

DANIEL FROTA: You describe in your article *Empirical Incompleteness and The Laws of Nature* the limits of numbers and measurement instruments in collecting data in order to account the physical world. Somehow it is a limit of the language of mathematics to describe things, isn't it? How do you deal with this dilemma between trusting a limited language and the will of extrapolate it?

MARCELO GLEISER: We try to understand things through all possible ways. We use all our possible tools for that: intuition, mathematics, forms of visualisation, analogies; that's what physicists and scientists do when they try to understand something. There was a French author from the 17th century called Bernard Le Bovier de Fontenelle, and in 1686 he wrote a brilliant book which was a dialogue on the possibility of other worlds' existence and life in other worlds. He used to say that "all philosophy is a product of only two things"—and by "philosophy" he means all human condition, let's say—"our curiosity"—of always wanting to know more—"and our myopia"—of not being able to see everything. I totally agree with him, this is philosophy, and you can apply that in science, art or any other creative activity by humans. All form of art or science is limited. In art for instance, you have the clear limit of the medium, as the painter that is constrained by the canvas, the writer by words and the sculptor by the physicality of materials. Besides that, there is the limit of the own artist. Subjectively, when he tries to come up with something new he bases himself on what he is, on his life experiences, on his view of the world, so his work is always connected to who he is in the end, in this world.

Since science, as art, is a constructed result of this unescapable correlation between things in the world and human condition, is there anything of fictitious in these data—that was collected by instruments already corrupted by this correlation and that are used to describe the physical world?

It shouldn't. You can create new concepts, new images...for instance what is an electron? An electron is a wave function, a particle, so you are already creating images that help you to think about the electron. But what the electron is, we don't know. We know the measurements that we see on electron's detectors, that's what we know. So, there is a difference between knowledge in terms of a collection of facts and measurements, and in terms of experiences that we have. Our creativity is the extension that can lead us to new forms of knowledge. In these new forms of knowledge you can create new instruments of expression and new ways of thinking—that's what the artists do, and that the scientists do as well. So, in 1600s there were no black holes, but nowadays there are. I mean, they always existed but we didn't know back then. We had to invent this new concept in order to find out that they were already there, or vice-versa.

Do you see any connection between these limitations and Whorf's theory of linguistic relativity, in which language conditions what you can say and think?

No doubts. So you are talking about the cognitive issue. I just finished writing a book called "The Island of Knowledge: The Limits of Science and the Search for Meaning" where I addressed this topic. The idea is basically how the mind functions and what it can do and what it cannot do. There are people that think there are no limits for our mind, and I disagree. Our world view and our

way of thinking about things, our mathematics and its mathematical truths are all creations of human mind. I'm not a solipsist, but everything comes from human mind. The way we conceptualise and structure the world and reality is obviously a product of how the human mind was developed in the last million years here on Earth. We are intrinsically conditioned by how we think in the end, since our brain functions in a determined way. I'm also not a "deconstructionist", on the contrary, but I think knowledge is a human form of knowing things. It is not an universal form. Our eyes, thoughts and verbal ability depend on how our brain functions, even comparing in different languages. There are only a few words to describe certain emotions. In different languages you can have more or less words, but always a finite, not always satisfactory, number.

Everything there is in the mind, passed before through the senses?

This is a very complex question. Yes, there is a direct information that we receive from the world, obviously sensorial, that we integrate in our minds and call it reality. But based on what we already now, from this accumulated knowledge from the world, and our experiences, we can intuit new knowledge that goes inside-out from the mind. 'Inside-out from the mind' but 'inside-out' between quotation marks, since all there is inside came at certain point from outside. In that sense, nothing comes nothing, meaning, all we create is a product from our history.

Besides being an astrophysicist, you are also a writer. Do you allow yourself the poetic license of jumping out of science's commitment to facts whenever you are on the writer's position?

When I'm writing on science, no. I can't escape from it when I'm writing a scientific text or an article like the *Empirical Incompleteness* one. For instance, the analogy of the anthropologist in the Amazon forest, that I repeat in my last book in details, is basically an instrument of comprehension, not an extrapolation. But when I wrote a novel for instance, called "Harmony of the World" based on Johannes Kepler's life, then yes, the poetic imagination runs freely. In fiction, you have the freedom that you can't have in Physics. You can use different ways to be inspired and make yourself understandable, but in the end, is the data that controls everything.

Which philosophical school do you identify your work with?

I'm a pragmatic. The type of philosophy I'm developing in my last book, I called "Natural Constructivism". We build narratives of reality based on our experience and our capacity of intuit new forms of knowledge. But this knowledge is a fluid construction. There are no absolute truths, everything is in flux. The idea that mathematics exist in an ideal space of abstract forms where the truth is, is a very platonian perspective, that is interesting as a reflection, but there are no correspondences with a practical realm. I'm very anti-platonian in this sense. I connect more with the presocratics from the Ionic School of Heraclitus, where everything is flux, than with Parmenides and Plato, that believe there are absolute truths to be found. For me this last approach is just a theoretical game, just another way of describing God.