Philosophical Computation

Reading for the Take Home Final *By David Wick*

From his book, *The Infamous Boundary*:

[. . .] Classical physics described the world revealed by our senses, but a sensible object is made up of atoms, and what worked for the whole need not work for the parts. Macroscopic phenomena should be explained in terms of laws governing microscopic events, not the other way around.[1]

[. . .]

Although agreeing that classical theories are dispensable, most [realists] regard understanding as on a par with prediction. This is a sticking point, for "understanding" is inevitably subjective and history-dependent. It would be impossible to generate agreement among all [realists] as to which features of a model remain in the arena of comprehensibility and which depart from it. Are fractal Brownian paths "understandable"? Is randomness?

The antithetical doctrine to [realism] in physics is not, as a reader exposed to the popular literature might conjecture, "sophisticated mysticism." It is closer to what I call "simple instrumentalism." Most physicists retreat to this [. . .] position when pressed on the realism question. "The role of theory is to predict what we see on the dials of our apparatus," they say, "and if the predictions are accurate, the theory is good. Answering these other questions — about what is 'really going on' — is a meaningless exercise."

[. . .] If the equations work, says Bohr, the theory is beyond criticism. The [realist] rejects this view as absurd. Let me put the counter-argument in the form of a parable:

One day, a group of physicists announced the discovery of the long-awaited "Theory of Everything," the ultimate theory which could predict in advance the outcome of any experiment that could ever be performed. The computations necessary for this feat could be carried out, the physicists argued, by a huge computer, which (they further proposed) might occupy one-third of

[1] Here we verge on the "holism-reductionism" question, [an] axis of contention I touch on below.

the state of Alaska — the glacial ice there being useful to cool its gigantic bank of superconducting superchips. This superproject was going to be very, very expensive, but after an extended campaign, in which the physicists relied on their time-tested argument "If we don't do it, someone else will!" the project was funded and brought to completion.

Finally, the great moment arrived. The dignitaries, shivering in their parkas, had given their speeches and departed, and it was time to demonstrate the power of this ultimate computer. The first to pose a question was the director of the soon-to-be-obsolete Large Hadron Collider in Geneva, who typed in "I have a proton-proton colliding beam experiment with a center-of-mass collision energy of one-times-ten-to-the-twelfth-power electron volts, equipped with a Higgs boson detector, and I measure the flux into a solid angle of 2.73645383746453 sterradians," and in a flash the answer appeared on the monitor: $3.14159260467268 \times 10^5$ cm^{-2} sec^{-1}.

The director admitted that this was correct, to all 14 decimal places. With an ashen face, she turned to go, and the next in line stepped up to ask his question. Another right answer. And so it went; experimental physicists studying everything from cosmic rays to gravitational waves to beach sand asked their question, received their answer, and departed. The theoreticians, it appeared, had finally solved the equation of the universe.

On another day, long after physicists had abandoned doing messy experiments, and the science called "experimental physics" had become an historical curiosity, a philosopher asked the leading theoretical physicist (whose job now consisted of entering data into the machine and making sure that it never ran out of ice),

"How does the program stored in the machine operate?"

"Um . . . well, to tell you the truth, no one really knows," replied the physicist.

"What! How can that be? Did you not program the machine yourselves?"

"Yes . . . with the labor of one thousand physicists, each spending years at the task. But you must understand, the algorithms are complex, esoteric, and far from intuitive . . . even for me. Many of the discoveries we made can only be called fortuitous, and none of us had the time to think out what they really meant."

"But surely you can give me some pictures or analogies to explain how the thing works!" exclaimed the philosopher.

"Um . . . I'm afraid not. Only on the level of 'If you want to predict the value of this particular quantity, perform the following algebraic operations . . .. '," the physicist admitted.

"But that's terrible," said the philosopher. "What have you achieved? Before you built this super-super-computer you had the even greater computer called Nature, which did the same thing, albeit in a slower and less convenient fashion. If you don't understand the workings of the one any better than the other, you have accomplished nothing!"

"No," said the physicist doubtfully, "that can't be right. We programmed it . . . so we must have understood it. At least I think so . . . hmm. Maybe you have a point there. Yes, I think you do . . ."

And with that the physicist ran off to found the discipline of "superphysics," the science of understanding how the program in the super-super-computer really works. And soon he had an enormous grant, a new Research Institute (of which he was made director), and his name on a hundred new papers. And he lived happily ever after.

[. . .]

The [realist] may not object to [simple (holistic) instrumentalism] on first hearing. When Bohr cites "wholeness" as a justification for instrumentalism, the hackles start to rise. But it is the suspicion that for Bohr "wholeness" has become an *explanatory principle* that really causes misgivings.

The primary source of theoretical progress in science has been the search for unification by means of reduction of disparate phenomena to a single set of causes. In physics, this reduction is usually expressed in terms of a few "fundamental forces" and a few "elementary particles." (Unfortunately, "few" currently means three or four in the first case and dozens in the second.) In biology, reductionism traditionally involves explaining the behavior of an organism on the basis of physico-chemical processes. From Maxwell and Darwin to Einstein and Watson/Crick, the search for a reductive treatment has been the source of all great explanatory successes in science.

But occasionally one encounters a tendency to work "from the top down," so to speak, arguing that a higher level of organization or description can provide explanations for events on the lower levels. In everyday speech we use expressions such as "fear starts the adrenaline flowing," implying such an explanation. But endocrinologists hope to reduce this phenomenon to physiology and chemistry, demonstrating that certain signals from the eyes or ears to the brain cause, let us say, an electrical wave to pass through the cerebral cortex, which triggers the release of a brain hormone, and so on. It is uncommon in this century (at least in physiology departments) to deny that this kind of explanation is possible — but it was quite common in the last. In another context, some Marxist political writers seem to regard "history" as a kind of invisible force acting on individuals or groups.

I can understand explanations based on interactions, even if they involve action at a distance. But I cannot understand explanations of atomic phenomena based on a principle akin to nationalism — as if elementary particles simply "know" their citizenship and so act accordingly. Political scientists think it worthwhile to investigate how citizens are persuaded by their government or by popular opinion to go to war or pay their taxes; if it should someday be proven that electrons are conscious, I would still want to know how they get their news.

[. . .] Schrödinger [once] indulged in a bit of mystical speculation, advancing the dubious notion that the biologist's increasing knowledge of the mechanisms of life will one day lead her to conclude "I am God." He reasoned from the contradiction between free will and determinism:

(i) My body functions as a pure mechanism according to the laws of Nature;

(ii) yet I know, by incontrovertible direct experience, that I am directing its motions, of which I foresee the effects. . . ,

(iii) so I am God, QED.