-Euclidean model of the hypersphere as representation of the Earth’s complex system, we take an ordinary 3-dimensional sphere (in mathematics an ordinary 4D sphere is denoted as S2: a 2-sphere, because it takes only the surface into account) and attach hemispheres on each point of its surface. So we get a complex 3-dimensional representation of a sphere with a 4-dimensional ‘real’ 4D Euclidean ‘tangent space’ consisting of interconnected, interchangeable hemispheres in imaginary movement that satisfy the Hamiltonian description.

2.3 The video time-line

The *GAIA 5.0* art-work mainly works on three layers of perception. One is purely esthetically attracting an audience with no a priori knowledge of the subject. The other is communicating the scientific topics at heart (like the CO₂ transport and tropical cyclone formation). A third motivation is to use the movie for proposing new representations in meteorology and open fundamental research questions: how can we depict the geometry of the Earth in a way that it includes the biosphere and what is the cause of Earth’ geophysical and geological dynamics ?

The timeline tells the story of Gaia embedded in a higher-dimensional space grid, narrating the original concept of the ancient idea of the ether as conceptualized by Plato & Pythagorus, -- only recently visualized as infinite 5-dimensional space by Quehenberger’s Quantum Cinema group (2010-13). Gaia displays the visualisation of the large-scale patterns of carbon dioxide concentrations and transport of the year 2006 as shown in fig 3a and fig.6b. (NASA, 2006). The subsequent transformation of the hypothetical space grid into the technological grid of satellites leads us to the visualization of collected observational data of two severe cyclones that occurred in 2018. The primordial planet depicted as Pangaea inside the dodecahedron refers to Johannes Kepler who assigned this Platonic shape to the trajectory of the planet Earth (Kepler, [1596] 2005, 16). The film continues by explaining how the chiral movement of the 5-dimensional space following Poincaré’s description of the homology sphere (Poincaré, 1904) leads to additional explanations for the formation of cyclones. This is usually ascribed to the Coriolis effect (Coriolis, 1832) which evoked a conflict between common sense and mathematics for four centuries (Persson, 2005). The text originally stated about the ether ‘... famously declared as superfluous in 1905.’, but Lydia Lunch concluded intuitively, ‘by Einstein -- who got it wrong.’

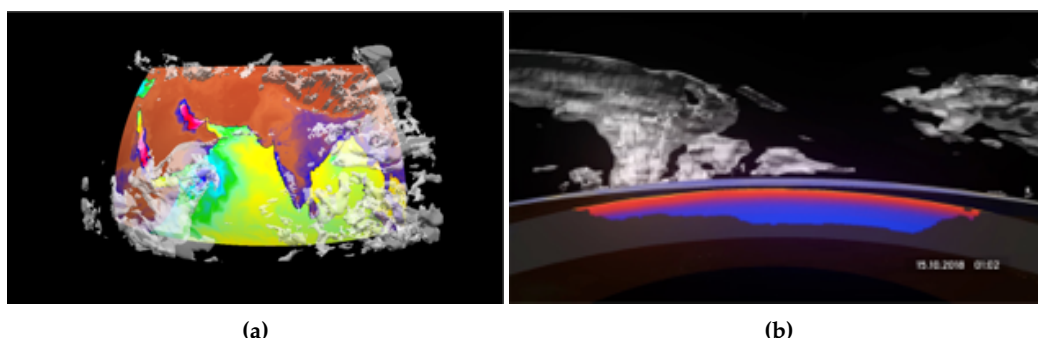


Figure 3. (a) Coupled METOC model, showing clouds & the temperature of the sea, colors range from 22°C (blue) to 34°C (red); Taiphoons over the Arabian Sea, October 13, 2018, Image generated from ECMWF data with the COVISE/OpenCOVER visualization program processed by Leyla Kern/HLRS (b) Taiphoons rendered (Image: GAIA 5.0 video still frame, min 7:04) The temperatures and the cross section of the ocean indicated temperature from red (24°C) to dark blue (10°C). from with clouds & humidity data; both images generated from ECMWF data with COVISE visualization program earth embedded in the hyper-Euclidean framework of 5-dimensional space. (Image: rendering F. Grünberger for GAIA 5.0 video by R. C-Z-Quehenberger, still frame, min 2: 06)

2.4 The COVISE/OpenCOVER visualization of cyclones

The 2019 Resonances theme DATAMI, was dedicated to „big data“. GAIA 5.0 uses coupled oceanic & atmospheric big data sets stored at the ECMWF of two very severe cyclones Luban & Titli that occurred in the Arabic sea and the Bay of Bengal October 2018. The visualization makes the 16 days of the stored event in a 2 minute time lapse alive again. By displaying the dynamics of the atmosphere connected with the cooling of the oceanic water the question arises whether the Earth is deliberately producing cyclones as mechanism for cooling oceanic water systems.

The visualisation of the ECMWF reanalysis data of the two typhoons were realized through the open source software COVISE/OpenCOVER at the High-Performance Computing Center Stuttgart (HLRS) accomplished by Leyla Kern. The HLRS is famous for its big data processing capacities and visualisation expertise. Their software enables interactive exploration of immersive environments and supports the processing of large data sets.

The resulting rendering allows the visual combination of both, oceanic and atmospheric dynamics (Quehenberger, Arnal, Mogensen, 2020). It allows to visualize the stored data of this event with the following parameters: Longitude, latitude, geopotential height, surface pressure, ocean depth on specific areas & wind components. This simultaneous visualisation seems important since ocean coupling in tropical cyclone forecasts will be even more important in the future, at higher atmospheric resolutions (Mogensen, 2017/18).

In the installation the coupled atmosphere-ocean visualization was executed as interactive holographic 3D big data visualisation model. Thus, the visitors of the exhibition can enjoy a virtual flight into the eyes of the cyclones by means of a virtual reality equipment, such as VR glasses and joysticks allowed to navigate through cloud formations.



217 3. Scientific and philosophical background of the Gaia Hypothesis

218 3.1 The Gaia Hypothesis

219 The Gaia hypothesis states that Life is a planetary-scale phenomenon. The chemist James Lovelock (*1919) de-
 220 veloped this idea during the 1960's when he was working for NASA searching Life on Mars. He further devel-
 221 oped it with the microbiologist Lynn Margulis (1938–2011) suggesting the earth's atmosphere is “a component
 222 part of the biosphere rather than as a mere environment for life“ (Lovelock & Margulis, 1974). Later Margulis
 223 brought autopoiesis (self-production), a clear-cut characterization of living systems (Maturana and Varela 1980)
 224 into Gaian science to the extent of presenting Gaia as an autopoietic system (Clarke, 2009).

225 “The Gaia phenomenon is therefor, a *sui generis* biological system and the embodiment of Life itself
 226 in the planetary domain. [...] Hence, self-production by closure to efficient causation is more funda-
 227 mental than self-regulation by feedback mechanisms.“ (Rubin & Crucifix, 2019)

228 This opposes the viewpoint of a necessity of a “Gaia 2.0“ as claimed by the French philosopher Bruno Latour and
 229 the British earth system scientist Timothy Lenton, who claim,

230 “Gaia has operated without foresight or planning on the part of organisms, but the evolution of hu-
 231 mans and their technology are changing that“ (Lenton and Latour, 2018).

232 Is this the voice of the overrated human consciousness (and therefore a presumed exceptionalism) (Sagan 2020),
 233 the hybris which lead to the Anthropocene -- the new planetary epoch in which humans have become the
 234 dominant force shaping Earth's bio-geophysical composition and processes ? -- We remain agnostic about the
 235 foresight of our planet, but the Life-Mind continuity thesis states that every biological phenomenon is a cognitive
 236 phenomenon (Maturana and Varela 1980, Friston, 2013). Hence, mind is prefigured in Life and belongs
 237 intrinsically to Life. Thus Gaia must be a cognitive system.

238 What Rubin & Crucifix call 'crucial' is that Life autopoietic organization is placed on a molecular level, and
 239 higher order autopoietic systems as Gaia should be produced through the autopoiesis of lower unities (cells and
 240 metacells) (Maturana, 1980). This would conclude a principle of Life as personified in Gaia, as uniting superior
 241 entity which in the last centuries and decades got replaced by Sky Gods and in cybernetics by the feedback
 242 omnipotent steersmen, lately.

243 The higher-dimensional geometry for the Earth is presenting an unifying view and thus contributing to current
 244 problems of representation in meteorology where scientists are calling for accurate maps of large regions of the
 245 sphere. The space model in GAIA 5.0 proposes 3-dimensional sub-spaces for the depiction of Gaia in contrast to
 246 current planar geoscience models which let them „keep shifting the tangent planes“ as Rubin & Crucifix (2019)
 247 suggested it. For the first time Gaia is depicted as a hypersphere (fig. 3b), as the theoretical biologist Robert
 248 Rosen once mentioned:

249 “The surface of the sphere is in some sense a limit of its planar approximations, but to specify it in
 250 this way requires a new concept (the topology of the sphere) that cannot be inferred from local planar
 251 maps alone.“ (Rosen, 1985)



252 3.2 Gaia in ancient Greek mythology and indigenous people

253 Mother Earth was allegedly ubiquitously worshipped during at least 40.000 years until during the troublesome
254 iron age when after all gods and goddess Astraea was fleeing from the new wickedness, greed and violence of hu-
255 manity and returned to the firmament according to Ovidius (Ovidius, [8 AD] 2008, 148f). Nowadays indigenous
256 peoples f.e. of South America continue to call her Pachamama and still live in harmony with nature. They contin-
257 ue to have their non-mechanical agricultural activities.

258 *GAIA 5.0* is also referring to ancient Greek mythology where the planet Earth was represented by the primordial
259 Goddess Gaia, Mother Earth who reigned with her son and husband Uranus, the God of the Sky.— Some say he
260 was conceived by Gaia, who would become his wife, while others say that he was the son of Aether and Gaia who
261 as herself born from love and light. Detroned by their children, a patriarchal dominated society established the
262 Dodekathēoi twelve Goddesses and Gods residing on Mount Olympus, during the 6th century b.c., . The number
263 12 seems again to refers to the twelve sides of the dodecahedron and the seat of the Gods as 'thin upper region of
264 air' synonymous with the ether. The ether was named Greek 'fifth element' by the Greek philosopher Plato
265 (428-348 B.C.) and "quintessence" by his scholar Aristotle. The search for this mysterious substance became a
266 century long target of Alchemists and moved into modern science as *luminiferous ether* but remained „undetected“,
267 before it was eliminated from science books in the 20th century.

268 The 'fifth element', known as fifth regular solid, the dodecahedron was only described in a cryptic note, by Plato
269 'yet there is a 5th combination [of triangles] which the god used in the delineation of the Universe.'
270 (Plato/ Timaios, 52b)

271 Only recently Plato's riddle of the 5th element could be solved by identifying the shape of the dodecahedron as
272 compositions of unit cells of 5-dimensional space (Quehenberger, 2016). This gives rise to the assumption that the
273 ancient 'geometry of the Earth' was originally conceptualized as hyper-Euclidean. The word geometry stems from
274 the Ancient Greek: γεωμετρία; geo-'earth', -metron „measurement' and indicates geometry as a way for the
275 perception of the world. It is a branch of mathematics concerned with questions of shape, size, relative position
276 of figures, and the properties of space.

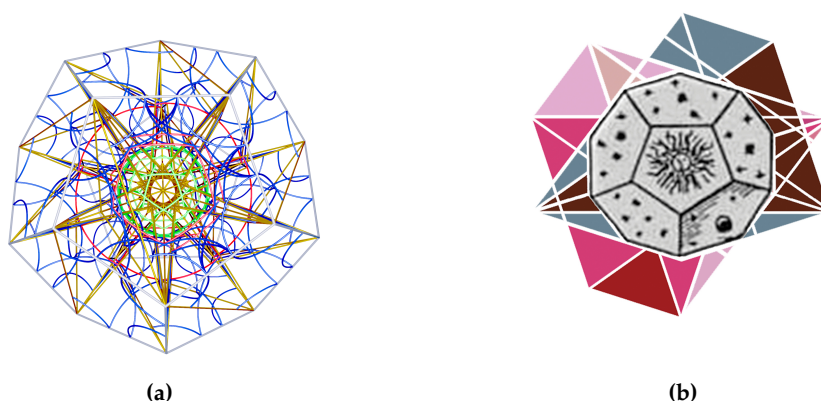
277 In Greek mythology Mnēmosynē, (from mnēmē; Greek for memory) the mother of the Muses is the one who
278 reminds her mother, Gaia, the earth. Geometry and grammar are attributed to the Muse Polymnia, also protector
279 of the divine hymns and the imitative arts. Thus, etymology unites the divine feminine, the Earth, geometry and
280 the arts and the ancient idea of the ether, recently identified as 5-dimensional space concept (Quehenberger,
281 2019). In texts by Aeschylus (c. 525/524 – c. 456/455 b.c) and Pindar (c.518-- 446 b.c.) the ether was also treated
282 meteorologically, namely as that layer 'in the etheric circle, a seat where the foggy cloud turns to snow' (Fürlinger,
283 1948). -- This means the ancients assumed space itself as responsible for aerosol formation just as visualized here
284 by means of the 5-dimensional space.

285 3.2 Geometrical figures used in *GAIA 5.0*

286 The currently used numerical weather simulations are based on temperature differences and thermodynamics, c.f.
287 how water or air moves as it is either heated by absorbing sunlight or cooled by emitting infrared radiation, as



288 well as how such processes operate over a rotating, spherical surface. All dynamical atmospheric effects are based
289 on the assumption that heating and cooling are heterogeneous in space and time because land and sea have
290 distinct heat capacities and dynamics and the process of forecasting starts with the initial conditions based on the
291 best possible description of the current state of the atmosphere, land surface and oceans (Bauer, 2016). In addition
292 to this the GAIA 5.0 video proposes the artistic assumption of an underlying spacial geometry which could be
293 responsible for the tectonic and meteorologic dynamics on earth.



294

295

296 **Figure 4.** (a) The *GAIA 5.0* web — Epta-dodecahedron, a 4-dimensional dodecahedron in a 72° twist (rczq,
297 2013) (b) Two epitahedra forming the 3-dimensional dodecahedron, as originally described as "5th element"
298 by Plato (rediscovered by Quehenberger), symbol for the Universe (dodecahedron in the center, drawing by
299 J. Kepler) drawing: R. Quehenberger)

300 The newly discovered 5-dimensional space cells are the 3D representation of the Penrose kites & darts tiling
301 (Gardner, 1977), the irregular pattern of the golden ratio ($1/2(1 \pm \sqrt{5}) = \Phi = 1,681\dots$ or $\phi = 0,618\dots$) and
302 related logarithmic spirals have scientific significance (f.e. in astronomy, biology, genetics, etc.) featured by many
303 popular 'golden ratio' books. (in the plane, named Epitahedra ($E \pm$): Two epitahedra are forming the 3-dimensional
304 dodecahedron usually mentioned in schoolbooks as Platonic solid (fig.4b) and twelve epitahedra confine the 4-
305 dimensional dodecahedron, named epita-dodecahedron (Quehenberger, 2013). All 4-dimensional Platonic solids
306 were constructed before by the British mathematician Alicia Stott Boole (1900).

307 The epita-dodecahedron works like the 4-dimensional dodecahedral space as conceptualized by the French
308 polymath and last universalist, the philosopher, mathematician, engineer and physicist Henri Poincaré (1854–
309 1912) who suggested it as model for the Universe, here probed as model for the Earth (Poincaré 1904). It is the
310 infinite 5-dimensional space that works like a "symmetry machine" for the generation of particles. Here it is
311 applied to the planet Earth and aims to explain the chiral dynamics which occur in the formation of cyclones as
312 well for the formation of aerosol particles. This 3-dimensional formation of the golden ratio seems logic, insofar
313 as the logarithmic spiral is a generation method for Penrose Patterns, the golden tiling of the plane (Kappraff,
314 2001). These patterns look the same at every scale (Penrose, 1974). Ultimate chaos results in the pattern of the
315 Golden ratio. Hence both characteristics of cyclones, their fractal and chiral nature could be explained by the
316 assumption of this underlying dynamic higher-dimensional space.



3.2 Meteorological aspects of the art work

The chiral motion of the Penrose tiles and the chiral counter-movements of the 3D tiles which are confining the epitadodecahedron is depicted in the geometry of GAIA 5.0. In fact it would present many solutions to forgotten problems, like the chiral movement of galaxies and cyclones, and seeds of sunflowers. Similarly we find in the turbulence of air in the vortices of taiphoons in smaller regions of air. The empirical logarithmic approximation is shown with several examples of satellite and radar images of a tropical cyclone (TC) (Yurchak, 2007). In meteorology the chiral movement of the water and air is described as heat transport to the atmosphere, vertical mixing in the ocean, and upwelling by Ekman pumping (Ekman, 1905). Walfrid Ekman (1874–1954) laid the mathematics for Bjerknes's theory of the current moving along an inward, clockwise spiral (Ekman 1905). Gaia 5.0 proposes that the Ekman spiral could lie inside the hemisphere in a fraction of the epitadodecahedral space. Could the dynamics of space itself interfere with hydrodynamics and geo-physical motion? The same effect is responsible for cyclones. -- So the question is: Do these dynamics of space itself interfere with hydrodynamics and geo-physical motion?

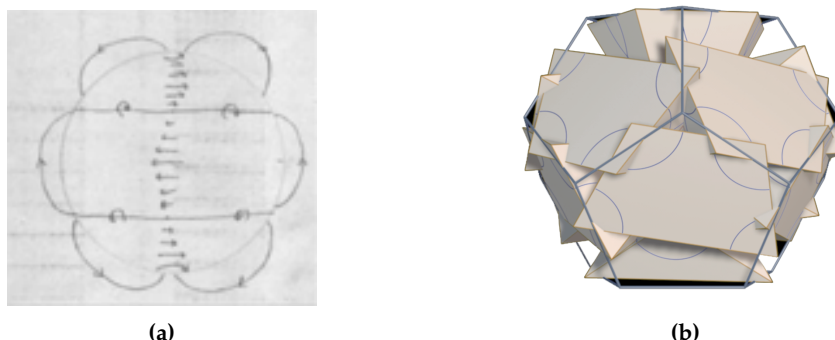


Figure 5. (a) V. Bjerknes „Vortex tubes in the atmosphere“, idealized sketch of the three-dimensional global circulation (in pencil) drawing from lecture notes of 1917, Section 82 (b) Side-view of the epitadodecahedron with counter-rotations of the pentagonal faces according to descriptions for the Poincaré homology sphere, (upper side to the left, lower side to the right) image: RCZQ, 2012.

In meteorology similar considerations were pondered around 1900. Incidentally the dynamic epitadodecahedron model corresponds to an early ether model (fig. 6.a) conceived by one of the founders of modern meteorology and oceanography, Ekman's teacher, Vilhelm Bjerknes (1862–1951). He adapted the hydrodynamic theory of the ether (V. Bjerknes, 1900) by his father Carl Anton Bjerknes (1825 –1903) as an application to meteorology (V. Bjerknes, 1898). As a matter of fact some basic principles of modern meteorology are derived from his model which comprises „vortex tubes in the atmosphere“ which reminds us of the vorticity lying in the counter-movement of the epitadhedra inside the 4-dimensional dodecahedral structure. Generally speaking, British scientists of the 19th century who laid the foundations of meteorology favored the

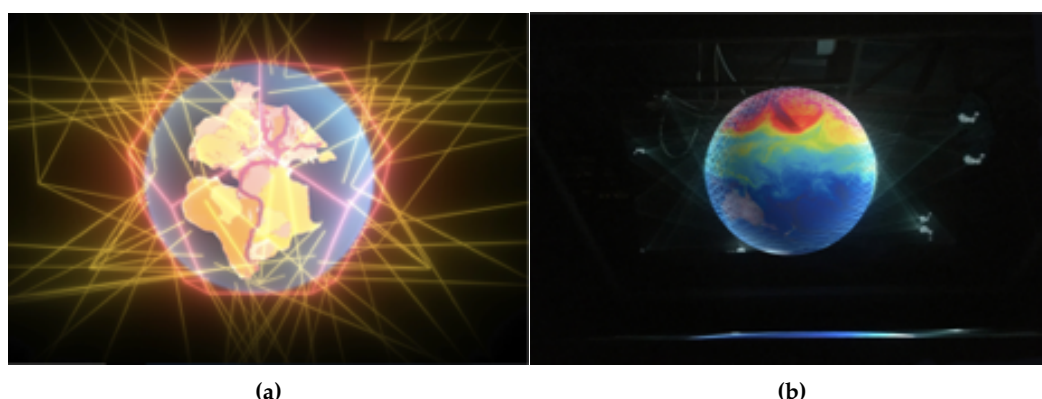


345 existence of an all-pervasive ether. Also many artists were fond of the ether in the early twentieth century. The
346 values of modernism was found in the complexities and contradictions of modern physics provided a fertile
347 ground for the development of new artistic languages (Navarro, 2018). Once more, the here described artwork
348 refers to it in the shape of the 5-dimensional space as follow up principle proposing new / old ontological
349 foundations.

350 3.3 Pangaea -- Kepler

351 Meteorology uses icosahedral models in order to stretch out the surface of the globe onto a plane as flat triangular
352 pieces. The world map projected onto the surface of a three-dimensional icosahedron that can be unfolded and
353 flattened to two dimensions was first presented as *Dymaxion Map* by the US-american geometer and architect R.
354 Buckminster Fuller (1895–1983) in 1943. Almost 20 years later in meteorology the icosahedral grid was
355 proposed originally during the 1960s by Gates and Riegel (1962 & 1963) a.o. It was chosen as model for
356 subdividing a sphere because it has the highest degree of symmetry for the design of an equal-area grid.
357 The dodecahedron is the geometrical dual of the icosahedron. The dodecahedron as shape for the Earth is
358 mentioned by Plato when he compares the planet with a piece of art that resembles a colorful football (Plato,
359 Phaidôn, 110b). Also the mathematician Johannes Kepler (1571-1630) who laid the foundations for modern
360 astronomy assigned the dodecahedron to the Earth (Kepler, 1596). This gave rise to a beautiful picture of the
361 primordial earth, Pangaea embedded in the small dodecahedron in the center of the epita-dodecahedron, fig.6a.

362



363

364

365 **Figure 6.** (a) The planet Earth inside the small dodecahedron in the center of the 4-dimensional dodecahedron, with the face of the supercontinent, Pangaea, (Image: GAIA 5.0 video still frame, min 1:33; animation
366 by F. Grünberger, 2019); (b) CO2 transport simulation projected of the globe with surrounded by a bunch of
367 satellites (Image: GAIA 5.0 video still frame, min 3:58, animation, by F. Grünberger; holographic projection
368 at the DATAMI - Resonances III, Festival at the JRC in Ispra)
369

370 In order to express the living system most lively we start with image of the primordial landmass, named Pangaea
371 (Wegener, 1912). Pangaea's outline reminds us of the shape of a female figure, who holds a baby in her left arm



372 while her head in a sleeping position is directed to the North Pole.

373 This film sequence is shaded with Lydia Lunch's velvet voice reciting:

374 "Pangaea, a dreaming living creature, dreaming of living creatures."

375 The video animation shows planet Earth in a time-lapse evolution from the primordial state as supercontinent

376 Pangaea, meaning 'All Earth', began to break apart about 200 million years ago, until the present positions of con-

377 tinents is reached. Plate tectonics theory predicts the earth's land mass will again form another supercontinent

378 in the future when the Americas will be joining Asia from the eastern side in the middle of the Pacific ocean,

379 in another 230 million years. Compared to a human life cycle this would mean the Earth is now— a 45 year old—

380 in the middle of her life span and yet climate change and the extinction of species is endangering her complete-

381 ness & beauty depending on the diversity of life. The *Panagea*- image in the video is taken from Alfred Wegener's

382 (1880–1930) vision of *Pangaea*, the German polar researcher, geophysicist and meteorologist who coined the

383 name for the primordial earth and first hypothesized the continental drift theory (Wegener, 1912). The video ani-

384 mation shows a slow displacement of the continents from the *Panagea* state to the present position: Afrika made a

385 36° counter-clock-wise turn, while South America has turned 36° clock-wise, the Pacific side of North America &

386 Alaska is the 72° counter-clock-wise flip of the *Pangaea* picture 72°. The same rotation angels are inherent in the

387 5-dimensional dodecahedral space and seem to undermine the assumption of a subscendent space dynamics.

388 GAIA 5.0 shows a poetic image of the Earth embedded in the center of this infinite 5-dimensional space inside the

389 highlighted shape of the dodecahedron. -- Actually this is a simple illustration and not the accurate picture,

390 because Kepler who also considered the Earth as living entity speaks of the relations of the trajectory of the planet

391 lying on a dodecahedron. Meanwhile the symmetries of the Kepler problem was solved by showing that the

392 equation for the conservation of energy can be written the same like of a sphere in 4-dimensional space

393 (Göransson, 2015). Then the ellipses would be circles on a 4-dimensional sphere and only appear elliptical on a

394 projection on the plane (Baez, 2015).-- We may also assume that Kepler was studying the relation of polyhedra in

395 the center of the 5-dimensional space as first visualized during the Quantum Cinema project (Quehenberger,

396 2013). He was asking for the cause of movement of planets, the 6-fold structure of honeycombs and hexagonal

397 snow flakes and used the same geometrical patterns and solids (Kepler, 1611). The fact that his seminal discovery

398 of the three celestial laws is based on artistic practices are still completely ignored by contemporary astronomy.

399 His astronomical findings are not only based on 2D pattern designs and regular solids and investigations on space-

400 filling shapes but also on musical relations. In order to find the appropriate shape of the space which enables all

401 sorts of matter, he already operated with hyper-Euclidean geometry and designed 4-dimensional polyhedra which

402 were re-discovered twice as models for quasicrystals living in 5- or 10-dimensional spaces (c.f. Levine &

403 Steinhardt, 1986). This means that not Newton but Descartes (Newton, 1666) and Kepler could support the

404 geometry underlying the planet Earth as featured in the GAIA 5.0 movie. Renée Descartes (1596–1650)

405 mentioned first interconnected coordinate frames for the representation of higher dimensional spaces (Descartes,

406 [1637], 1902). He proposed that all matter is just a result of transformations of spaces is Pythagorean and

407 precedes modern Group Theory for 200 years. On the contrary Isaac Newton thought in terms of point mechanics,

408 speed and direction (Newton, 1699).

409 What is remarkable about the higher-dimensional space configurations is that they must be regarded as 3D spaces



410 in movement. Space itself becomes a perpetuum mobile in $\dim < 3$. -- This new mode which is relying on
411 Poincaré's and Brower's concepts about higher dimensional spaces naturally opposes Minkowski's pseudo 4-
412 dimensional concept which is currently successfully used for GPS systems but also for natural phenomena.

413 The English philosopher Margaret Cavendish, Duchess of Newcastle (1623-1673) was the first who argued that
414 this gender constructed science hinders all that will lead to an objective epistemology. By redefining gender in
415 Cavendish's theory of matter she claims that there is no rest in Nature, and that this constant movement is not
416 induced by an external force because nature is an active, moving, powerful being, capable of movement within
417 itself (Walters, 2014).

418 **3.4 Chaos Theory, the Lorenz attractor & non-linearity in atmospheric fluctuations**

419 Henri Poincaré not only first predicted gravity waves (Poincaré, 1905) but he was also the first proponent of
420 chaos theory in the 1880s (Poincaré, 1890). Poincaré even proposed that that such phenomena could be common,
421 for example, in meteorology. This happened 70 years later when the MIT-meteorologist Edward Lorenz
422 developed the first chaotic attractor from it (Lorenz, 1963). The Lorenz attractor has been almost ignored for a
423 decade but got a household name after he coined the term „butterfly effect“ in order to illustrate the sensitive
424 dependence on initial conditions:

425 'If a single flap of a butterfly's wing can be instrumental in generating a tornado, so also can all the
426 previous and subsequent flaps of its wings.....More generally, I am proposing that over the years
427 minuscule disturbances neither increase nor decrease the frequency of occurrences of various weather
428 events such as tornados.' (Lorenz, 1972)

429 The Lorenz attractor is a strange attractor, a fractal, and a self-excited attractor with respect to all three equilibria
430 is a set of chaotic solutions of the Lorenz system. The atmosphere is a highly dynamical system, and exhibits
431 many chaotic features. An operational weather forecasting model tries to model an initial value problem, in fact
432 one of the most famous examples of a chaotic system. His theory and application of chaotic dynamics was derived
433 from a simplified model of convection in the earth's atmosphere. It also arises naturally in dynamos, models of
434 lasers and electric circuits (Haken, 1975). This effect was also considered for the stable circular limit cycle which
435 appears in the twisting perturbation of electro-magnetic forces in the space of 5-dimensions, known as light in its
436 dual form as wave and particle (Quehenberger, 2012).

437 Chaos theory tells us that the critical value of both equilibrium points lose stability through a subcritical Hopf
438 bifurcation (Hirsch, Smale, Devaney, 2003). Hopf bifurcation (also sometimes called Poincaré-Andronov-Hopf
439 bifurcation) is a critical point where a system's stability switches and a periodic solution arises.

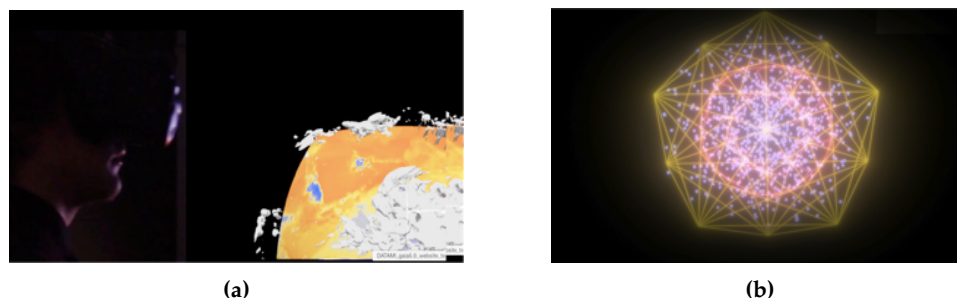
440 Recently the JRC researcher Daniel Tirelli made an analogy between a mechanical system (cable) and thermo-
441 hydraulic system (atmosphere) where you have an increasing input of energy: for cables, the multiple solutions in
442 chaotic systems, is represented by the existence of multiple basins of energy, which are the number of modes of
443 vibrations activated during its motion (Peng, et al.). As they are not unique, they can absorb more energy by
444 multiplicity than in classical mechanical system (one solution only). Moreover, for the same displacement of the
445 cable as these new modes have higher frequencies they can absorb, each one, more energy due to the higher speed
446 of the cable (Tirelli, 2013). Therefore, the analogy is nearly perfect and could be resume in a multiplication of



447 small and important atmospheric events, (storms) for the atmosphere, and more modes activated for the cables.
448 Then for each event, more extreme phenomena (wind velocity, hail dimension etc. greater) for the atmosphere,
449 and faster motion for the cable (modes of higher frequency). This analogy is due to the presence of non-linearity
450 in both systems, cables and atmosphere flows.
451 In the time of the dramatic vision of the atmospheric changes, this window of 'non linearity' of phenomena gives
452 however a rather optimistic view of the global change. In effect comparing again the chaotic behavior of human
453 heart motion to the chaotic behavior of the climate we can observe the following: in most of cardiac pathologies
454 (restriction of flows) the heart need to push the blood with a higher speed to oxygen each part of the body. Its
455 results in a greater contraction of the muscle, which can reach the break. The sudden changes of cardiac rhythm,
456 commanded by the brain is a safety reaction to avoid this type of cardiac crisis. The behavior changes from cyclic
457 to chaotic for safety reason! -- Seeing more analogies between the human body and atmospheric behavior will
458 help us to perceive the Earth as living system.

459 4. The dynamic formation of aerosol particles

460 Finally, with a zoom into atmospheric micro-processes the GAIA 5.0 video proposes a geometrical aerosol forma-
461 tion model based on the hypothesis that the same underlying dynamic geometrical framework is responsible for
462 the formation process of aerosol particles on the minutest level. The scientific idea of 'a higher multidimensional
463 view' was presented in a "3-D global Chemical Transport Model and in a General Circulation Model" by JRC -
464 scientists seemed to coincide well with the here described intention for the visualization (Raes, van Dingenen, et
465 al. 2000).



466
467
468 **Figure 7.** (a) Visitor with VR glasses navigating through clouds of the COVSE visualisation, at Bozar, Brus-
469 sels Jan. 2020 (image RCZQ) (b) the icosahedron model with epitahedra forming an epitahedron in the center,
470 here suggested as aerosol formation model (GAIA 5.0 video. 8:37min)

471 The higher-dimensional aerosol formation model is inspired by the visualization of the most simple Galois group
472 by permutations of one epitahedron in the framework of an icosahedron (Kostant, 2005). The permutation of one
473 epitahedron performing rotations over a Hamiltonian path over 11 vertices of the icosahedron creates visually a
474 hyperbolic dodecahedron (see red outline in fig.7b) which suggests that a 'new inner space' is created. So we can



475 imagine that the discrete space works like mathematical machine that not only produces symmetries as appropri-
476 ate for group theory to describe the formation of subatomic particles but works also as a 'mixer' which forms
477 aerosol particles dynamically.

478 This dynamic epitahedron model corresponds also to currently used fullerene (C60 and C70) model compounds
479 for the simulation of molecular dynamics which lead to nanometer-sized particle formation and growth in the at-
480 mosphere. (c.f. Liu et al., 2016). Due to a symmetry convergence the C60 structure can be replaced by a dynamic
481 epitahedron model in the framework of an icosahedron. Our proposed model has the advantage of inherent dy-
482 namics which allow a dynamical simulation and works on the assumption of a higher dimensional spacial struc-
483 ture as aerosol particle formation generator.

484 5. Discussion and conclusion

485 The exhibition in Ispra at the JRC with 2000 estimated visitors attracted mainly the experts of the different re-
486 search groups at the laboratories of the JRC. Whereas the Resonances III exhibition at the BozarLab in the center
487 of Brussels was counting 1100 dedicated visitors besides more than 20k visitors passing single exhibit at central
488 location in famous Bozar Centre for Fine Arts. In March the GAIA 5.0 art work was presented at the Milan Dig-
489 ital Week 2020 as online event with 1000 viewers.

490 Around 300 persons attended the opening event. The visitors of the GAIA 5.0 had much fun navigating through
491 the clouds and cyclones enabled by the virtual reality (VR) equipment while others could see the full video as
492 holographic projection. Discussions on higher dimensions and their representation as well as on weather models
493 based on Coriolis force, differential heating and cooling took place.

494 Certainly many discussions on higher dimensions took place with interested exhibition visitors who demanded
495 clarifications: Eg.: Gustav T. Fechner's 'shadow-beeings' inspired Edwin Abbott Abbott (1838--1926) to his
496 influential mathematical satire «Flatland -- A Romance of Many Dimensions» (1884) in order to illustrate that
497 mathematicians are hardly able to imagine a sphere, not to speak of any higher dimensional object. Ironically
498 »Flatland« is still referred to as 'proof' of a 'natural in-imaginability of higher dimensions' in mathematics books,
499 -- despite Abbott's plea,

500 "Yet I exist in the hope that these memoirs ... may find their way to the minds of humanity in Some
501 Dimension, and may stir up a race of rebels who shall refuse to be confined to limited Dimensionali-
502 ty." (Abbott, 1884)

503 Similary art influenced science when another novel, namely H. G. Wells' »Time Machine«, with the fiction of
504 travel on the 'time'-axis towards a distant future (Wells, 1895). Also the expanding universe was inspired by
505 Edgar Allen Poe's »Eureka« (Poe, 1848).

506 The discussions with visitors also addressed the feminist perspective on current scientific and technological
507 developments as a result of a 400 years long focus on empirical studies which successfully cut out all non-
508 observable entities as well as women from science. This was already discussed in the 16th century between
509 Francis Bacon (1561–1626) who established materialistic philosophy (Bacon, 1620) and the feminist anti-
510 empiricist, Margaret Cavendish. She ascribed the pejorative approach to nature to the Aristotelian description of
511 the female applied to the conception of nature as merely passive, empty, lifeless female body (Cavendish, 1664).



512 In contrast to the prevailing materialistic approach in science the philosopher Giordano Bruno (1548–1600) —
 513 who got burned by the Catholic church a.o. for his concept of infinite and many worlds, — suggested to regard
 514 nature herself as artist (Bruno, [1584] 2015). Bruno cited explicitly female methods of production and also
 515 addressed the misogynous reservations of his time responsible for the maltreatment of nature — those who think
 516 badly of women cannot be able to worship nature in her female role. Shouldn't she who designs and creates
 517 everything considered to be the greatest artist?
 518 — In summary, the audience understood that art can be a tool for creating a visual and audible, a sensuous access
 519 to the perception of meteorologic dynamics and the complex space we inhabit. The perennial concept of
 520 autonomously dynamical higher-dimensional spaces, Plato's theory of everything renders valid in the light of 5-
 521 dimensional hyper-Euclidean geometry. This shall help to understand not only the formation of aerosols and
 522 cyclones, but also the perpetual motion of the Earth and the entire Universe, for which there is currently no other
 523 valid explanation. If GAIA 5.0 can produce in the minds of the spectators some humble amazement for the
 524 wonders of the animate world in order to handle it with care, the purpose of this art-work was achieved.

525 **Supplementary Materials:** C.-Z.-Quehenberger, R.: GAIA 5.0 — A Holographic Image - Ambience,
 526 film: <https://doi.org/10.5446/49792>

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 530 and Louise Arnal at the European Centre for Medium-range Weather Forecasts (ECMWF), Reading, UK; and
 531 SciArt experts Leyla Kern and Dr.-Ing. Uwe Wössner for COVISE/OpenCOVER visualizations at the High
 532 Performance Computing Center (HRLS) in Stuttgart communicated by A. Wierse (SOCOS) during this DATAMI-
 533 Resonances III SciArt research project. Parts of the here presented hyper-Euclidean representation of higher
 534 mathematics was previously developed by her for the visualization of quantum phenomena during the SciArt
 535 project *Quantum Cinema - a digital vision* (2010-2013).

536 **Author contributions:** S.R. contributed statements concerning Gaia hypothesis and the general presentation of
 537 the article, D.T. contributed his observations on cables and chaos theory applied to climate science and L.K.
 538 visualized the ECMWF data of the cyclones;



539 **Appendix A**

540 Text of the video GAIA 5.0 narrated by Lydia Lunch:

541

542 There is this boundary space between zero and one:

543 Series of roots of ones fractioned to infinity: phi --

544
$$\Phi = \sqrt{1 + \sqrt{1 + \sqrt{1 + \sqrt{1 + \dots}}}}$$

545 famously a topic of many obscure speculations on the foundations of the Universe.

546 In the context of the infinite 5-dimensional space

547 which works like a machine that cuts each piece into Δ golden triangles

548 it may well gain a new/ old significance.

549 Plato's ascribed the permutations of these triangles to the wet nurse of becoming

550 who cradles them into matter in all sorts of symmetries, colors, states of aggregation

551 & frequencies, forming the living intelligent pattern of the world.

552 In the center of this infinite 5D space machine

553 we find the geometrical shape of the dodecahedron,

554 a regular 12-sided shape that the astronomer Johannes Kepler assigned to the earth

555 & before him Plato & Pythagorus

556 Pangaea, the dreaming creature, dreaming of living creatures living in living creatures

557 Plato named the construction of triangles which is forming this shape "the 5th

558 element", Aristotle spoke of it as „quintessence"—also known as the all permeating luminiferous

559 aether —synonymous for the seat of the gods & electromagnetic forces,

560 the light & intelligence; ---

561 famously declared as superfluous in 1905 by Einstein -- who was wrong.

562 The visualization of the hypersphere S3 by means of the unit cells

563 of 5-dimensional space conforms to the Poincaré homology sphere

564 which gives rise to new interpretation of the earth' intrinsic dynamic

565 relying on the geometry of space itself.

566 — Where would the dynamics stem from, other-wise?

567 In meteorology the Coriolis force causes moving objects on the surface

568 of the Earth to be deflected to the right in the Northern Hemisphere

569 and to the left in the Southern Hemisphere.

570 This corresponds to Poincaré's description of counter-movements of the pentagons

571 of the dodecahedron, here visualized by epitahedra.

572 The same effect is responsible for the rotation of large cyclones.

573 This imaginary sparkling space grid was replaced & actually realized

574 by means of technical devices forming the radiance grid of satellites

575 which now provides us continuously with surveillance data of earth' features:

576 both atmospheric and oceanic.

577 Two very severe cyclones Titli & Luban formed simultaneously

578 in the central Arabian Sea.



579 Moving upon ashore, Cyclone Luban produced flooding rains
 580 in Somalia, Oman, and Yemen.
 581 The storm by Wednesday October 11 had reached wind speeds of 119-137km/hr
 582 gusting up to 160km/hr
 583 This was all over the west central Arabian Sea around the system's centre.

584 The direct impact of these storms coming together
 585 with heavy rains and strong winds
 586 affected the coastline of Oman on the Arabian Peninsula starting from October 13, 2018
 587 until they actually struck Yemen on October 14 in the midst of
 588 not only a civil war but a cholera outbreak.
 589 The storm killed 24 people in the country and injured another 124 people.

590 When Titli made landfall in the south-Indian state of Andhra Pradesh,
 591 at peak intensity and affected more than 5.7 million people &
 592 killed at least 85 due to heavy flooding and landslides
 593 causing damage of US\$ 920 million in South and West Bengal in total.
 594 The life period of the system was 210 hours
 595 very unusual a rare occurrence post-monsoon season.

596 Based on an underlying 5-dimensional space grid
 597 we may also model a dynamic genesis of aerosol particles:
 598 We take the icosahedral symmetries and use what Plato called „5th element“
 599 higher dimensional spatial structure as formation generator.
 600 It is inspired by fullerene (C60 and C70) model compounds
 601 for the simulation of molecular dynamics.
 602 These spacial features may well subscend dynamics in the air
 603 that shall lead to nanometer-sized particle formation and growth in the atmosphere.

604 Thus we are in the midst of a living pattern
 605 that forms life & light & dust in the same way.

606 References

- 607 Abbott, E.A.: Flatland: A romance of many dimensions. London: Seeley, 1884.
 608 Beckett, R.B. (ed.): C.R. Leslie's record of Constable's Royal Institution lectures 1 and 4, 1836, Ipswich: Suffolk
 609 Records Society, 1970, 39, 69.
 610 Bacon, F.: The New Organon: Or, True Directions Concerning the Interpretation of Nature, [1620] London:
 611 London: Longman, 1857, New York: Bartleby, 2010, 169.
 612 Baez, J.C.: Planets in the Fourth Dimension, [https://johncarlosbaez.wordpress.com/2015/03/17/](https://johncarlosbaez.wordpress.com/2015/03/17/planets-in-the-4th-dimension/)
 613 [planets in the 4th dimension/](https://johncarlosbaez.wordpress.com/2015/03/17/planets-in-the-4th-dimension/)
 614 Bauer, P.: Today's weather forecast: Good with a strong chance of improvement, October 18, 2016. [https://](https://www.earthmagazine.org/article/todays-weather-forecast-good-strong-chance-improvement)
 615 www.earthmagazine.org/article/todays-weather-forecast-good-strong-chance-improvement
 616 Bjerknes, V.: Über einen hydrodynamischen Zirkulationssatz und seine Anwendung auf die Mechanik der
 617 Atmosphäre und des Weltmeeres. Kongl. Svenska vetenskaps-akademiens Handlingar. Bd. 31, 1898, 1–35.
 618 ———. Das dynamische Prinzip der Zirkulationsbewegungen in der Atmosphäre. Meteorol. Z. 1900, 97–106.
 619 ———. Vorlesungen über Hydrodynamische Fernkräfte nach C. A. Bjerknes Theorie, Leipzig: Johann Ambrosius
 620 Barth, 1900.



- 621 Stott, A. Boole: On certain series of sections of the regular four-dimensional hypersolids, *Verhandelingen der*
 622 *Koninklijke Akademie van Wetenschappen te Amsterdam (eerste sectie)* 1900.
 623 Bruno, G.: Von der Ursache, dem Prinzip und dem Einen, [orig.1584, London] (Ed.) Bruno Kern, Wiesbaden:
 624 Matrixverlag, 2015, 132.
 625 Cavendish, M.: Philosophical Letters: or, Modest Reflections Upon Some Opinions in Natural Philosophy,
 626 Maintained by Several Famous and Learned Authors of This Age, Expressed by Way of Letters. London,
 627 1664. 445–8.
 628 Coriolis, G-G.: Mémoire sur le principe des forces vives dans les mouvements relatifs des machines, *Journal de*
 629 *l'École polytechnique*, vol. XIII, cahier XXI, 1832, 268–302 (read at the Académie des sciences, 6 June
 630 1831)
 631 Clarke, B.: Neocybernetics of Gaia: The Emergence of Second-Order Gaia Theory, in: *Gaia in Turmoil: Climate*
 632 *Change, Biodepletion, and Earth Ethics in an Age of Crisis*, edited by H. Bruce Rinker and Eileen Crist.
 633 Cambridge, Mass.: MIT Press, 2009, 138.
 634 Clark, R.W.: *Einstein The Life and Times*, New York/ Cleveland: The World Publishing Company, 1972, 328.
 635 datami project website: Gaia 5.0 — A Holographic Image - Ambience, [https://resonances.jrc.ec.europa.eu/](https://resonances.jrc.ec.europa.eu/installation/gaia-50-holographic-image-ambience)
 636 [installation/gaia-50-holographic-image-ambience](https://resonances.jrc.ec.europa.eu/installation/gaia-50-holographic-image-ambience)
 637 Descartes, R.: *Discours de la méthode* [1637], Paris: Adam et Tannery, 1902.
 638 Ekman, V. W.: On the influence of the Earth's rotation on ocean currents. *Arch. Math. Astron. Phys.*, 2, 1905, 1–
 639 52.
 640 European Space Agency: Probing satellites' mysterious death tumbling, European Space Agency, May 29, 2014.
 641 <https://phys.org/news/2014-05-probing-satellites-mysterious-death.html>
 642 Fechner, G.T.: *Der Raum hat vier Dimensionen*, (The space has four dimensions) as part of „4 Paradoxa“, 1846.
 643 Fourier, J.: *Theorie analytique de la chaleur*, Paris: Firmin Didot, 1822.
 644 Friston, K.: Life as we know it, *Journal of The Royal Society Interface*, Vol. 10 No. 86, 2013.
 645 Furlinger, F.: *Studies on the concept of aither in Greek literature until Plato*, dissertation [unpublished], Innsbruck,
 646 1948, 79.
 647 Gardner, M.: Extraordinary non-periodic tiling that enriches the theory of tiles, *Scientific American*, Vol. 236,
 648 No.11, Jan. 1977, 10–121.
 649 Gates, W. L. and Riegel, C. A.: A Study of Numerical Errors in the Integration of Barotropic Flow on a Spherical
 650 Grid, *Journal of Geophysical Research*, vol. 67, No. 2, Feb. 1962, 773–784.
 651 ——— Comparative Numerical Integration of Simple Atmospheric Models on a Spherical Grid, *Tellus*, vol. 15,
 652 No. 4, Nov. 1963, 406–423.
 653 Göransson, J.: Symmetries of the Kepler problem. March 8, 2015. [http://math.ucr.edu/home/baez/mathematical/](http://math.ucr.edu/home/baez/mathematical/Goransson_Kepler.pdf)
 654 [Goransson_Kepler.pdf](http://math.ucr.edu/home/baez/mathematical/Goransson_Kepler.pdf)
 655 Grunert, F.P., Fiordimela, C., Eeckels, A.: DATAMI Resonances III, European Commission - JRC Ispra, 2020–
 656 2021.
 657 Gwynne, P.: Debate rages over 5G impact on US weather forecasting, *Environment and Energy News*, 31 May
 658 2019. <https://physicsworld.com/a/debate-rages-over-5g-impact-on-us-weather-forecasting/>
 659 Haken, H.: Analogy between higher instabilities in fluids and lasers,. *Physics Letters A*. 53 (1) 1975, 77–78.
 660 doi:10.1016/0375-9601(75)90353-9.
 661 Hegel's Aesthetics: *Lectures on Fine Art*, trans. T. M. Knox, Oxford: Clarendon, Vol I, 1975, 11.
 662 Henderson, L.D.: *Duchamp in Context: Science and Technology in the Large Glass and Related Works*. Princeton,
 663 NJ: Princeton University Press, 2005.
 664 Hirsch, M.W.; Smale, S., Devaney, R.: *Differential Equations, Dynamical Systems, & An Introduction to Chaos*
 665 (Second ed.). Boston, MA: Academic Press, 2003.
 666 Howard, L.: On the modification of clouds, and on the principles of their production, suspension and destruction,
 667 *The Philosophical Magazine*: Vol. 16, No. 62, 1803, 97–107.
 668 Illingworth, S.: *A sonnet to science Scientists and their poetry*, Manchester: Manchester University Press, 2019,
 669 52.
 670 Kappraff, J.: *Connections: The Geometric Bridge between Art and Science*, Singapur: World Scientific
 671 Publishing, 2001, 54ff.
 672 Kepler, J.: *Mysterium Cosmographicum* [1596], in: *Was die Welt im Innersten zusammenhält. Antworten aus*
 673 *Keplers Schriften*, (Ed.) Fritz Kraft, Wiesbaden: matrixverlag, 2005, 347.
 674 ——— *Harmonices Mundi, libri V*, Linz, 1619, in: *Was die Welt im Innersten zusammenhält*, 2005, 572.
 675 ——— *Strena vom Sechseckigen Schnee, Neujahrgabe oder Vom Sechseckigen Schnee*, Unter Mitwirkung von
 676 M. Caspar u.F. Neuhardt, [1611] transl. by Fritz Rossmann, Berlin: W. Keiper 1943, 16 f.
 677 Kostant, B.: The Graph of the Truncated Icosahedron and the Last Letter of Galois, *Notices of the AMS*, Sept



2005. Retrieved from: <http://www.ams.org/notices/199509/kostant.pdf>
- Lanza, T., Illingworth, S. et al.: Special Issue: Five years of Earth sciences and art at the EGU (2015–2019), Geoscience Communication, Copernicus, 2020–2021.
- Lenton, T.M. and Latour, B.: Gaia 2.0, Science 14, Vol. 361, Issue 6407, 2018, 1066–1068.
- Levine, D. & Steinhardt, P. J.: Quasicrystals. I. Definition and structure, Phys. Rev. B, Vol. 34 (2), 1986, 596–618.
- Liu, Y., Wang, Z., Wang, S., Fang, H., Wang, D.: Soot Nanoparticles Could Partake in Nucleation of Biogenic Particles in the Atmosphere: Using Fullerene as a Model Compound. Atmosphere 7 (3) 2016, 45.doi:10.3390/atmos7030045.
- Lorenz, E.: Deterministic Nonperiodic Flow, Journal of Atmospheric Sciences, Vol.20, 1963, 130–141.
- Predictability: „Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?“ Presented before the American Association for the Advancement of Science, December 29, 1972.
- Lovelock, J.E. & Margulis, L.: Atmospheric homeostasis by and for the biosphere: the Gaia hypothesis, Tellus. Series A. Stockholm: International Meteorological Institute. 26 (1–2), 1974, 2–10.
- Mandelbrot, B.: The Fractal Geometry of Nature, New York: W.H. Freeman, 1977.
- Margulis, L.: Gaia is a tough bitch. In: The Third Culture: Beyond the Scientific Revolution (ed.) John Brockman, New York: Simon & Schuster, 1995; https://www.edge.org/conversation/lynn_margulis-chapter-7-gaia-is-a-tough-bitch
- Maturana, H.R., Varela, F.J.: Autopoiesis and cognition: The realization of the living. D. Reidel, Boston. 1980.
- Maxwell, J.-C.: On physical lines of force. Part II: The Theory of Molecular Vortices applied to Electric Currents, Philosophical Magazine, 21 series 4, 1861a, 348.
- The Theory of the Primary Colours, The British Journal of Photography. August 9, 1861b.
- Mogensen, K. : Ocean coupling in tropical cyclone forecasts, ECMWF newsletter No. 154, Winter 2017/18, 29–34. <https://www.ecmwf.int/en/elibrary/18204-ocean-coupling-tropical-cyclone-forecasts>
- NASA: A Year in the Life of Earth's CO₂, Visualisation - Jan.1, 2006 - Dec. 31, 2006 (3:05 min) <http://svs.gsfc.nasa.gov/goto?11719>, NASA Goddard Media Studios, Courtesy of NASA/JPL-Caltech.
- Navarro, J. (Ed.): Ether and Modernity: The recalcitrance of an epistemic object in the early twentieth century, Oxford: Oxford University Press, 2018.
- Newton, I.: Descartes, Space and Body, 1666, transl. J.Bennett 2017, <https://www.earlymoderntexts.com/assets/pdfs/newton1666.pdf>.
- Ovidius Naso, P.: *Metamorphoses*. Translated by A. D. Melville; introduction and notes by E. J. Kenney. Oxford: Oxford University Press.[8 AD], 2008.
- Peng, Z.K., Lang, Z.Q., Billings, S.A. and Lu, Y.: Analysis of bilinear oscillators under harmonic loading using nonlinear output frequency response functions, International Journal of Mechanical Sciences, Vol.49 No.11, 2007, 1213–1225.
- Penrose, R.: The role of aesthetics, Bulletin of the Institute of Mathematics and Its Applications, Vol. 10, No. 2, 1974, 266–271.
- Persson, A. O.: The Coriolis Effect: Four centuries of conflict between common sense and mathematics, Part I: A history to 1885, History of Meteorology 2, 2005.
- Platon : Timaios, Stuttgart: Philipp Reclam jun., 2003.
- [c. 385- 378] Phaidôn, Berlin: Insel, 1994.
- Poe, E.A.: Eureka, A Prose Poem: Or the Physical and Metaphysical Universe. New York: Leavitt, Trow & CO. Prs., 1848.
- Poincaré, J. H.: Sur le problème des trois corps et les équations de la dynamique. Divergence des séries de M. Lindstedt, Acta Mathematica. 13 (1–2), 1890, 1–270.
- La Science et l'Hypothèse, Paris: Ernest Flammarion, 1902 (germ. transl. 1904).
- Cinquième complément à l'analysis situs, Rendiconti del Circolo Matematico di Palermo (1884–1940) 18, 1904a, 45–110.
- Quantum Cinema - a digital Vision, SciArt project by R. C.-Z.- Quehenberger, head P. Weibel, Dept. of Media Theory, University of applied Arts Vienna, funded by the Austrian Science Fund (FWF) in the PEEK framework, 2010–2013. <http://quantumcinema.uni-ak.ac.at>
- From the Pentagon inequality to the Poincaré Universe, 3D animated film, 2012, 03:02 min, <https://vimeo.com/54676456>
- Quehenberger, R. C.-Z., Arnal, L., Mogensen, K.: GAIA 5.0: A science–art project using ECMWF, (Ed.) Lentze, G; European Centre for Medium-Range Weather Forecasts, Shinfield Park, Reading, RG2 9AX, UK, ECMWF Newsletter No. 162, Winter 2019/2020, 13. <https://www.ecmwf.int/node/19356>
- Quehenberger, R. C.-Z.: A newly discovered Heptahedron named Epitahedron, Symmetry: Culture and Science,



- 735 25 (3) 2014, 177–192.
- 736 ——— A reflection on theories of light. *Quantum Theory: Reconsideration of Foundations 6*, AIP Conf. Proc.
- 737 1508, 2012, 459–463. doi: 10.1063/1.4773164
- 738 ——— The epita-dodecahedron visualizing Poincaré's dodecahedral space, film, IMAGINARY, International
- 739 Conference of Mathematicians, ICM Seoul 2014; <https://imaginary.org/tr/node/750>
- 740 ——— Visualization of the Icosahedral Group PSL (2,11), vimeo.com/50231760
- 741 ——— Quantum information traced back to ancient Egyptian mysteries. *Technoetic Arts: A Journal of Speculative*
- 742 *Research*; Vol. 11, Issue 3, 2013, 319.
- 743 ——— On the Hermeneutics of the Penrose Pattern — Art Research on the Phenomenology of higher dimensional
- 744 Spaces, Dissertation, [unpublished] thesis, 2019.
- 745 ——— A quest for an epistemic reset in higher dimensional space, Linnaeus Conference: Towards Ultimate
- 746 Quantum Theory (UQT) Växjö, Schweden, June 11–14, 2018, Entropy Best Poster Award,
- 747 <https://res.mdpi.com/data/1st-place-r.c.-z.-quehenberger.pdf>
- 748 Raes, F., van Dingenen, R., Vignati, E., Wilson, J., Putaud, J.-P., Seinfeld, J.H., Adams, P.: Formation and cycling
- 749 of aerosols in the global troposphere, *Atmospheric Environment* 34, 2000, 4215–4240.
- 750 RAL Annual Report 2018: Four-Dimensional Weather System (4DWX), NCAR Research Applications
- 751 Laboratory, retrieved from <https://nar.ucar.edu/2018/ral/four-dimensional-weather-system-4dwx>)
- 752 Richardson, F.: Atmospheric diffusion shown on a distance-neighbour graph. In: *Proceedings of the Royal Society*
- 753 *A. Containing Papers of a Mathematical and Physical Character*, Vol. 110, No. 756, 1926, 709–737.
- 754 Rosen, R.: *Anticipatory systems*. Pergamon Press. New York, 1985.
- 755 Rubin, S., & Crucifix, M.: More than planetary-scale feedback self-regulation: A Biological-centred approach to
- 756 the Gaia Hypothesis. *Earth*, ArXiv, 2019. doi.org/10.31223/osf.io/hs6t9
- 757 Snow, C. P.: *The Two Cultures*. London: Cambridge University Press [1959], 2001.
- 758 Schlegel, V.: Quelques théorèmes de Géométrie à n dimensions, *Bulletin de la Société Mathématique de France*
- 759 10, 1882, 194.
- 760 ——— Über den sogenannten vierdimensionalen Raum, *Naturwissenschaftliche Wochenschrift*, Berlin: Hermann
- 761 Riemann, 1888.
- 762 Tirelli, D.: Vibration Mitigation without Dissipative Devices: First Large-Scale Testing of a State Switched
- 763 Inducer, Special Issue. *International Conference on Structural Engineering Dynamics 2013*, Hindawi, Shock
- 764 and Vibration, Vol. 2014, doi.org/10.1155/2014/135767.
- 765 Toole, B.A.: *Ada, the Enchantress of Numbers: Poetical Science*, Sausalito CA: Critical Connection, 2010, 136.
- 766 UNOSA (United Nations Office of Outer Space Affairs) Online Index of Objects Launched into Outer Space.
- 767 Retrieved 31 March 2020, <https://www.unoosa.org/oosa/osoindex/search-ng.jsp>
- 768 Virilio, P.: *Lost Dimension*, New York: semiotexte, 1991, 50 (orig. *L'espace critique*, Paris: C. Bourgois, 1984).
- 769 Wagner, R.: "The Artwork of the Future" (German: *Das Kunstwerk der Zukunft*) [Leipzig: 1849] trans. Emma
- 770 Warner, London, 2013, VI/0012 (Trans. from germ. „...brachte ich den Philister gegen mich auf, der den
- 771 Künstler sich nur albern, nie aber denkend vorstellen will.“)
- 772 Walters, L.: *Margaret Cavendish: Gender, Science and Politics*, Cambridge : Cambridge University Press, 2014,
- 773 62–68.
- 774 Wegener, A.: Die Herausbildung der Grossformen der Erdrinde (Kontinente und Ozeane), auf geophysikalischer
- 775 Grundlage, *Petermanns Geographische Mitteilungen*, 63, 1912, 185–195, 253–256, 305–309.
- 776 Wells, H.G.: *The Time Machine: An Invention*, London: Heinemann, 1895.
- 777 Whewell, W.: Review of *On the Connexion of the Physical Sciences* by Mrs. Somerville, *The Quarterly Review*.
- 778 51: 54–68. March 1834.
- 779 Yurchak, B.S.: Description of cloud-rain bands in a tropical cyclone by a hyperbolic-logarithmic spiral. *Russ.*
- 780 *Meteorol. Hydrol.* 32, 2007, 8–18. doi.org/10.3103/S1068373907010025
- 781 Žižek, S.: *Disparities*, London / New York: Bloomsbury Publishing, 2016, 145.