

SCIENCE AND ART OF SCULPTURING FLUIDS

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Abstract

The role of aesthetics is analysed through examples of my work in both science and art & science. This paper is part of the *Water is in the Air* workshop.

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 an specific experiment to perform measurement of one of these mechanism 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 the planetary atmospheres are the result of a fusion whereby smaller structures transfer energy from small to large scales. Such co-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]. Another example, are my researches on ocean or atmosphere at mesoscale horizontal scales between approximately

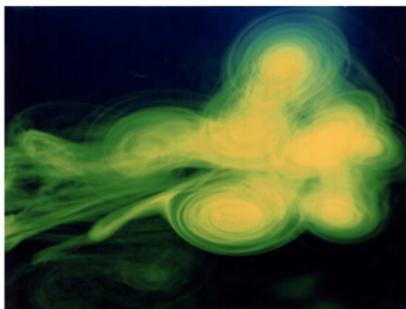


Fig. 1. Top view of the zigzag instability destructuring a vertical vortex dipole [2].

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 ever encountered in the ocean, were created. Visualizing flow with dye (figure 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 this instability cannot 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 design and selected by the

researcher to make the statement stronger by their subjective aesthete 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

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 (figure 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 the observers and engage them into a scientific search to decompose this complex scenery into elementary processes.



Fig. 2. “Tornado apprivoisée” a 3m high open tornado simulator

Art using Science

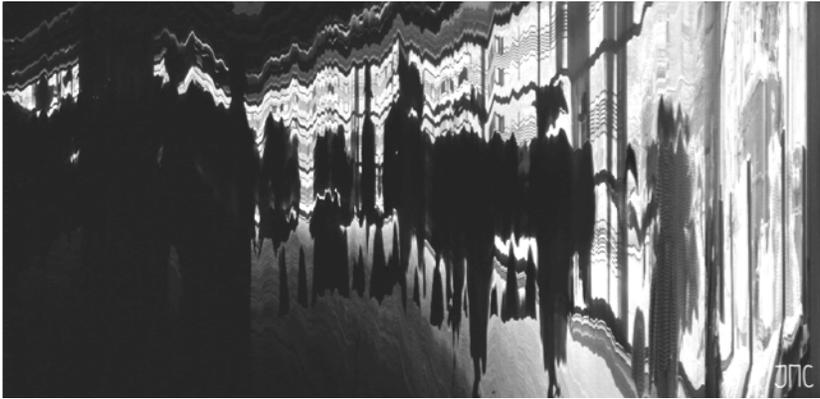
If science is aesthetic, and if aesthetic may serve scientific proof and the mediation of science, the science may serve art first by extending the field of possibilities, scientific effect or results have become material for the artists to play with and construct their own proposal. I practice this Art using science with the sculptor Manolis Maridakis to produce three works: the first of which made 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 large scale disk since at

small scale the stiffness of the water surface is sufficient to smooth the flow.

Art & Science, sensitive rather than sensible side of science

But working with Laurent Karst and François Eudes Chanfrault forming the artist group Labofactory or with the duo HeHe, there is another path between art and science that mixes both imaginations, and not facts or techniques since science is not only the rigor of the proof, that I call the pipe where once the problem stated at one end, any scientist or computer will come to the same conclusion. Innovation or breakthrough consist of formulating non-incremental questions not visible from inside the pipe. Formulating questions in science is pure imagination and intuition that 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. To me these pieces are like writing poems using scientific vocabulary and by doing so re-interrogating my scientific practice. The Labofactory “infraespace” installation is made of twelve computer controlled cubic drums each has 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 through 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 they are not audible, are 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

Fig. 3. “Time trace” “Femme en noir” extracted from the spatio-temporal cut of the movie “à bout de souffle” by J.L. Godard.



space. A light projector underneath the water, immerses the public into a shadow graphic effect where bright and dark fringes magnify the waters wave. 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 the 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 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 that misses 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 cut through classical movies. Science is not dealing with forms but with dynamics and the form cannot be distinguish 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 vertical cut the whole image being a direct immersion into the director 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 has the very human wavy texture given by the uncontrolled motion of the shoulder born camera. Being an image in time it carries dynamical information, a kind of imbalance that sets the image in motion.

References and Notes

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