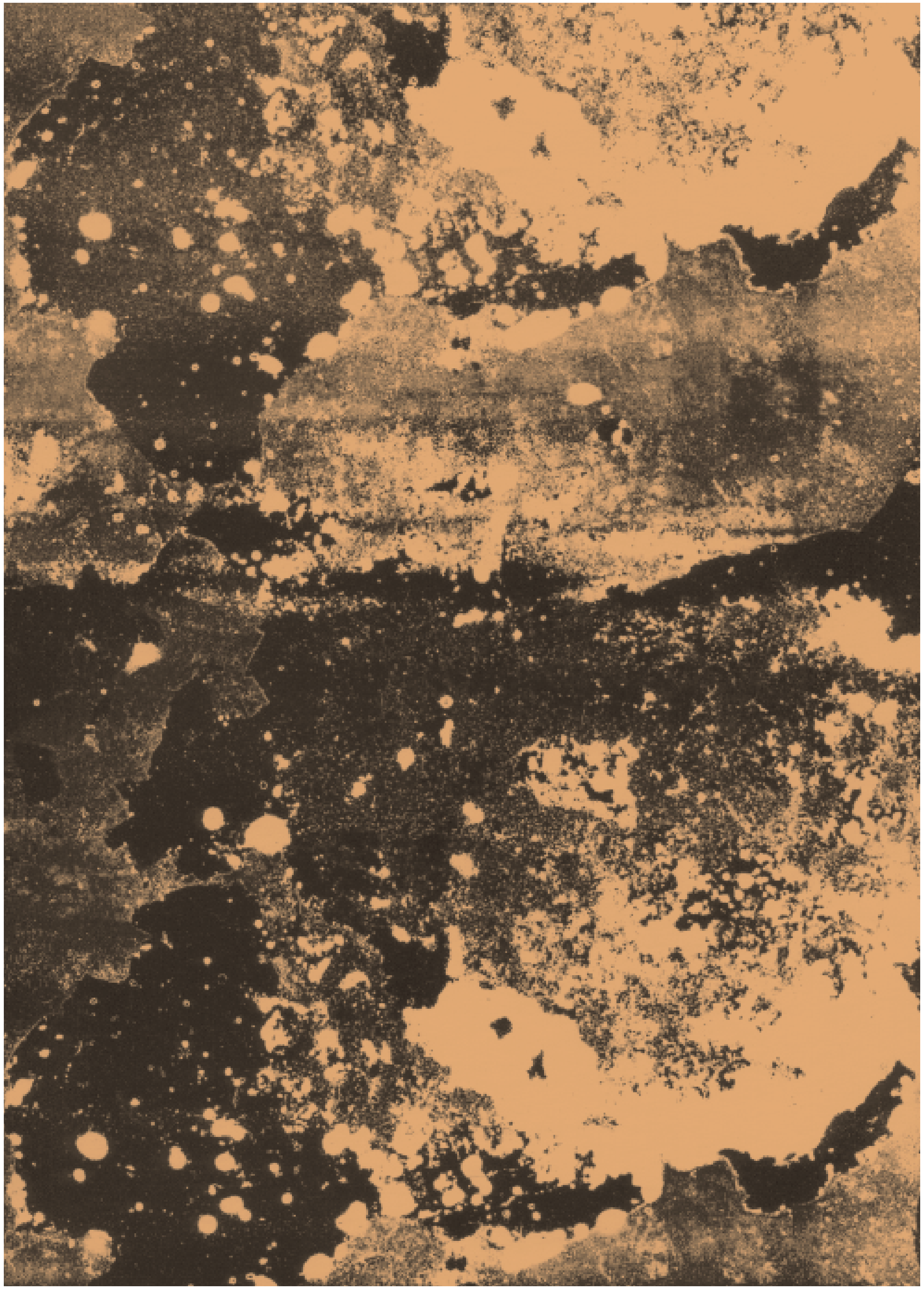

AN ONTOLOGY FOR PHYSICISTS' LABORATORY LIFE

Pablo Jensen

ARE PHYSICS and the AIME project compatible? The answer is not obvious, because physicists are often convinced materialists, while AIME rests on a rebuttal of Alfred North Whitehead's "bifurcation of nature."[1] In other words, physicists frequently argue that only atoms (or more recent "fundamental" particles) exist, the rest being "perceptions" of our mind, while AIME fights that idealism of res extensa and seeks ontological pluralism in things and not in representations (Latour *Inquiry*, ch. 5). In this article, I summarize my experience as a diplomat physicist[2] involved in AIME and propose a metaphysics compatible with both AIME and physicists' practices.

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1. FUNDAMENTALISM

WHAT I WILL CALL physics "fundamentalism" is quite common in the media. For example, *The Economist* celebrates the opening of the Large Hadron Collider in this way: "[p]article physics is … the hidden principle underlying so much else. … The LHC … cost about $10 billion to build. That is still a relatively small amount, though, to pay for knowing how things really work" ("Science's great leap"). Unsurprisingly, it is proclaimed by some particle physicists: "Particle physicists construct accelerators kilometers in circumference and detectors the size of basketball pavilions not ultimately to find the *t* quark or the Higgs boson, but because that is the only way to learn why our everyday world is the way it is" (Cahn 959). The importance of particle physics is justified by a "constructivist" hypothesis: "Given the masses of the quarks and leptons, and nine other closely related quantities, [the current theory of particle interaction] can account, *in principle*, for all the phenomena in our daily lives" (Ibid. 952; emphasis added).

It is worth reading the whole sentence, which ends with "and *in fact*, for all the data obtained from experiments at accelerator laboratories around the world" (Ibid. 952–53). To start elaborating on the ver-

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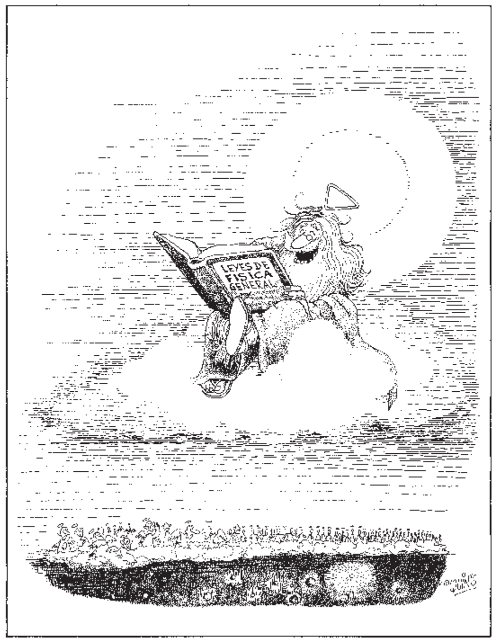
[1] A detailed analysis of Whitehead's arguments, in line with AIME's project, is provided by Didier Debaise's last book *L'appât des possibles*.
[2] A physicist, I should add, "tamed" by philosophers, enough to be interested in the project, but a physicist anyway, to remain interesting for the project. Not representing physicists but somewhat representative of them.

tiginous gap between "fact" and "principle," Nobel laureate Philip Anderson wrote his famous piece "More is different." He showed, using rigorous physics arguments, why we cannot hope to reconstruct the world from the fundamental level. However, somewhat paradoxically for the article that became the antireductionist manifesto,[3] he begins by stating that most active scientists would " … [accept] without question [that t]he workings of our minds and bodies, and of all animate or inanimate matter are assumed to be *controlled by* the same set of fundamental laws … which we feel we know pretty well" (Anderson 393; emphasis added).

In summary, many physicists[4] share the "fundamentalist" vision: The world is *controlled by* a set of fundamental particles and laws. As the official press release of the 2013 Nobel Prize in Physics puts it: "[E]verything, from flowers and people to stars and planets, consists of just a few building blocks: matter particles. These particles are governed by forces mediated by force particles that make sure everything works as it should."



1 Joaquín S. Lavado (Quino) / Caminito S.a.s. Literary Agency. 1991. Quino. *Humano se nace*. Buenos Aires: Ediciones de la Flor, 1991.

2. RELIGIOUS ORIGIN OF THE FUNDAMENTALIST VISION

AS NOTED BY BRUNO LATOUR in *An Inquiry into Modes of Existence* (ch. 6), this fundamentalist vision is a heritage of the seventeenth century religious world view, in which God's "invisible Hand … wields the vast Machine, and directs all its Springs and Motions" (Atterbury 249). Many human cultures have noticed that the material world is rather stable, showing loose regularities (seasons, fall of objects, and so on). They have often included these regularities in their world views, as in classical China where the world is seen as "regulated" by a constant interplay between polarities.[5] The fundamentalist vision extrapolates these terrestrial regularities to reach an ideal, literally supernatural territory, where perfect, mathematical laws systematically connect causes and effects. As historians of science have shown (e.g., Cartwright), the idea of laws controlling the world rests on the belief in an omnipotent, transcendent God held by the European scientists that invented this vision in the seventeenth century. As early as 1630, Descartes extrapolated the isolated regularities found by scientists (e.g., Boyle's law on gases, equality of angles in the reflection of light) to proclaim the universality of "laws of nature" in a letter to his friend Mersenne: "Please do not hesitate to assert and proclaim everywhere that it is God who has laid down these laws in nature just as a king lays down laws in his kingdom" (23). The idea of natural laws governing the behavior of all natural bodies gained widespread acceptance in the late seventeenth century, under the impetus of the Royal Society (Roux).

Today, this idea survives without the Divine Character that made sense of it, which leads to many conceptual problems. First, the metaphor of laws becomes rather strange: Where do these perfect, supernatural laws come from? Who created them? How comes that the world is exactly as scientists hoped it to be? (Midgley) Thinking in terms of "laws" seems legitimate for humans that create and respect them because they have a moral sense or fear punishment, but why would things respect them? Second, the very idea of "control" only makes sense for an *external* agent that exerts it on a system, as a supernatural God could do with His invisible hand.[6] Finally, the concept of a fundamental or ultimate level leads into an infinite regression if there is not an omnipotent God to stop it, as the poet Jorge Luis Borges understood long ago.

[THE GAME OF CHESS]

…

Over the black and white of their path
They foray and deliver armed battle.

¶

They do not know it is the artful hand
Of the player that rules their fate,
They do not know that an adamant rigor
Subdues their free will and their span.

¶

But the player likewise is a prisoner
(The maxim is Omar's) on another board
Of dead-black nights and of white days.
God moves the player and he, the piece.
What god behind God originates the scheme
Of dust and time and dream and agony?

¶

(Borges *Dreamtigers* 59)

3. TOWARDS A NONFUNDAMENTALIST ONTOLOGY

AT THIS POINT, physicists may argue that, whatever the conceptual problems, in practice they are able, in their labs, to bring out reliably some laws. Can we understand this, and more generally, the possibility of making a successful mathematical science without a hidden God controlling the machine? To start imagining a secular metaphysics and avoid fanciful hypothesis, it seems reasonable to start with a careful description of scientists in action.[7]

3.1 IN PRACTICE, MATTER IS CONTROLLED BY OUR MACHINES—The main point is that scientists have to tame a wild world in their labs to ensure reproducibility. A helpful image – suggested by Bruno Latour in unpublished notes – is the taming of a tiger for a circus show. Transforming a tiger jumping freely in the jungle into a tiger jumping reliably through a ring of fire in a circus demands a lot of careful, attentive work. And the trainer should never forget that the tiger often dreams of jumping again freely in the jungle. Scientists carry out a similar transformation of the world to stabilize it by trial and error. This work has been summarized by sociologist of science (and former physicist) Andrew Pickering under the name of "dance of agency." Starting with some idea (say, a particle detector), a scientist actively builds a machine, and then becomes passive while the agency of the world, as recorded by the device, takes over. Switching back to an active role, she then reacts to the machine's performance – which

[3] Anderson's article has been cited more than 800 times by many different fields (e.g., physics, chemistry, history, and psychology).
[4] According to the first results of a survey I'm conducting, roughly 60% of them.
[5] For a fascinating account of the sophisticated classical Chinese world view, see Jullien.

[6] According to Leibniz, the idea of God's transcendence states that He is not in the world as a vital principle animating the living beings, but rather as "an inventor … to his machine …, a prince … to his subjects … and a father … to his children" (266).
[7] For an introduction, see Latour, *Science in Action*.

is usually not what she expects. This dance of agency continues until an autonomous machine is obtained – something that she and others can use as a reliable tool to do things with, to carry on research. This creative work finds stable "islands," stable material and human configurations which can be reproduced in other places, but need constant maintenance to remain stable. The point is that theories and laws grow on these islands – they do not give them to us.

In these empirical investigations, scientists working at different levels of organization (e.g., molecules, atoms, nuclei) appear to deal with the world independently, like in the parable of the blind men trying to figure out the shape of the elephant by touching different parts. Each observation enriches the description of the world and each blind man ends with a different (and real) version of the animal. In addition to this experimental work, theorists make connections between the different versions, an important task as it creates "turntables" which guide subsequent investigations, as exemplified by the periodic table of chemical elements or Navier-Stokes equations for hydrodynamics.

3.2 GETTING RID OF THE FUNDAMENTALIST ONTOLOGY — My scope is to show that we do not need to assume a world "*already* made of 'objective knowledge'" (Latour *Inquiry* 90) to allow for the existence of a highly mathematical science as physics. To this end, AIME opposes the "reference" **[REF]** and "reproduction" **[REP]** modes. However, I find the reproduction mode hard to understand and to distinguish from the "metamorphose" mode **[MET]**. More importantly, **[REP]** is difficult to map empirically, as recognized by Latour: "A leap impossible for human eyes to discern" (Latour *Inquiry* 101), a major drawback for a physicist! Finally, the reproduction mode suffers from problems internal to the AIME project. As noted by Didier Debaise in the AIME workshops,[8] **[REP]** is not accompanied by the corresponding modern institutions and it sometimes flirts with a general ontology (as in "[beings of reproduction] *precede* the human, infinitely" (Latour *Inquiry* 203)), tending towards a general metaphysics, common to all humanity, instead of focusing on modern values as urged by AIME.

Here, playing the role of a diplomat physicist within AIME, I propose a different solution, which sticks to the empirical description of physicists at work offered above and may satisfy them. The world is seen as an active entity, in some respects more similar to a living being than to a machine. Of course, since no one has direct access to the world, world-pictures are not falsifiable, but they can be more or less logically compelling or coherent. They represent a way of connecting our experiences and they make us more sensitive to some aspects of reality while obscuring others, therefore leading us towards different worlds, different political agendas. On this ground, we can examine the differences between the fundamentalist and the active ontologies, on three levels: their conceptual coherence, the feeling of mastery, and the relations of physics with the public.

3.2.1 CONCEPTUAL COHERENCE — Our metaphysics avoids the unverifiable hypothesis put forward by the fundamentalist vision that, before taming, the world is already "made in" mathematical laws, waiting merely to be discovered. Tigers jumping in the jungle are not already tamed "in principle," but it turns out that most of them can be tamed for a while. Our vision extends to the whole world what French philosopher Jean-Paul Sartre pointed out for humans: once we give up the idea of a God predefining essences, it is more coherent to assume that "existence precedes essence." The laws, the properties of the particles, are not the cause of their actions, but their consequences, by which we mean a convenient summary of their (past) actions, always open to modification. In a word, laws describe, they do not prescribe. In addition, the active vision does not claim privilege for any level of organization which would be fundamental. It rather sees every level as constituted, defined by a certain scale of intervention and observation (Bitbol). Theorists' work is interpreted as connecting locally different levels, rather than reducing everything to a fundamental level. There are partial "explanations," that is, partial reductions of large-scale diversity to a set of lower-scale entities, but no control anywhere except by the experimental setup.

3.2.2 MASTERY — The fundamental view gives confidence that the world can be mastered, since it is "already" controlled, by God or some hidden laws. This trust certainly played an important role in making possible the scientific revolution. Today, the fundamental view is still appealing for many (theoretical) physicists, who are driven into this science for "ontological" reasons, to discover what the world is really like, something akin to a religious quest. As mathematician Bertrand Russell puts it: "I wanted certainty in the kind of way in which people want religious faith." Russell wanted to discover a truth independent of human existence, and hated those humanists that only pay attention to our "petty planet and the creeping animalcules that crawl on its surface" ("Reflections" 54). I remember having been thrilled by his book *My Philosophical Development* during my student years, as I was also driven to physics by ontological reasons, which may explain why I ended up working with philosophers. Physicists love elegant equations that seem to "contain" many phenomena of the world. They give them a feeling of mastery over a world united by fundamental equations, with no need for those terrestrial approximations engineers have to deal with.

Instead, the active view gives a feeling of uncontrolled liveliness: If you want the world to behave as a machine, you need to tame it by building one. Strictly speaking then, these "law machines" are the only place where laws exist. This vision makes conceptual room for the enormous (and expensive!) technological network needed to purify, standardize the world, and make it reproducible in the labs. It highlights the connection between science and technology and the creativity of manual work, which is often neglected but was decisive on many occasions as shown by historians (Conner). It also helps in understanding the role played by chance in many discoveries. In sum, this vision gives a more lively account of science in the making, for it feels very different to try to uncover a stability, guaranteed by already existent laws, or to try to tame an often surprising world.

As a diplomat, I seek a way of conciliating the active ontology with physicists' libido for simple explanations, because this desire has proved fruitful, as in the case of Einstein's "miraculous year" of 1905. Pushed by his faith in the conceptual unity of physics, he published three papers that solved major puzzles situated at the intersection of different fields (Renn). Confidence in the predictive power of simple fluid dynamics also helped building climate science (Edwards). In my own experience, this conciliation is not easy, at least for "ontological" physicists, because it may seem less thrilling to build "turntables" than to discover how the world "really" works.

PHYSICS AND THE PUBLIC — Finally, the active ontology commands less prestige (and funding) for "fundamental" physics, since it becomes one approach among many others to understand the world. It also clarifies public debates about the relation of physics with society. In a recent paper that generated many discussions within the physics community, Art Hobson states that "[p]hysicists are still unable to reach consensus on the principles or meaning of science's most fundamental and accurate theory, quantum physics. … This confusion has huge real-life implications … [and] quantum-inspired pseudoscience has become dangerous to science and society" (Hobson 211). He then gives the example of the highly successful "quantum healing," which can alleged-

[8] Most clearly in the workshop held in Porquerolles in April 2014 (available at modesofexistence.org).

ly cure all our ills. Hobson's argument suggests that to fight pseudo-science, we first need to close controversies among scientists and then teach "lay" people what we have agreed upon. I doubt the mere possibility of such a strategy: Scientists are (fortunately) reluctant to shut their mouths on these metaphysical issues, as shown by the immediate replies to Hobson's paper, and lay people would not follow anyway. More to the point, I think that the whole fundamentalist approach and its unacknowledged religious background is quite fragile when pitted against pseudo-science. The idea of a single level of supernatural inspiration controlling the whole world is great food for mysticism. When physicists claim that their theories control everything, they legitimate the idea that quantum mechanics could be relevant for health. Instead, a vision grounded in physicists' practice, acknowledging that there is no scientific link between quantum mechanics and health, would help people seeking advice from doctors rather than from quantum gurus. Relativizing the fundamentalist approach – the idea that the world is governed by hidden laws – is even more important in genetics or economics.

4. BEWARE OF THE TIGER!

THE IDEA OF FUNDAMENTAL LAWS controlling the world has so far survived the elimination of God, as a chicken running with its head off. I suggest here a world-picture that avoids those metaphors (control, fundamental level, and laws) which are of religious origin. We may feel a bit dizzy by this bottomless vision of the world. We may also feel unsure in a world that lacks any transcendent guarantee of stability. But this may actually be a blessing in disguise: ecological crises are the sign of too much trust in our mastery of the world. We'd better become more sensitive to surprises, to consequences exceeding the known causes, the previsions. We thought we could get cheap energy by burning coal, oil, and gas, but, unexpectedly, we end up with global warming. We thought we could master the atom, and we end up with Fukushima. Tigers do jump back into the wild.

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