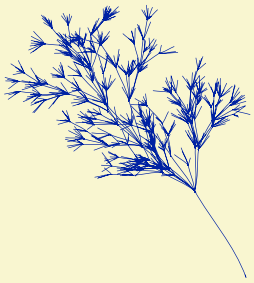
SCIENCE AND POETRY: BETWEEN THE COMPLEXITY OF THE LEAFY AND THE TRANSPARENT

DAVID JOU
DEPARTMENT OF PHYSICS
UNIVERSITAT AUTÒNOMA DE BARCELONA



Images of complexity tend to be of one of two types: the leafy or ramified and the transparent. In the former group are the forest and the brain; in the latter group, air and light. Leafiness, clearly, bears a direct suggestion of structural complexity: the dense, the multicoloured, the different, the interwoven, the inextricable. But transparency also has its complexity, more dynamic than structural: the turbulence of the wind, the quantum and cosmic fluctuations of light in the eye and in the background radiation of the universe. Between the structural and the dynamic there stretches a broad domain of complexity that combines time and space, geometry and movement.

COMPLEXITY OF SYSTEMS

One of the measures most often used to define complexity is the quantity of information required to describe a given system. Describing a pane of glass is easy: you give its basic pattern, its fundamental cell, and indicate that it is regularly repeated *ad infinitum*. Describing a gas is relatively simple too: particles with random velocities and positions are distributed within a volume —with a large enough number of particles, this will give a Gaussian probability distribution of velocities.

But between the regular and the random lies a multitude of phenomena. The greater the quantity of information needed to describe it; the more complex we consider it to be.

To a certain extent, therefore, complexity becomes a narrative: e.g. the description of a structure or the history of an evolution, as in biology. The narrative makes clock time dance to a changing and different rhythm, between hectic and sluggish, between action and contemplation. In the narrative, time flows irregularly: it is not a constant rhythm, but a sinuous, undulating intensity. This is why many sacred texts are narratives: in them time is not an absolute, but a succession of certain very dense instants, which forge meaning and reveal reality, and of many superficial, light, routine instants, with no relevant novelty or meaning of their own. We know this well, because it is precisely the time of our vital experience: elastic, fluid, an eventful linked series of blinding flashes and unceasing opacities.

It is interesting to note that that informational relativity of time —closer to us than Einsteinian relativity— is not exclusive to the intimacies of psychology and the subtleties of history, but can be found, at least latently, in very simple materials. Water, for example, acts like a solid, impenetrable surface when struck sharply with the palm of the hand and yet yields like a liquid mass to a gently and unhurriedly introduced hand. Many materials display that same twin behaviour to a far more extreme degree than water; being both solid and liquid, elastic and viscous —or *viscoelastic* to give it its scientific term.

The molecular explanation for this diversity of behaviour is not difficult to grasp, at least not in a qualitative outline. Each system contains certain characteristic internal times of its own, related, for example, to the average time between successive molecular collisions. If a disruption occurs in a much shorter length of time, then the particles have no time to move position significantly and the system retains a resistance similar to that of a solid. If, on the other hand, the disruption is slow (with respect to the internal time scale), the molecules move as in a liquid. Solid and liquid are absolute concepts in our naive experience, but they overlap subtly when the time scales vary. Rocks are solid in our everyday experience, on scales of months or years or centuries, but not on a scale of millennia. Over large time scales, rocks appear to flow gently; in just the same way as continents, which are fixed tight to the globe in our regular historical experience, sail majestically across the subterranean magma at scales of tens of millions of years.

The classical thermodynamic description refers only to states of balance and quasi-static processes, i.e. processes that are very slow with respect to the internal times of the system. When the system is out of balance, the rate at which its states vary can become comparable to or greater than the internal pace of the system. In this case, there will be no time to reach equilibrium. In the theory we have developed at the Autonomous University of Barcelona, extended ir-

reversible thermodynamics, we generalise the entropy or measure of molecular disorder, to situations at a distance from balance.

The key to this extension is the introduction of flows of energy, mass, current, quantity of movement, as basic variables in the entropy, alongside its classic variables: energy, volume and composition. When the flow is small, the generalised entropy is reduced to classic entropy, since the contribution of the flows will be insignificantly small. If the flow is large with respect to the characteristic variation time of the system, the system will not be capable of achieving equilibrium, and the flow will have a considerable effect on it.

Interestingly, a good way of understanding that situation is to look at the sociology of migration. It takes a certain time for outsiders to integrate into any group. In authoritarian societies, that time is short, since the new arrival is obliged to adapt immediately. If the society is less authoritarian, or if it lacks the state resources to exercise that authority, the adaptation time is longer, due to the greater tolerance or less exigency. Let us imagine now that people start coming to this society from another culture, who will in turn need a certain internal adaptation time (essentially to learn the language and customs). If the flow of recent arrivals is relatively small, they will adapt in a short time and the society will remain more or less homogenous, although its general cultural patterns will change with the incorporation of new information. If the flow of recent arrivals is large compared to the time scale of adaptation to the new society, the number of unadapted new arrivals will grow more and more, and society may end up being split into two or more social blocs, leading on occasions to significant conflict.

Flows, a factor of complexity, are precisely one of the most visible characteristics of our time: large-scale flows of information, people, goods, capital, great transport and communication facilities, aeroplanes and computers, satellites. For this reason, when we measure the degree of disorder or the degree of complexity of a physical, chemical, biological or social system, we need to take into account the flows that feed and structure it.

COMPLEXITY OF THE SELF

We have mentioned that complexity shares aspects in common with narrative. As we have said, this can be expressed in the number of bits —quanta of information— needed to describe the system. Let us take our self as a system. How many bits would we need to describe all our lived experience; everything we have seen, heard, touched, tasted, felt and thought? In order to make a simple approximation, we shall work on the basis that this information is processed in our brain. One hun-

dred thousand million neurons firing off at a pace of around a thousand times per second —at most— gives one hundred billion bits per second.

If we multiply this number by the number of seconds in an eighty-year life, we get more or less half Avogadro's constant. This number —approximately equivalent to a six followed by twenty-three zeros— is the quantity of molecules in a mole of a substance, e.g. the number of molecules in two grams of hydrogen. In other words, if we could store one bit of information in each molecule of hydrogen, we would need just one gram of hydrogen to contain all the information in our life. I address this subject in greater detail in my books *Reescribiendo el Génesis; de la gloria de Dios al sabotaje del universo* (Destino, Barcelona, 2008) and *Cerebro y universo, dos cosmologías* (Destino, Barcelona, 2011).

So we are complex, but our complexity is not infinite. In actual fact, we need far fewer bits of information than we have said, since much of that information never enters our conscious or unconscious: it simply slips through without our perceiving it. With a thousandth or a ten-thousandth of that amount of information, we would have more than enough.

Poetry seeks —in part— to compress that amount of information into many fewer bits, selecting the most significant ones, the most profound, the most emotional, the most personal, the most unrepeatable and unique. In this respect it is in contrast with science, which seeks not the unrepeatable, not the unique, but the repeatable, the verifiable. Science aspires to explain the «leafiness» of the genome and the brain, whereas poetry seeks to illuminate the transparency of feeling and thought.

Science and poetry, then, both see us as a complex system, but turn their attention to different complexities. Science focuses on the corporeal, the molecular, the cellular, the systemic. Poetry focuses on intense, founding, unforgettable experiences. To put it another way, when science sees a letter (a missive), it turns its attention to the chemical make-up of the paper and the ink, the energy needed to manufacture the paper and the ink and the geometric complexity of the calligraphy. Poetry, on the other hand, will perhaps feel attracted by the sentiments aroused by the letter: the memory of a love evoked or the promise of a meeting in prospect.

Complexity is not only a measure of the internal self, but also of our relationship with the universe. From the point of view of distances and volumes, we are infinitely small in comparison with the visible universe. Our planet is an infinitesimal point in comparison with the galaxy, and utterly invisible at a cosmic scale. But, what if the most relevant measure of our being in the world were not space but complexity?

How different things look from that perspective! The brain is more complex than the visible universe. The human brain contains around ten thousand million neurons, similar to the number of galaxies in the visible universe. However all galaxies mutually interact in accordance with a single law: the law of gravity. Neurons, on the other hand, inter-

act mutually through synapses, or contacts through which neurotransmitters are exchanged. Synapses can be excitatory or inhibitory; around fifty different types of neurotransmitters are involved —in each synapse there is a type of neurotransmitter— and the intensity of each synapse can vary with time, depending on learning and forgetting. For this reason, although brain and universe have a similar number of elementary components —galaxies in one case and neurons in the other— the brain is much more complex since it requires the specification of many different types of synapses.

Incorporating complexity into our view of the world therefore marks a Copernican revolution (or perhaps an anti-Copernican one) in the way we view our relationship with the world. Countering the official theory of our irrelevant smallness, an enigmatic, but not insignificant, presence now emerges.

COMPLEXITY OF POETRY

Scientific language works hard to be univocal and precise; poetic language, on the other hand, aspires to be polysemic, polyhedral, evocative, suggestive. Poetry does not necessarily aspire to a complex language, but to condense the complexity of situations or feelings into words and rhythms, sometimes very simple ones, that are capable of expanding their resonance. Faced with a scientific text, most readers should be able to understand it, since an effort has been made to be univocal and unequivocal. Faced with a poetic text, on the other hand, it is both to be expected and to be hoped for that they will experience a plurality of perspectives. The scientific text is a photograph, taken from a single perspective; the poetic text is a hologram, with many perspectives.

Indeed, in the context of the science of complexity, a poem could well be compared to a hologram. A hologram is a collection of points on a transparent plate, resulting from the interference of two wave fronts, one of which has been in contact with the object to be represented, and the other of which has gone directly to the plate. These points, located on a two-dimensional plate, contain three-dimensional information about the object. They also allow the object to be seen from different angles, if the orientation of the plate is changed. Finally, each small fragment of the hologram contains the information of the whole. In a poem, a two-dimensional collection of signs is likewise capable of showing —in all its dimensionality and in a plurality of perspectives— the external or internal landscape, the world and its image or feeling in the observer. In the same way the signs (words) condense the interference of the subject being dealt with and of the poet's verbal, emotional or intellectual experience.

In my poetry —around twenty books published together in two volumes as *L'èxtasi i el càlcul* (Viena, Barcelona, 2002) and *L'Huracà sobre els mapes* (Viena, Barcelona, 2004)— I have spoken not only of science, but also of religion, cinema, cities, love, animals, politics and art… One more or less experimental facet of my poetry consists of making the book a visibly and explicitly dynamic whole, so that the shape evolves throughout the book, paralleling the development of its contents.

For example, one of the books, entitled *Arbre* (1983) is a collection of poems, each one in the form of a tree, but with two unusual features: the tree grows from a seed to a leafy tree, which, when autumn comes, gradually loses its foliage until it is reduced to a trunk; the second characteristic is that the verses corresponding to the ground, one in each poem of the book, in turn form a transverse poem; the same occurs with the verses representing the roots and trunk. Thus, the book has a dynamic, Heraclitean aspect, in the growth and falling of its leaves, and a static or Parmenidean aspect in the transverse poems that bind together the book as a whole. I have explored other natural shapes, such as summits, caves, starry skies and the genome. I would like to explore the multiple suggestions of the brain. In any case, in order to become completely conversant in the subject, I am writing the book I have already mentioned, *Cerebro y universo, dos cosmologías* (Destino, Barcelona, 2011). Preparing for a poetic exploration can stimulate one to extend one's scientific knowledge.

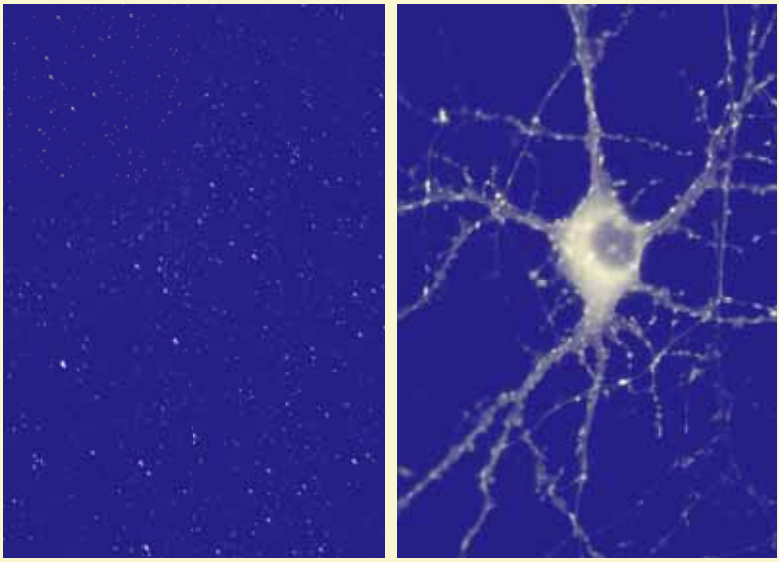
The formal techniques I mentioned in the last paragraph combine the experience of cinema —a subject to which I have devoted an entire book, *Los ojos del halcón maltés* (El Cuervo, Barcelona, 2003)— and Einstein's general theory of relativity, whereby the content of mass and energy alters the metrics of space. From the cinema, the book takes the dynamism of the whole that is not contained in the individual calligrams; from general relativity, it takes the flexibility of form, in which the growing verses in turn depict the growing aspect of reality. This, more or less, is what happens with the expanding universe: space grows, and its metre varies over time, in parallel with its contents.

Poetry often has the vocation and the will to be a universe. Those formal devices, taken from art and science, underline this desire to play at creating the book as a creator might design a universe —with laws of its own and with dynamic forms— playing at the same time with the predictable and the unpredictable, with the flash and the darkness.

Reflecting on the theories of chaos and complexity is a stimulus for exploration in poetry. That exploration gains greater possibilities if it is performed not in isolated poems, but in the space of an entire and sufficiently well-organised book. Leafiness and transparency can then be deployed in all their complexity. All that is needed is to encounter in the reader a certain complicity, a resonance.

THE PRESENT WORLD IS CHARACTERIZED BY THE HIGH VALUES OF PEOPLE, INFORMATION, CAPITAL, GOODS AND ENERGY FLOWS.

EL MUNDO ACTUAL ESTÁ CARACTERIZADO POR VALORES ELEVADOS DE LOS FLUJOS DE PERSONAS, DE INFORMACIÓN, DE CAPITALES, DE MERCANCÍAS Y DE ENERGÍA.



THE COMPLEXITY OF THE UNIVERSE DESCRIBED IN SCALE
OF GALAXIES IS LESS THAN THE COMPLEXITY OF THE BRAIN,
DESCRIBED IN SCALE OF NEURONS.

LA COMPLEJIDAD DEL UNIVERSO DESCRITO
A ESCALA DE GALAXIAS ES MENOR QUE LA DEL CEREBRO,
DESCRITO A NIVEL DE NEURONAS.

THE AMOUNT OF BITS PROCESSED BY THE CORTEX DURING A WHOLE LIFE IS HALF A MOLE OF BITS, THAT'S TO SAY, ABOUT THREE BILLION TRILLION.

EL CONJUNTO DE BITS PROCESADOS POR LA CORTEZA CEREBRAL A LO LARGO DE UNA VIDA ES DEL ORDEN DE MEDIO MOL DE BITS, ES DECIR, UNOS TRES MIL MILLONES DE BILLONES.