Special Section of
Leonardo Transactions

Water Is in the Air

Annick Bureaud and Roger F. Malina, Guest Editors

We are pleased to present a selection of papers presented at the Water Is in the Air workshop, held 25–26 June 2012 in Marseille, France. Recognizing that water is at the core of many economic, social and political issues as well as cultural and symbolic ones, the workshop presented and discussed trans-disciplinary topics, using artistic and scientific projects about water as case studies.

The workshop was organized by Annick Bureaud, Roger F. Malina and Pascale Hurtado under the auspices of the European StudioLab consortium led by the Science Gallery in Dublin, and was hosted by IMéRA, the Institut Méditerranéen de Recherches Avancées at the Aix Marseille University.

Video documentation of all the talks is available online at <www.olats.org/studiolab/eau.php?in=acte>.

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Science and Art of Sculpturing Fluids

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* This paper represents work presented at the Water Is in the Air worskhop organized in Marseille, France, by Leonardo/Olats in collaboration with IMéRA, 25-26 June 2012, as part of the European project StudioLab.

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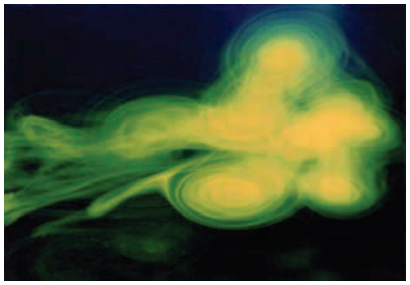
Abstract

The role of aesthetics is analysed through examples of the author's work in both science and art & science.

Fundamental research aims at building an understanding of natural phenomena by constructing a representation made of elementary mechanisms. A scientific proof is then the design of a specific experiment to perform measurement of one of these mechanisms as much as possible in isolation, in order to exclude the complexity and the artefacts coming from the interaction of different processes acting in the dynamics or in the measures implemented.

For example, in my research, I questioned the idea that large vortex structures observed in planetary atmospheres are the result of a fusion, whereby smaller structures transfer energy from small to large scales. Such a so-called inverse cascade was assumed to be due to the shallowness of the troposphere, 10km deep, compared to the horizontal scale of the vortices, around 1000km. To reproduce a similar free shallow flow in the laboratory, Y. Couder, my PhD adviser, had the idea to use soap films stretched flat on a frame or made hemispherical by a pressure difference. Then by displacing objects in or close to the membrane, such as a rack of cylinders or disks in differential rotation, vortices were generated on their surface. Tracking the evolution of the vortices allows us to demonstrate and quantify the inverse cascade of energy from small to large scales [1].

Fig. 1. Top view of the zigzag instability destructuring a vertical vortex dipole [2]. (© Jean-Marc Chomaz)



Another example is my research on the ocean or the atmosphere at mesoscale horizontal scales between approximately 10m and 100km, where motion cannot be assumed to be uniform across the vertical but is organized in layers as the density of the fluid increases with depth. Such a fluid is called stratified, and by a series of experiments, where vertically uniform vortices were generated by a set of vertical flaps that rotated around their vertical axis, we isolated a new mechanism responsible for the layering of the ocean that we named Zigzag instability. From this observation we proposed a new scaling law that invalidated the turbulence models used in atmosphere and ocean numerical simulation [2].

The concept of scaling laws is essential in science, since it states that the phenomena observed at one particular scale is representative of a broader class of flows, if non dimensional numbers, to be defined, have the same values. Turbulence in the ocean is controlled by the balance between buoyancy due to the stratification and the momentum of fluid blobs defining the Froude number. Motion in a one-meter high tank in the laboratory will be similar to a much larger scale ocean flow if the Froude number is the same in both cases. Since the size is thousands of times smaller, the velocity has to be smaller in the lab and the stratification higher, with up to 20% variation of the density over half a meter, compared to 1% over kilometres in the ocean. In our experiment [3], tall columnar vortices, never encountered in the ocean, were created. Visualizing flow with dye (Fig. 1), we have shown that tall vortices were breaking apart vertically under the action of the zigzag instability. In neither the atmosphere nor the ocean can this instability be observed because it is so strong that it dismantles any nascent attempt of tall vortices to appear. But as an effect of the pushed back instability, energy cascades at the mesoscale from large scale to small.

The Aesthetics of Scientific Questioning and of Proof

As illustrated by these two examples, fundamental research aims at defining and at the same time answering simple questions through a highly aesthetic process of disentanglement of the complexity of the reality often evidencing broken symmetries or lost invariance. The proofs, experimental images, data, numerical simulations or equations from a theory intrinsically carry the aesthetic of this questioning and are designed and selected by the researcher to make the statement stronger by their subjective aesthetic aspect even though the proof itself is objective. In science, aesthetics then comes into play at least at three different levels, in the quest of elementary processes, in the proof and in the images, sketches or equations that convey the proof. In this last case, aesthetic serves the proof in a subjective way since it intends to convince our peers.

Science is an intrinsically aesthetic search for elementary processes that may touch even a robot mind but it has to be shared among humans and a more sensitive aesthetic delivers proof.

Aesthetics in the Mediation of Science

Fig. 2. "Tornade apprivoisée" a 3m high open tornado simulator. (© Jean-Marc Chomaz)

When mediation of scientific ideas is targeting a non-scientific public, the aesthetic may be pushed by adding complexity to the demonstration in order to trigger questioning and not only to give easy answers. For "The Tornado Tamed" demonstrator (Fig. 2), by adding hot colour lights and irregular injections of smoke, the tornado seems to form instantly when smoke is emitted and illuminates the core of the vortex, and to disorganize when smoke reaches the periphery, giving the illusion of an aesthetic life cycle that puzzles observers and engages them in a scientific search to decompose this complex scenery into elementary processes.

Art using Science

If science is aesthetics, and if aesthetics may serve scientific proof and the mediation of science, then science may serve art first by extending the field of possibilities, scientific effect or results to become material for artists to play with

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and construct their own proposal. I have practiced this art using science with the sculptor Manolis Maridakis to produce three works. The first one consisted of a two-meter water disk for which the scientific challenge was to reduce the turbulence of the flow, to keep the disk smooth—a problem that appears only for a large-scale disk since at a small scale the stiffness of the water surface is sufficient to smooth the flow.

Art & Science, Sensitive Rather Than Sensible Side of Science

Working with Laurent Karst and François Eudes Chanfrault forming the artist group Labofactory, or with the duo HeHe, I investigated another path between art and science that mixes both types of imagination. Formulating questions in science is pure imagination and intuition; this does not involve only the rational side of the brain but the sensitive side, which is able to understand faster and anticipate. With scientific intuition one suddenly sees far ahead in a direction hidden to us before. Then it will take years for the rational side to move and pave the way toward that invented frontier, validating or invalidating what the sensitive side has foreseen. Instead of showing scientific language, proof or technique, it is possible with art & science to directly attempt to share the sensitive side, to build art pieces spanning both artistic and scientific imaginations.

The Labofactory "infraespace" installation is made of 12 computer controlled cubic drums, each with a different and artificial specialized sound. Each percussion of each drum produces a 20cm vortex ring visualized by smoke that shoots up through the air. The ring travels between a light inside the drum and a light 4 meters above, giving an intrinsic rhythm to the installation. Without percussion each drum appears as a black 50cm high cube with a 20cm hole filled with bright smoke looking like a volcano. This large installation can be played live, and the public is then immersed in a ballet of ephemeral rings evoking jellyfishes in an abyssal world.

The Labofactory installation "Wave" proposes a different universe, where electronic music is played live and composed to include infrasound that, since it is not audible, is rendered on the surface of a shallow water tank installed flush at the top of three 3m long black steles. Shallow water waves behave like sound and unfold time into space. A light projector underneath the water immerses the public in a shadow graphic effect where bright and dark fringes magnify the water's wave.

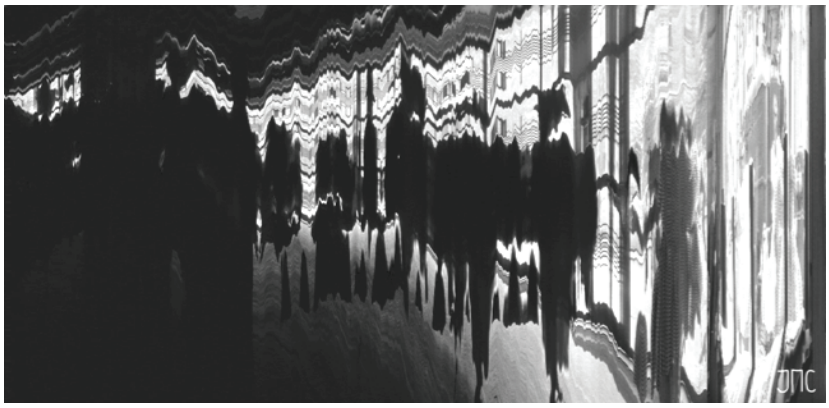

Fig. 3. "Time trace" "Femme en noir" extracted from the spatio-temporal cut of the movie "à bout de souffle" by J.L. Godard. (© Jean-Marc Chomaz)

The work with the duo HeHe is different and more committed to political issues, but if it proposes an unusual angle of view it never imposes an answer or a point of view. Their motto is the present impossibility to discriminate the atmosphere from man-made emissions, their "man made clouds". One of their approaches is to use toy models in an odd situation to displace the viewpoint of the watcher. In *Fleur de Lys* a toy model power plant is set inside a water tank in a scene looking like our lab, and fluorescent plumes are emitted sporadically from the cooling tower in an ever going, slowly evolving nuclear accident, producing a fascinating green toxic cloud. In "Domestic Disaster 3: Planet Laboratory" we mix the HeHe "man made clouds" with my intention to stress the fragility of the atmosphere in our only spaceship, which lacks a windshield. In a laboratory-like staging, a toy globe with a realistic satellite printing is rotating with the music of a Theremin. The water is already greenish and dimly lit. Suddenly a green cloud of dye is injected close to the pole. It slowly moves in a thin boundary layer close to the globe surface, experiencing instability and exhibiting spiralling patterns. Eventually the dye escapes at the equator to the open spaces and mixes.

My final example will be my photo series "time traces" where I produce spatio-temporal cuts through classical movies. Science is not dealing with forms but with dynamics, and the form cannot be distinguished from its creation process. This brings a kind of equivalence between time and space, and equations ruling different processes involve in a similar way time and space variables, the only difference being the causality principle that applies to time. Spatio-temporal images where variations of a quantity are plotted versus time and space are then the tools commonly used to unravel complex dynamics. A movie is also a space-time journey since the director has ordered a time series of scenes with particular visual rhythm and dominant colours and prescribed in each scene the space-time motions of the actors and the camera. The tool science uses to analyse space-time processes can be transposed to movies by producing a single image by the concatenation of the same vertical line cut out of the thousand images of the film. Within this space-time cut, each scene will be separated by a vertical cut, the whole image being a direct immersion into the director's space-time imagination revealing unforeseen symmetries and constructions. Figure 3 presents the "femme en noir" image extracted from the spatio-temporal cut of the movie "à bout de souffle" by Jean-Luc Godard. In that "nouvelle vague" movement, the camera was carried on the shoulder, enabling the story to be told at the human level since the spectator, staged by the camera, became a character in the scenario. The "time trace" images issuing from this movie have the very human wavy texture given by the uncontrolled motion of the shoulder-borne camera. Being an image in time, it carries dynamic information, a kind of imbalance that sets the image in motion.

References and Notes

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3. C.H.K. Williamson & J.M. Chomaz. "Gallery of Fluid Motion, Instabilities of Stratified Vortex Pairs", **Physics of Fluids,** Vol. 9, p. S4 (1997).