
What does a scientific theory tell us about the world? Do the theoretical entities it employs exist “out there”, or is it only a useful tool to make predictions about the results of experiments? Philosophers and physicists are divided on the attitude towards these “metaphysical” issues. The latter have mostly tended to shrug at these questions, but there were always a few, notably Planck, Einstein, and Schrödinger, and more recently John S. Bell, who stubbornly insisted on posing them. In philosophy, too, the camps have always been divided between positivists and realists; between those who see the purpose of science in supplying a merely empirically adequate story, and those who insist on interpreting science literally. Clearly there are pros and cons to each view: the former stops short of explaining, for example, the recent quests for the Higgs Boson or dark matter; the latter, on the other hand, falls into the obvious trap of scientific change - particles, waves, fields, strings - these were all at some point in the history of science contenders to the throne as the basic building blocks of nature, which means that a strictly literal interpretation of the theories that was committed to them would run into a contradiction.

Bernard d’Espagnat (born 1921), the 2009 Templeton Prize winner, is an accomplished theoretical physicist and a philosopher, who has been striding this dividing line for many years. In his book *On Physics and Philosophy (OPP)* he combines his twofold expertise to argue that features of our best theory for the constitution of matter, namely quantum theory, support a revolutionary view on metaphysics and epistemology. The essence of this view, dubbed “veiled realism”, which d’Espagnat has expressed in two of his earlier books (e.g., *In Search of Reality*, Springer 1983; *Veiled Reality*, Westview 2003), is that the empirical regularities on which our scientific knowledge is based point at an underlying “noumenal” reality, whose structure is completely different from the phenomenal, empirically apparent one.

The book is not without merit. It succeeds in discussing the essential puzzles of quantum theory without relying on any mathematical formalism. It presupposes no previous knowledge of science or philosophy, and is very readable, to the extent that familiarity with its two prequels may be an asset, but is not necessary. And yet, I found its main thesis utterly unconvincing, and in what follows I shall try to spell out my reasons.

Veiled realism is a hybrid between positivism and scientific realism. Its positivist roots are the Kantian distinction between the “noumena” and the “phenomena”, the unobserved (and, according to d’Espagnat, also inaccessible) and the empirically accessible scientific image. Given this distinction, says d’Espagnat, any realist position must acknowledge that a strictly literal interpretation of the ontology is untenable. One is pushed, then to search for a view of reality which penetrates deeper than the phenomenal level but at the same time is not naive, hence flexible enough to allow scientific change.
To support this view, d’Espagnat relies primarily on an assumption about the universality of quantum theory, and on two technical results, germane to that theory, that were conceived in the mid 1930s, elaborated on in the 1960s, and since then have become part and parcel of the foundations of physics. The first is Bell’s theorem, a result proved by the late John S. Bell (1964), motivated by Einstein, Podolosky and Rosen’s famous “paradox” (1935). According to this theorem no local hidden variables theory can reproduce the statistical predictions of quantum theory; the second is d’Espagnat’s own elaboration (1965) on the intrinsic difference between quantum entanglement and lack thereof. These two technical results help to establish the distinction, crucial to d’Espagnat’s view, between the apparent (“phenomenal”) and the veiled (“noumenal”).

Start with Bell’s theorem. The history and the philosophy of this theorem are well known, but those unfamiliar with them can consult OPP’s 3rd chapter. In short, the theorem states that the correlations that exist between the results of two separated quantum experiments cannot be explained with a local hidden variable theory. In other words, these correlations are “nonlocal”, but, and this is the crucial point, they cannot be exploited to, say, send signals faster than light. Empirical reality is thus strictly local - all known interactions in physics are local interactions, and there is no action at a distance - but the quantum correlations point at a “veiled” reality which is completely different and nonlocal.

Another evidence for the difference between the empirically apparent and the ontologically veiled is manifest, according to d’Espagnat, in the distinction between a composite system whose parts are entangled, and a similar system whose parts are separable (in 1965 d’Espagnat coined the terms improper and proper mixtures for such systems, respectively). No experiment that probes the degrees of freedom of the parts alone can distinguish between the two mixtures. In other words, improper and proper mixtures in one’s lab look the same in all the possible experiments that are confined to that lab, notwithstanding the fact that the former is entangled and the latter isn’t. Here, again, the empirical appearance notwithstanding, the “veiled” reality is completely different.

The important point is that in both these cases it is quantum theory itself that prevents us from accessing the underlying reality, hence keeping it “veiled”. Consequently, the universality of quantum theory is an essential assumption in d’Espagnat’s reasoning: in the case of nonlocality, a no-signaling theorem (Ghirardi, Rimini & Weber 1980) prohibits the utilization of the nonlocal correlations for the purpose of sending signals faster than light. In the case of proper vs. improper mixtures it is the structure of the theory that limits the detection of entanglement to specific “witnesses” - operators whose degrees of freedom supersede those of the composed system; any other operator whose degrees of freedom are confined to that system alone will fail to distinguish between the proper and the improper mixtures (this feature of quantum theory was evident already in Schrödinger’s famous paper from 1935, where the term “entanglement” was first coined).

In adhering to the universality of quantum theory d’Espagnat is not alone; many contemporary physicists share this assumption, implicitly and sometimes also explicitly.
And yet it is this assumption that, at least to my mind, makes the entire monumental project of OPP suspect.

My worry is threefold. First, claims about universality in science are dangerous. Not only they signify uncontrolled extrapolation, but they also go against the empiricist tradition which part of d’Espagnat’s project rests on. Take the debate on the unification of quantum theory with gravity as an example. All our experiments show that at least down to the scale of $10^{-13}$ cm, quantum field theory gives extremely accurate predictions and thus presumably describes correctly all non-gravitational interactions. But the relevant scale for quantum gravity is 20 orders of magnitude below that. Who knows what physics one might encounter down there? To declare that quantum theory is universal -- that any theory is universal -- is just a leap of faith, a case of “putting physics upside down” (Rosenfeld 1963) and while many physicists are guilty of such a leap, it does not make this declaration any more compelling.

A second, somewhat related point, is that the only scientific reason to believe in quantum theory comes from the results of experiments, i.e., from the apparent (empirical) reality. Now, at least two alternatives to quantum theory (see, e.g., OPP Chapter 9) share with it the same empirical predictions for all the experiments done so far, and, as such, are equally supported by this apparent reality. One of these, namely Bohmian mechanics (Bohm 1952), is empirically indistinguishable from quantum theory in principle (since in order to distinguish between the two one would require actual infinite precision in one’s experiments). The other, namely, the collapse theory of Ghirardi, Rimini & Weber (1986), is empirically indistinguishable from quantum theory only in practice (since in order to distinguish between the two one would require finite precision in one’s experiments but still beyond our current reach).

Both these alternatives, to repeat, share the same phenomenal reality with quantum theory, but are detrimental to d’Espagnat’s worldview. The latter, namely the collapse theory, is inconsistent with “veiled realism”, and is much more realistic (some may even say naively so). The other theory, Bohmian mechanics, may seem at first blush more friendly to d’Espagnat’s project, as it, too, points at a “veiled”, undetectable, ontology. But with friends like that, who needs enemies: Bohmian mechanics draws almost no attention from working physicists, and is commonly deemed conspiratorial (similar to Lorenz’ pre-relativistic ether theory). Surely d’Espagnat would not like to equate “veiled realism” with a such conspiratorial theory, but then, on what grounds can he distinguish between the two (inaccessible!) veiled realities if they share the same phenomenal evidence?

Finally, and from a more methodological perspective, there is an interesting double bind that exists in the attempts to test the universality of quantum theory. On one hand we would like to confirm this universality, extending the validity of quantum theory from the well-tested microscopic scale to the yet-to-be-tested macroscopic scale; on the other hand, what stands in our way of doing so is exactly this universality, namely, the fact that entanglement persists also in the macroscopic scale and leads to decoherence (OPP Chapter 8), which in turn prevents, or at least makes it difficult, to test quantum theory.
So far I have only questioned the soundness of d'Espagnat's argument from the universality of quantum theory to his worldview of “veiled realism”. But is the argument even valid? d'Espagnat's first venture into the metaphysics of “veiled realism” made it into a front page coverage in the Le Monde in 1979. Yet truth be told, I find the whole idea of a “noumenal” world, a world completely different than the “phenomenal” and at the same time also totally inaccessible, quite suspect.

In philosophy Kant’s metaphysics is a well-known example of such a veil-doctrine. Kant brings us news, not much admittedly, but still some news, of another world, inaccessible to human mind. Coming from a fellow human being, this news is quite surprising; it exemplifies what the Australian philosopher David Stove (1991) called “the Ishmael effect”: if the statement were true, it couldn’t have been made. If only Kant were more than human, credibility could have been given to his claim, yet Kant was but an 18th century philosopher. Alas, a 20th century physicist fares no better in this respect when he tells us that, according to a universal physical theory, there is a veiled reality out there, inaccessible to us.

The uncertainty principle, the nonlocal correlations, and the measurement problem are no doubt three of the greatest puzzles of quantum physics. They have prompted Bernard d’Espagnat to five decades of search for reality, but he has probably not found it yet, even in this book.

References


Amit Hagar
HPS Department
Indiana University, Bloomington
hagara@indiana.edu