Book's prologue on the chaotic behaviour of tropical cyclones.

1 Introduction

> *Knowledge is proud that he has learned so much wisdom is humble that he knows no more.*
> *William Cowper*

Among the elements that contribute to the destiny of the world, order and disorder hold a prominent place. This alliance forms a chaos that seems inextricable.

Physics, which has been shaken to its foundations for over a century, has finally emerged fortified. It now allows a better understanding of the world and offers a fresh perspective on these concepts of order and disorder.

By stirring it again a little more, without disturbing public peace and quiet, physics can give us even more information which could be regarded as shreds of truth. Shedding new light on order and disorder in Nature is a topic that will first lead us into the turmoil of the harmful effects of chaos before a salutary return to serenity.

The subject is so vast that we must remain wise and humble in our ignorance. Socrates is credited with the maxim:

The only thing I know is that I know nothing.

Though we may know little, we are nevertheless slightly better informed than Socrates and Cowper, thanks to them and to the many famous or anonymous thinkers who, ever since Antiquity, have sought to discover some of the mysteries of the world.

While we must remain humble in view of the magnitude of the task before us, the topic is so mind-boggling that the posture of self-proclaimed wise man is untenable.

Observation of the movement of the planets, since ancient times, encouraged thinkers to consider our world as eternal.

Classical mechanics, ever since its origin based on order, has been a field of mathematics; it makes it possible to describe the movement of astronomical objects such as the planets and also material bodies around us. After Galileo and Newton, great names distinguished themselves. It was very fruitful and it is an indisputable reference. Since friction is not taken into account, reversibility is ensured: we go from the past to the future or from the future to the past without any change in its laws. It's perfect, you never get old. Fantastic!

The principle of least action, which states that Nature does not like to tire itself, sums up the situation.

But some troublemakers introduced disorder through the second law of thermodynamics. They were not welcome.

Irreversibilities were finally taken into account via entropy.[1] All irreversibilities, during any transformation in an isolated system, generate disorder (entropy), which can therefore only increase with time. This helped us to grasp a little better what time was. We realized that it was associated with disorder and adorned with an arrow pointing to the future: the arrow of time. Some deduced from this that the world would eventually die. But Nature is not bound to follow our reasoning.

To better understand the nature of entropy, some sought its roots in the molecular world, but faced with their huge number, they had to resort to probabilities.

Our world was not *necessarily* going to die, it was only *probably* going to die. A little optimism does no harm!

[1]Entropy = disorder, irreversibility, friction, etc.

The introduction of irreversibilities into the equations of mechanics was a grain of sand which complicated their resolution, to say the least. Therefore, they were simplified, linearized and minimized to get round the problem. This is how fluid mechanics arrived at the Navier-Stokes equations, which are a rather murky business for specialists, and then the equations of Reynolds, which are even more mysterious, when turbulence comes into play. This turbulence is the first sign of chaos, but of weak chaos.

Little by little, in the field of energy, physics deviated from mathematics, which lagged behind, stuck in the linear domain by remaining close to its bases : the world of order.

In the 1970s, other troublemakers, specialists of chaos, made their appearance. Physics was abandoning determinism, whose praises had been sung for so long, and descending into chaos; but one of many surprises awaited it: in this chaos, order lay hidden.

This was sensational news. Many scientists fell off their stool out of amazement.

A system driven towards disorder can create order. And we suddenly realized that as disorder had been increasing from the very first moments of the world, there was nothing to prevent order from occurring locally. The only condition was that overall, disorder should increase. Everything became clearer.

The most imposing example is that of our Universe.

Why is it necessary to wait billions of years after the fantastic initial imbalance in temperature due to the Big Bang to reach a final equilibrium where everything is homogenized? Because dissipative structures appeared, blocking progress towards ultimate disorder. Order appeared. Depending on one's beliefs, these dissipative structures, or self-organized structures, either emerged spontaneously or were created: they are the planets, the trees, the birds, mankind. Order was born from disorder.

The reader may wonder, at this stage, how we ended up in this mess.
Let me come to the point.

Let us move down a notch or two and get back to the topic in hand.

A system subjected to an intense disequilibrium and which therefore dissipates energy sees order appear.
The orderly structures thus formed are sometimes unacceptable, because the order which is introduced into a system prevents it from quickly reaching its final point of equilibrium. This is fortunate for our Universe. But unfortunate in a few but crucial cases.

Order and disorder acting simultaneously disrupt any system.

Some of these self-organized dissipative structures are very dangerous for our safety: for example, the supersonic jets in the control valves which make our electric power supply plants vibrate by weakening them.

When energy is dissipated, by the opening of a valve for example to prevent the explosion of a reservoir, the microscopic world reacts by creating self-organized structures that can impede access to the final equilibrium. What is worse, the molecular system organizes itself to degrade the kinetic energy of flows as it pleases, disregarding our safety, installations and environment. The order which appears in dissipative structures that have become threatening must be destroyed.

Troubling experiments on valves led me to state a principle which I called the principle of worst action, because it is diametrically opposed to the principle of least action of deterministic mechanics, whence its name.

By removing the order contained in a dissipative structure, the principle of worst action allows the entire system to rapidly attain, unhindered, its final equilibrium. It releases the second law of thermodynamics trapped in the meshes of chaos.

The principle of worst action is intended to create great disorder in the molecular system; its name is therefore perfectly adapted to the microscopic world.[2]

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[2]The reader will have understood that if correctly applied, this principle could bring calm to our macroscopic world. It could therefore be called otherwise for our macroscopic world. It will be up to philosophers and linguists to decide.

In addition to valves that carry high-powered fluids and that try to get rid of their motive power, the self-organized structures called hurricanes, typhoons or tropical cyclones depending on the region of the globe, could also be an area where the principle of worst action can be applied.

These tropical cyclones release a considerable motive power, causing havoc in inhabited areas; they must be weakened and downgraded to tropical storms.

By excessive imbalances, a tropical storm system crosses a bifurcation and a more or less chaotic zone. Then order appears in the midst of disorder. This explains why a tropical storm turns into a highly ordered structure, namely a hurricane with its eye and eye wall. The system that has changed into a hurricane becomes an enormous and terrifying open-air heat engine, mobile over the sea surface - terrifying but nonetheless ordered.

A proactive solution is to intentionally destroy these highly dangerous structures by applying the principle of worst action. To escape dissipative structures and the chaotic zones that accompany them, this principle allows us to create massive disorder in the microscopic world by eliminating the order that emerges when dissipative structures are formed.

A vistemboir - a device that applies the principle of worst action - provides an exchange of information from our macroscopic world towards the microscopic world so as to rapidly increase disorder in it.

The principle of worst action, by exchanging information between our macroscopic world and the world of molecules, reverses the roles: it creates great disorder in the molecular system so as to escape chaos in our macroscopic world.

This principle of worst action instructs the molecular system not to build these dangerous structures or to fight them when they appear. It must be used when order emerges in areas where reason dictates that only disorder should exist.

Because these concepts resulting from chaos theory and non-linear thermodynamics profoundly modify our vision of the world, it seemed useful to recall them here and to apply them.

This book therefore concerns an unexplored field of physics: one where energy has to be quickly and massively dissipated. Various problems are raised and dealt:

- Is it sensible to let chaos invade safety valves (and other dissipative systems) whereas their job is to protect people, installations and the environment?
- Have we learnt the lesson that Nature taught us at the time of Three Mile Island, the worst nuclear accident ever to occur in the USA?
- Is it judicious to let the microscopic world take charge of the control devices of our major energy installations?
- Are we going to continue to submit to the dreadful weather phenomena of tropical cyclones which create havoc and ruin?

Besides being ignorant, have we gone crazy?

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