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Instrument and Noumenon: Experimental Science and the Mysticism of the Instrument

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Introduction: Philosophy of Science after Kuhn

1962 WITNESSED the publication of what is without doubt one of the most influential philosophical works of the 20th century, Thomas Kuhn's *The Structure of Scientific Revolutions* (*SSR*).[1] This book was to have a lasting effect on the philosophical culture of the late 20th century, helping to give rise to the emergence of a more widely sociologized world where every intellectual activity was deemed "paradigmatic" and all forms of conceptuality "professionalised."[2] However, today, the significance of this

[1] Kuhn, *Structure,* 1972.

[2] This research programme was also often referred to as the *Strong Programme* in the *Sociology of Scientific Knowledge (SSK)*. It was through *SSK* that the key philosophical terms of art of Kuhn's *oeuvre*–"paradigm shift", scientific inquiry as "puzzle-solving," radical theoretical discovery as "gestalt switch" between paradigms, the history of science as dislocated by "scientific revolutions" and so on–became the lexicon for a new sociology-inspired discourse in the philosophy of science and a set of general intellectual tools deployed for unmasking science as a professional form of life, "created and developed at particular moments in history in particular cultures." Harding, *Science Question,* 200. Kuhn we might say was a prime instigator of the intellectual "revolt against science" that had such a profound effect on the intellectual life of the western academy in the latter part of the 20th century.

book now requires significant reconsideration. For although, as it has often been pointed out, *SSR's* main thesis challenged, and ultimately overturned, the philosophical hegemony of the neo-rationalist philosophies of science advocated by Karl Popper and his followers, a more significant, but often less recognised, aspect of the intellectual legacy of this book has been the contribution that it was to make to a new and "radical" research programme in the Social Sciences, the so-called "Science Studies movement" that attempted to "unmask" scientific knowledge as a social and cultural "construction."[3] Moreover, this research programme, in many ways, was to set the intellectual agenda in Anglo-Saxon Philosophy and Social Theory for over thirty years (and only recently "turned degenerative," to borrow a term from Imre Lakatos, in the wake of so-called *Sokal affair*).[4] More specifically, after *SSR,* it became something of a new intellectual orthodoxy to view modern science as not, in essence, a broad body of theoretical knowledge with justifiable epistemological claims with respect to the "nature of nature", but merely a programmatic mode of "puzzle solving" constrained by a set of specific socio-historical paradigmatic "background conditions." It is the latter, according to Kuhn's followers, that provided the professional scientist with a deep "structure of relevance" conditioning all levels of scientific practice: from attention, to expectation, to perception and ultimately to the moment of theorisation itself. Importantly, very often this idea gave succour to attempts by more radical Kuhnians to politicise scientific inquiry, typically by showing how experimental science's socio-historical background establishes a relationship between wealth, efficiency and scientific truth.[5]

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[3] For classic examples of research in this tradition, see Bloor, *Knowledge and Social Imagery,* Latour and Woolgar, *Laboratory Life,* Collins, *Changing Order.*

[4] The *Sokal Affair*–an academic scandal brought about by a Belgian physicist submitting a hoax article to a broadly post-structuralist journal, *Social Text.* Sokal, a man of impeccable leftist political credentials, tried to shame leading science studies researchers into accepting that they had simply "got science wrong" and this was due to their inability to fully understand what scientists "actually do." Sokal's aim was to use the "success" of his hoax to defend an essentially rationalist conception of scientific knowledge (that was then coming under increasing pressure from the so-called post-modern turn, especially in its "deconstructive" mode). The significance of this affair, in my view, was not that it demonstrated the truth of more orthodox philosophical positions vis-à-vis science, but that it brought out Kuhnism's "philosophical dirty washing" for all to see.

[5] Lyotard, *Postmodern Condition*, 45

In this paper, I will explore the limitations of this approach–what has sometimes been referred to as "the Kuhnification of science"[6]–in a spirit of "intellectual adventure" and show how, in its "understandable" desire to sociologize and historicize science, the question of the deeper metaphysical significance of scientific research, especially the question of how the theoretical "products" of experimental science have provided a historical basis for a particular–perhaps even definitively modern, *epistemic*–conception of worldhood was lost.[7] Against Kuhn's communitarian and professionalised conception of science, I will propose an alternative thoroughgoing *technological* conception via a speculative exploration of the philosophical significance of the "mediating" role that instrumentation plays in experimental practices–suggesting that scientific instrumentation should be understood *onto-epistemically,* as an "epistemic opening" that mediates the paradigmatic aims of experimental scientists with modern science's most significant metaphysical realm, "the unknown."[8] For this

[6] See Fuller, *Kuhn,* 36, 317-18, 336-37.

[7] The neglect of the phenomenology of scientific forms of worldhood in Kuhnian approaches to science has allowed Kuhnians to draw a highly counter-intuitive conclusion: that scientists engaging in normal science do not strictly *discover, uncover or disclose* anything at all, but merely routinely apply paradigmatic webs of concepts and techniques to experimentally-induced "novelties" in order to solve paradigmatically sanctioned "puzzles." Thus for most Kuhnians, and for Kuhn himself, experiments typically have very little epistemological significance in themselves, as they are viewed as mere means for, what Kuhn termed, "elaborating the paradigm" by increasing its "accuracy and its scope." Kuhn, *Structure*, 25. In this respect, Kuhn and his Kuhnian sociological apologists are very much in accord with the positivists. For in orthodox positivist accounts of science, the instrumental background was seen as only consisting of a complex set of means to achieve greater precision in the measurement of experimental "findings" (I come back to a discussion of the phenomenological significance of the seeking-finding dimension of experimentation later in the paper, as it suggests a useful starting point for a quasi-theological philosophical of science). At times however, Kuhn does seem to recognise that experimentation has an explicit epistemological significance; for example, when he recognises that the demand for experimentation emerges out of the scientist's difficulties "in developing points of contact between theory and nature." Kuhn, *Structure*, 30. This might suggest, in the way of Marx and Marxism, that "Kuhn was not a really Kuhnian."

[8] The ontological status of this realm is perhaps, overall, modernity's most vexed philosophical issue and in order to solve it we will almost certainly need to resurrect mediaeval conceptions of the idea of "degrees of existence." Clearly, as things are "discovered" in this realm it cannot be viewed as "inexistent"–it is not "a void." However, it cannot possess "as much existence" as "manifestly known realms", as, ontologically, it stands in a dependent relationship to them. We might say, that analogically, that "the unknown" possesses a similar but less significant (lower) mode of existence to that presupposed by more everyday ways of knowing. One of the key issues here is how to understand how a 'lower' form of worldhood is

reason, I claim, we need to view science as presupposing a metaphysics rather than a sociology, and one that brings out a rather different image of modern scientific practice–science as a "mysticism of the instrument" (and in this way, I indicate how this points us towards a more telling philosophical conception of science "as quasi-theology").[9] In order to begin this revisionary work, I will be drawing upon on Martin Heidegger's and Gaston Bachelard's phenomenologies of science, claiming that, in tandem, their philosophical ruminations allow us to make much better philosophical sense modern science's most profound, and in historical terms extraordinary, claim: that experimental science takes human thought and perception into an unknown world, a world where empirical "discoveries," eventually theorised in science as "nature," are revealed by "unnatural" technological means (leaving the question of the relationship between nature and being, as well as that between scientific naturalism and technology, again, in historical terms, entirely "up for grabs").

The Philosophical Significance of the "Technological Background"

As Merleau-Ponty observed, in order to understand the wider metaphysical significance of the invisible "microworlds" postulated by the experimental sciences–a world of hidden fields, particles and forces–one cannot simply conceive of such worlds as comprised of very small objects (that, if only we were small enough, would be directly perceivable). As a result, the philosopher of today is forced to understand how the (technological) practices of the experimental scientist are reconfiguring the relationship between the visible and invisible (something that he claims, in turn, demands "a revision of our

capable of correcting the errors and limitations of a higher form. Would this "power to correct" not imply a radical ontological "levelling out"? The democratic metaphysics of science here cuts against the epistemological demand for a metaphysical hierarchy. Clearly, the only way out of this dilemma is to accept that "correction from below" does not undermine hierarchy but rather *perfects it*.

[9] The need for an ontological conception of scientific equipment, a conception that, to put the matter bluntly, starts from the assumption that scientific instruments are not tools and that scientific instrumentation, and thus measurement, involves a very different relation between mind and world to that involved in ordinary mundane forms of tool use.

ontology...a re-examination of the notions of subject and object").[10] Instrumentation, as Merleau-Ponty recognises, is clearly key making the "invisible visible" here, showing the extent to which scientific instrumentation, like philosophical reflection, takes us beyond naive forms of perceptual faith into a world where meaningful concepts are no longer, essentially, constrained by actual or possible sense experience (for example, in the context of contemporary scientific research, "bosons" are abstract entities that stand only in "very loose" relation to the ontologies of the perceptual world).[11]

For this reason, instrumentation can be seen as facilitating a form of technologically-assisted observation, "a way of seeing"–that translates into an entire new way of knowing–that is only related to "ordinary forms of seeing" by way of "family resemblance."[12] Instrumentation, we might say, takes the perception of the experimental scientist (and ultimately his/her conceptuality as well) into an "other world" whose ontology is entirely unfamiliar from the "ordinary third person" phenomenological point of view.[13] In this regard, importantly, when instrumentation is conceived, not a set of paradigm-strengthening procedures, but as an onto-epistemic relation between visible and invisible realms, Kuhn-inspired conceptions of experimental science can be seen to have offered too shallow a phenomenology of scientific practice, as they have overlooked a more basic and fundamental aspect of modern science–the phenomenological power of what might be termed modern science's "technological background": the "mediating milieu" that not only shapes the comportment of the experimental scientist's practice but also provides an "opening" that makes possible the general modes microworld exploration that continue to be one of modern science's defining ontological characteristics.

In fact, at the beginning of the twenty-first century, this technological background now "type identifies" experimental science as an epistemological

[10] Merleau-Ponty, *Visible and Invisible*, 22.

[11] Science is primarily a *visual* as opposed to a professional puzzle-solving culture. However, the practice of science is a practice of "looking beyond" the extant visual, augmented by the phenomenological powers of scientific instrumentation. This is a form of seeing where, as many philosophers of science have observed, the distinction between theory and observation collapses.

[12] See Shapere, "The Concept of Observation."

[13] See McMullin, "Enlarging the World," 101.

form of life. More precisely, there is currently what can only be conceived as an "internal relation" between science and technology, in that each seems to presuppose the other in epistemological and metaphysical terms. Science cannot proceed without significant "technological support" and technology cannot be maintained and developed without scientific knowledge. Overall, science and technology, we now see, form a unity; not only as an institutionalised "technoscience," but also at the more micro-levels of specific experimental practices. As Wittgenstein observed, the use of instruments is now part of the "characteristic physiogamy of science", to the extent that, as he puts it, "[i]f I see somebody in a laboratory pouring liquid into a test tube and heating it over a Bunsen burner, I am inclined to say that he is making an experiment."[14] Consider also, here, the wider philosophical significance of the following description of the technological background from a popular book on experimental physics (interestingly, from a theological point of view, titled *The Second Creation*).[15]

> Twenty feet from where we stood, a dozen men surrounded a metal object that resembled a giant wedding band, silver in colour and fifty feet in diameter. The men wore hardhats and gloves and heavy boots; some had toolkits in their belts….Inside the shiny band at their feet was a spool of high precision cable lent by a laboratory in Japan and wound to a tolerance of thousands of an inch…Perhaps fifty feet away stood its destination – a metal shed. Inside its featureless grey walls, scores of physicists had spent almost ten years and millions of dollars in government funds to penetrate deeper into the heart of matter than human kind had ever been before.[16]

The question here is what such (typical, and in my view, broadly accurate) accounts reveal in philosophical terms. It is not immediately clear what philosophical conception of science that they imply. However, what is immediately apparent is that they clearly imply much more than the Kuhnian

[14] Wittgenstein, *Remarks*, 379.

[15] One of the most significant features of *SSR*–and much of Kuhnian philosophy too– is its rejection of the accounts of the history of science found in popular science and scientific textbooks. For most Kuhnians, populist and textbook accounts of the history science generally offer an overly 'Whiggish' narrative of scientific progress that overlooks radical "epistemological breaks" in the history of science and the essential "incommensurability" of scientific paradigms. However, popular scientific texts can bring out important and philosophically salient aspects of science that remain tacit in scientific "self-conceptions."

[16]Crease and Mann, *Second Creation*, 1.

image of the scientist as "puzzle-solver." I suggest that the model of science implicit in such accounts is essentially a Baconian one, in that they manifestly privilege the instrumental over and above the social aspects of scientific practice.[17] As is now well-known, the purpose of scientific instrumentation, for

[17] However, many notable Kuhnians have argued that any attempt to revive the "old Baconian" idea of science–that claims that science is epistemological only to the extent that it is both instrumental and experimental–will fail as they will not take account of the under-determination of theory by evidence and the complex relationships that necessarily exists between empirical fact and social value. Seen thus, a Baconian conception, in practical experimental terms, can only leads to what certain Kuhnians have termed the problem of "the experimenter's regress." See Collins, "Relativist Programme," 80. This problem emerges from the (Kuhnian) assumption that scientific inquiry is essentially hermeneutic in nature. In Kuhnian accounts, scientific theory cannot be seen as founded upon instrumentally disclosed forms of observation, because what counts as an "experimental observation" itself is understood to be always and everywhere determined by a wider paradigmatic social context. The way out of this regress, according Kuhnians, is to appeal to a wider set of community norms capable of supporting and/or sanctioning theoretical claims on the basis of "observational evidence." Thus according to the Kuhnian historian of science Steven Shapin, stating that experimental results "fit" or "confirm" a theory can only be done when the idea of "adequate fit is characterised through its instantiation by a relevant community of reasonable people." Shapin, *Social History*, 310. For Shapin, experiments are, in reality, largely instrumental exercises in the *skilled* use of equipment and are typically devised simply in to increase the *precision* of specific experimental effects; effects that, ultimately, only serve as "rhetoric" supporting wider theoretical claims and assertions. Here, instruments cannot be viewed onto-epistemologically, for three basic reasons: firstly because they are prone to mechanical error; secondly because their outputs always require interpretation and finally because they are in need skilled technicians in order to calibrate them (that is, to subject them to a paradigmatic evaluation). However, much of this analysis begs the question of onto-epistemological significance of instrumentation and remains stuck in a closed sociological universe. Even a cursory examination of the historical record of experimental science shows that scientists do not typically use instruments to enhance the precision of "experimental performances" but rather "occupy"–inhabit–an environment that is always and everywhere technological in a way that radically alters their "natural" phenomenological horizons. Kuhn himself seems to have recognised this when he claims that instrumentation–what he terms "the apparatus"–is more centrally significant to science and possesses a more significant status than orthodox philosophy of science has hitherto been prepared to recognize. More specifically, when he acknowledges that "the existence of the paradigm sets the problem to be solved; often the paradigm theory is implicated directly in the design of the apparatus to solve the problem." Kuhn, *Structure*, 27. Seen thus, scientific instruments are not really devices or instruments at all, but rather a set of ontological functions that take specific theoretical arguments; a quasi-epistemological context in themselves that constitutes the observational world of the scientist in theoretically salient ways (and it was Bachelard–see below–who famously claimed that instruments are "materialised theories"). Moreover, interestingly, some Kuhnian scholars accept that instrumentation is central to any adequate understanding of science–but for them this simply reinforces the socially constructed nature of scientific knowledge because all that can be said about the philosophical significance of instrumentation is that it "co-ordinates' a "weaving together" of "observation, theory

Bacon, was to excavate a hidden truth and then to transform that truth into a readily usable form. Thus he writes "[i]f it then be true that Democritus said, that 'the truth of nature lieth in certain deep mines and hidden caves', and if it be true likewise that the Alchemists do so much to inculcate, that Vulcan is a second nature... it were good to divide natural philosophy into the mine and the furnace."[18] The metaphor of experimentation as "mining and smelting" is clearly more consonant with mundane ethnographical accounts of science like the one above. More specifically, such mundane ethnographies show, à la Bacon, that modern scientists deploy an array of specialized devices in order to pursue a mode of reality not only constructively but also, and more importantly, in radically exploratory manner–by technologically inducing phenomena in a way that allows the scientist to "excavate" the forces and tendencies "hidden" within them.[19] The particular forensics involved here are highly esoteric from the perspective of non-scientists (and, we might say that from this vantage point such accounts suggest that scientific experiments are exercises in "controlled magic", in that they are grounded in what can only appear as an "occult skill" deployed in highly specialized ways in order to produce very particular epistemological effects).[20] Moreover, such mundane accounts are also

formation and material manipulation." Herrnstein Smith, *Belief and Resistance,* 136. Of course, the idea of co-ordination here is highly "metaphysically loaded" and, as such, it is an idea that simply cannot be given an adequate philosophical treatment in Kuhnian accounts.

[18] Bacon, *New Organon,* 172.

[19] As is well known, Bacon aimed to produce a new and better method of reasoning about natural phenomena–reasoning by "induction" of phenomena by instrumental by means; a change that he believed would require the total reconstruction of sciences, arts and all human knowledge upon proper foundations (he referred to this change as "the great instauration"). When viewed in Baconian terms, the technological background has both a theoretical as well as a practical aspect: a theoretical aspect resulting from an "inquisition of causes" and a practical or operative part resulting from the "production of effects." Thus for Bacon, philosophical reflection on the technological background collapses the Aristotelian distinction between theoretical and practical forms of reasoning.

[20] Thus unlike Galileo, Bacon did not attempt to found scientific knowledge on the *a priori* certainties of mathematics, as for him mathematics must always remain subordinate to artifice. Experimental science for Bacon is thus better conceived as a branch of the mechanical arts. As he puts it "[n]either the naked hand nor the intellect left to itself can effect much. It is by instruments and helps that work is accomplished, which are as much needed by the intellect as by the hand. And as the instruments either impel or guide its motion, so the instruments of the mind either encourage or admonish the intellect." Bacon, *New Organon*, 321. Importantly in this context, Bacon thought of the practices and techniques

philosophically important because they show the extent to which the technological background is a "de-worlding" phenomenon, the basis for a mode of practice that calls the basic structures of the lifeworld into question[21]–and also because they allow the philosopher of science to begin from the "correct starting point"; science's most mysterious philosophical secret: the visual output of instruments, hidden within the closed space of the laboratory, that somehow opens up the very possibility of scientific thought.[22]

Overall, therefore, once we take the intelligent step back from experimental science, the technological background can be understood as proving a "focal opening" through which the sensibility and conceptuality of the scientist are brought into contact with a general epistemological otherness; one that provides the novel phenomenological events and experiences that enter into extant scientific worlds as disruptions to existing schemes and, ultimately, as material for the theoretical reflection and innovation. In facilitating this combination of the perceptually immanent and theoretically transcendent, the technological background, in effect, functions as an epistemological prosthesis that enhances the experimental scientist's ability to "penetrate phenomena" at the level of both perception and cognition.[23] Given their typical immersion within instrumentation, experimental scientists are, in a sense, "epistemologically augmented" individuals–and in a very particular way: empowered to discern the

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of the craftsman as experiments. In this way, the history of science is first and foremost a history of its instrumentation–a key an important counter-Kuhnian insight.

[21] Think of the simple Geiger counter, a device that does not just count but "amplifies" certain signals from an unknown beyond, thereby revealing certain "radioactive" dimensions of the world. And one can also see such forms of world-disclosure at work in the Boyle's air pump (a device often used by Kuhnians to demonstrate the fundamentally social nature of scientific instrumentation). Even Shapin recognises that one of the functions of this device is that it might make manifest the invisible and normally insensible effects of the air.

[22] In this way, science is fundamentally concerned with knowing via a technologically mediated form of seeing: a kind of "abstract seeing" that allows the scientist to "world the world theoretically." The separation of seeing and knowing in classical empiricism–where the former is viewed as the foundation for the latter–remains the central confusion obstructing a perspicuous and judicious philosophical account of modern science. Seeing is the epiphenomenon of science, it is the phenomenological product of a prior technological mode of mediation between the known world and what lies, epistemically, beyond it. Nevertheless, without this seeing, we would never have any grounds for saying anything about scientific worlds at all.

[23] See Clark and Chalmers, "Extended Mind", 7-19.

"nature" residing within phenomena as well as that residing beyond historically given phenomenological horizons, dimensions that reside beyond our "natural"–that is "unassisted"–sensory apparatus.[24]

However, how are we to convert these intuitions (derived from popular accounts of experimentation) into what Wilfred Sellars termed an adequate "philosophical theory of the instrument"; a theory that can account for "a detection of the theoretical state by virtue of a connection of that state with processes…which can be registered in the instrument?"[25] In order to work towards the development of such a theory, I suggest that we need to turn to the two great philosopher-theorists of the instrument of the 20th century–Heidegger and Bachelard. For here we can see attempts to understand the nature and significance of modern science in terms of a sophisticated phenomenology of instrumentation, one that, like all good contemporary philosophical reflections regarding the nature and significance of science, eventually takes us back to the metaphysics of Kant.

Heidegger on Experimentation, Instrumentation and the Phenomenology of Scientific Worlds

Heidegger is rightly famed for his analyses of the ontological significance of modern technology, especially in *The Question Concerning Technology,* where he reveals modern technology's secret relationship to history and to Being–an analysis where technology is shown, as a metaphysics that he believes is the *sine*

[24] See Gruender, "Instrumentally Aided Perception." Don Ihde has termed this kind of realism, "instrumental realism." See Ihde, *Technology*. Recognition of the instrumentally conditioned nature of scientific reality has led many philosophers, most famously Ian Hacking, to claim that scientists do not strictly "see" with/through their instruments because scientific phenomena do "not exist outside of a certain apparatus." Hacking *Representing*, 226. And in Hacking's view, once they are viewed as instrumentally conditioned interventions "beyond the appearances,", experiments must be seen as *productive of* scientific reality–yet are also realist, to the extent that these created phenomena are real. However, what do scientists do with their instruments if they don't see with/though them? Clearly, such activities involve a form of seeing, although it is rather different in both form and content to what we ordinarily mean by that term.

[25] Sellars, "Theoretical Explanation,"151.

qua non of both the modern and the "destiny of the West", to be neither "a thing" nor "a means", but rather an "ontological process" through which things are "brought forth" into an "open" and revealed to us as entities with an actual or potential utility.[26] This conception of technology has important implications for how philosophers conceive of science–as the later Heidegger in particular recognised–as it suggests that the domain of entities postulated by theoretical science is itself the most important "ontic" product of a prior technological disclosure of existence as a whole. However, when it comes to exploring the science-technology relationship, in many ways, Heidegger's philosophical reflections on science in Division II of *Being and Time* are equally significant in this regard, and are emblematic of one of the dominant motifs running throughout both his early and later thinking: that science is no longer a stand alone, *sui generis*, mode of intellectual inquiry but is now simply one important species of technics, albeit now rendered metaphysical (and thus absolutized) in the context of modernity.[27]

There is no attempt to relativize science in Heidegger's philosophy (or to reduce it to the level of a mere construct). Heidegger makes this point well when he writes that "science is one way, indeed one decisive way, in which all that is presents itself to us."[28] Science is accordingly the real of the modern for Heidegger, and to be confronted with it requires in the end a philosophical decision that is simultaneously ontological and political. As such, Heidegger's philosophy of science can be very usefully deployed in order to illuminate the

[26] See Hood, "Conceptions of Technology," 347-348. One of the key problems facing contemporary philosophy of science is how to distinguish between the different senses of a variety of instrumental terms, terms that are often used interchangeably in contemporary philosophical discussions. More specifically, terms such as "tool", "device", "instrument", "equipment" and "technology" have subtly different senses, the disambiguation of which would seem to be an important primary analytical task for the contemporary philosopher of science, especially when attempting to delineate the philosophical significance of technological mediation.

[27] For the later Heidegger, modern technology and theoretical science form a historic unity; they are, we might say "looped together" because not only does modern technology demand the employment of mathematical physical science as an accompanying and supporting set of discourses, but also because science itself requires the application of specific technologies in order to legitimate its claim for a universal *mathesis*. In other words, modern technology worlds the world as mathematical, but then this provides specific facticities that can then be used in the further development of modern technology.

[28] Heidegger, "Science and Reflection," 176.

philosophical significance of scientific instrumentation that is in question here (and he can with some justification, I think, be viewed as a philosophical innovator in this area of inquiry). For Heidegger, the technological background of experimental science reveals a world that is essentially "real" but, as "mathematical," in no sense "primordially true." In fact, Heidegger views this mathematical world as the consequence of a prior "entrapping of the real" in instrumentation and in his view it therefore comes closest to what scientists today term "nature" (a system of causes understood mathematically). As Heidegger puts it:

> Science sets upon the real. It orders it into place that at any given time the real will exhibit itself as an interacting network .i.e. a surveyable series of related causes. The real becomes surveyable and capable of being followed out in its sequences. The real becomes secured in its objectness. From this there results spheres or areas of objects that scientific observation can entrap after its fashion. *Entrapping representation*, which secures everything in that objectness that is capable of being followed out, is the fundamental characteristic in representing through which modern science corresponds to the real.[29]

For Heidegger experimental science secures "its object domains" by "setting upon" the real, "entrapping" it in representation. It is through this "setting upon and entrapping" that science's theoretical objects (so entrapped) are "shown" to reside within a wider "network of causes." But what does Heidegger mean by "the real" here? Heidegger does not answer this question in any adequate way, but what is clear is that for him this "setting upon and entrapping" has its basis in scientific instrumentation (an idea that was later to be generalised as a general philosophical theory of technology as *das Gestell*) and that this entrapping is always a "capturing" (although what it is, precisely, that is captured in instruments is never fully spelled out). In Heidegger's view, this demonstrates that however "'uninteresting" and "obvious" the instrumental dimensions of scientific research may be, "they are by no means a matter of indifference ontologically."[30] But what is the ontological significance of instrumentation (our question has simply been pushed one step further back)? Heidegger's thinking here is more suggestive than conclusive. In his view, the use of scientific instrumentation facilitates what he terms a "change over": from the concerned

[29] Heidegger, "Science and Reflection," 167; my emphasis.

[30] Heidegger, *Being and Time*, 409.

absorption of the ordinary tool user to the characteristic theoretical attitudes concerned with discovering, detecting, decoding and, ultimately, discovering "hidden natures." In his view, this change over is made possible by instrumentation phenomenologically "freeing entities for their being"–"releasing them from their confinement" (in what might be termed "tradition") and ultimately securing them as new kinds of objects in a way that it makes them candidates for "scientific knowledge."[31] Instrumentation, we might say, opens up the possibility for beings to exist in a radically different way and for human inquiry to take a radically different form–demonstrating that scientific knowledge is always more than a "fabrication of man."[32] Reading between the lines, we can say that the overall significance of Heidegger's account of science is that it demonstrates that experimental science is a process that facilitates an encounter with something radically *other* to our ordinary ways of being in the world and it is by such means that that the experimental scientist opens up a world as a basis for a new kind of theoretical understanding.[33] Instrumentation, it seems, provides the experimental scientist with a unique sense of "*da"* (a technological "abstract experience" of "thereness" and "newness"), an opening that is the key ontological pre-supposition of the experimental scientist's specific paradigmatic projects and something that guarantees that all scientific knowledge claims will always be tinged with a sense of skepticism (as this space, in itself, is essentially one where the certitude of the concrete is essentially lacking). But this simply pushes the question we are addressing further back still–for what is the ontological status of this *"da"*? Some Heideggerean scholars have claimed that it is an opening to "things in themselves."[34] Such claims, although insightful, are of course too strong (for why should instrumentation allow for an opening to an absolute, and not an opening that is more "instrumental" in nature). What is perhaps more sustainable, is to view the epistemic spaces

[31] Heidegger, *Being and Time*, 413. Interestingly, Heidegger also claims that this change over presupposes a particular kind of transcendence, a transcendence where *Dasein* rather than being absorbed and involved in entities, stands over and against them as a "researcher."

[32] Heidegger, "Science and Reflection,"156. However, this clearly isn't discovery in any "ontic" sense, but an ontological mode of discovery (such that it is by no means clear in Heidegger's phenomenology of science where the real ends and the ontological begins).

[33] Glazebrook, *Philosophy of Science,* 109.

[34] See Dreyfus and Spinosa, "Things-in-Themselves."

opened by instrumentation as the result of a change-over from an concerned practical absorption in the known world to a detached contemplative engagement with a another phenomenology that appears from a world beyond the known world; a change over from a worldly (secular) attitude to one that we might usefully view as essentially "religious" in nature.

In this way, Heidegger's reflections succeed in taking us towards the metaphysics of epistemology of perhaps the key thinker in this context–Kant. More specifically, they suggest that scientific instrumentation is an opening out onto what Kant referred to as "the noumenon"–the space that he believed to be the absolutely unknowable, but that contemporary technoscience has, since, in some sense, shown to be fundamentally accessible, explorable and, at least ideally, in some form *conceivable* (if not knowable in the ordinary sense of the term). This claim is the basis of Bachelard's philosophical project, and it is to his ideas that we now turn.

Bachelard and Experimental Science as Noumenal Exploration

As is well known, for Kant, noumena are things residing beyond actual possible sense experience, and although are they radically unknowable they are capable of being "cogitated" by the understanding alone, to the extent that they function as a certain "limit concept" to the realm of legitimate knowledge. However by restricting the nature of our access to the noumenal realm Kant was merely highlighting the inaccessibility of this domain given the state technological development at the time (especially with respect to instrumental capacities of the experimental sciences). As has been well documented, post-Kantian science has undermined any attempt at a Kantian setting of cognitive limits and boundaries to thought and perception (and Kuhnian historicism can be seen as a failed attempt to retain an idealist ordering of science, by shifting the focus of philosophical attention from Kant to Hegel). Kant, we might say, could not foresee the enormous techno-theoretical advances made by contemporary science–especially in theoretical physics–in the twentieth century and so he failed to understand the historicity of the distinction between phenomena and noumena. Thus, importantly, recognition of the philosophical significance of

these developments forces us acknowledge the possibility of a more positive conception of the Kantian noumenon. As science became less speculative and more "instrumentally interventionist" in the twentieth century the noumenon began to emerge in new theoretically salient ways problematizing Kantian schemes in ways that questioned Kant's founding skepticism (this idea is also central to Wilfred Sellars' influential metaphysics of science).[35] As the limits of the known became increasingly blurred in new scientific methodologies now rendered increasingly dynamic and powerful by modern technics, "the currently known" became reconceived as part of a more expansive "unknown."[36] In the 20th century, the "noumenality" of the experimental scientist thus emerged, historically, out of a recognition that the cognitive structures of the *lebenswelt* can be enhanced in ways that take thought beyond them.[37] In this way, the basic noumenality of contemporary science was, more generally, derived from a sense of a basic "modern dissatisfaction with traditional ways of knowing"–with the world as it is "epistemically given"–and so in order to address these epistemic problems science began the process of setting up an alternative "instrumentally worlded world" in order to bring about new perceptions and cognitions that, through a radical ontological innovation, began the process of constructing an alternative epistemology, one based on a much more expansive conception of perception and on one deemed to be more satisfying in modern contexts where tradition seemed to be losing its epistemic traction.[38]

The question of the relationship between experimental scientist and the noumenon was central to the work of Gaston Bachelard. Bachelard recognized that in order to make sense of the experimenter's "instrumental investment" in phenomena, requires that the philosopher take the metaphysical problem of science more seriously that hitherto (and not to sociologize science away, as it is

[35] Sellars, "Scientific Image."

[36] Oizerman, "Kant's Doctrine," 337.

[37] Clearly, this shows the extent to which the "quasi-ethical" orientation of the scientist is a counter-ethics where "ordinary life is never enough"–life, here, needs knowledge in order to thrive and that the "world of life"–the world of our common life together–needs to be augmented by theoretical insights delivered from the exploration of other worlds.

[38] Thus, today, the sense of "the noumenal," needs to be modified in such a way that it is no longer that which is fundamentally and transcendentally real but unknowable, but as an expansive and unknown whole; the world itself conceived as "unknown."

in most Kuhnian accounts). More specifically, for Bachelard, philosophers of science should refuse a "theory of knowledge" in favor a more nuanced phenomenological account that recognizes that within the experimental sciences there is a profound entanglement of technique and theorization. According to Bachelard there is a profound "doubling" and "looping" here, as for him science both "produces" its theoretical objects through its instruments as well as its instruments through its theories.[39] However, Bachelard understands this entanglement in Kantian terms, in terms of a general *noumenology of technics*–as for him the "always ever so artificial, delicate and hidden scientific fact is in always product of a technologically mediated encounter with the trans-phenomenal."[40] In this way, Bachelard claims that reflection on the significance of the relation between science and technics demands that modern philosophy move beyond Kantian skepticism about the possibility of articulating what is "in the noumenon" towards a more positive conception of the noumenon, not as the space of an cognitively inaccessible "in itself" but as an instrumentally conditioned space of the unknown and the "yet to be discovered." More specifically, for Bachelard, the noumenon must now be conceived as a "complete structure" and thus as much more than a mere epistemological postulate or conventional sign, albeit a structure whose precise ontological status is radically ambiguous.[41] Bachelard recognizes, therefore, that the modern scientist's attitude of "epistemological incompleteness" towards the world, what he termed the modern scientist's basic "epistemological postulate," automatically generates a concern with the noumenal aspects of existence.[42] Again, instrumentation is of central importance here and in his view scientific equipment is the means to achieve a certain kind of "epistemic transcendence", from the known into an "unknown world."[43] Seen this, for Bachelard, philosophers need to recognize that the *epistemic vector* of contemporary science is something that allows the experimental scientist to effectively "realize the noumenon" via an instrumentally

[39] See Bolduc and Chazal, "The Bachelardian Tradition." 79.

[40] Bachelard, "Noumena," 83.

[41] Bachelard, "Noumena," 74-76.

[42] Bachelard, "Polemics and Poetics," 24.

[43] Bachelard, "Noumena," 74.

induced series of phenomenological events (a process that he famously termed "phenomeno-technique"). As he puts it:

> [t]he relation between the phenomena and noumena of science is no longer to be seen as some remote or indolent dialectics; it is instead, an alternating movement which always tends towards the effective realisation of the noumenon, after first rectifying a few projects. In this way, then, the true phenomenology of science is essentially a phenomeno-technique. It reinforces what cannot be glimpsed just beyond appearances. It is instructed by what it has constructed.[44]

Thus in Bachelard's reflections on modern science, instrumentation and noumenon form a phenomenological unity. For Bachelard, the noumenon, a formerly hidden and hitherto unknown realm, *via media* of instrumentation, is both disclosed and ultimately made available for observation, measurement and ultimately for the final forms of theorisation that are constitutive of scientific knowledge as such. Instruments, after Bachelard, we might say, by means of a specialized deployment, disclose the noumenon by expanding ordinary phenomenological horizons in a way that enables the experimenter to "entrap" this realm's ontological potential in representations–to borrow from Heidegger– in ways that makes it salient for theoretical reflection.[45]

Does Philosophy of Science Need a 'Theological Turn'? Science and the Noumenon

Heidegger and Bachelard show us the extent to which any systematic examination of the philosophical significance of the technological background allows for a deeper appreciation of the relationship between "the real", "the noumenal" and "the transcendent" as they emerge out of the practices of modern

[44] Bachelard , "Scientific Mind," 54.

[45] Scientific practice is thus radically epistemologically other– it is Platonic in the sense that it lies outside and beyond human sensibility and is only made available by means of a certain *"techgnosis."* The idea that scientific knowledge is the true universal knowledge, the main assumption behind all forms of "scientific realism" presupposes that scientific reality is, in theory, available to all though the universality of technological procedure. However, given the specialised nature such procedures it is now clear that the democratic ideal of science is in fact an illusion.

experimental science. Seen thus, in viewing scientific experimentation as a form of "epistemic transcendence," their work not only allows for a critique of the sociological conception of science developed by followers of Kuhn, but also for an alternative conception of science that collapses entrenched distinctions between science and theology. More specifically, their focus on the epistemology of instrumentation shows the extent to which science is itself a form of "mysticism"–a quest for an unknown and possibly in any absolute sense unknowable knowledge, that we deem to be knowledge only because it goes beyond what we currently know, what we know cannot be the final word on knowledge as such. When viewed by these lights, "the real of science," the true object of its inquiries and the fundamental reference of all its theoretical terms, is not a domain of entities as such, but the unknown itself; a space that science itself creates through the experimental scientist's use of instruments for wider epistemic ends. Heidegger claimed that science "does not think," but in fact it is better to claim that science "will never know," as it is merely a process that is perpetually invalidating of what we thought we that we knew in a technological exploration of the infinity of the unknown.

Such an analysis clearly points us towards a re-mapping of philosophical concerns on the theological terrain–as here we can discern the important theological motifs of "mysticism" and "transcendence." However, we need to differentiate between "strong" and "weak" conceptions of theology here: between, respectively, attempts to view science as belonging to, and an expression of, some particular theological tradition or other, and attempts to view science has possessing a "family resemblance" to "the religious and the theological" (and thus in need of a much looser theological framing). A strong conception might, for example, view the instrumental background, as its concerned with transcending the epistemological limitations of the inherited body, as a powerful phenomenological *demiurge* that guides and shapes scientific endeavour in its quest to articulate the epistemically significant contours of another world (beyond the one biologically and culturally donated to human beings). This of course would be to view science as in some way *Gnostic*–a western heresy that "dares to know" perhaps what cannot and should not be known (Kant is the great *ag*nostic in this regard). However this kind of strong theological move is both too quick and, too glib (and overall unhelpful). In fact,

to position science as essentially Gnostic, Christian, Jewish, Islamic, Pagan (or whatever) is to misunderstand the radical novelty of science in metaphysical and theological terms (and thus obscure the fact that now science, when viewed by orthodox theological lights, can only be viewed as a counter-theology). For example, Kuhnians like Shapin, claim that science, at its origins, was basically a "reformed Christian" endeavour, a Protestant quest for non-mediated access to being, where the experimental scientist, as "Christian virtuoso", is seen as engaged an attempt to purify belief of pagan superstition, Papist idolatry and other "badges of anti-Christ."[46] However, even if this were the case, it has long since left this dimension behind and has now emerged as a movement that shows no respect for any established religious sensibility, even those of its origins (it is thus, today, in many ways, a self-devouring religion in that it is undermining in its own basis in religious terms). Thus any strong theological conception, we might say, is still too sociological and insufficiently metaphysical, and although there may be something to strong theological accounts as heuristic social histories science, they can have little purchase in philosophical contexts where science presents itself as a form of worlding that is both more distinctive and more autonomous with respect to religious traditions of all kinds. Thus what is needed, as a far of contemporary philosophy of science is concerned, is a weaker theological reading of the history of science that focuses upon the specific phenomenological orientations of the experimental scientist rather than science as a world-historical "intellectual movement". Thus, when viewed in these weaker theological terms, what is important about the account of instrumentation offered above is the extent which it suggests to us an image of the experimental scientist as a *seeker*–of the unknown–through an "instrumental portal": a "clearing" that creates a noumenal space into which science projects its ideas of "nature." "The seeker" is of course an ancient figure of mysticism, and there is some mileage, I think, in developing the idea that science involves a "mysticism of the instrument" (where the experimental scientist is the instrument's "modern ascetic contemplative").[47] Here we can see continuity

[46] Shapin, *Scientific Revolutions*. But it can also be viewed as Pagan, with experimental scientists seen worshipping at the instrumental altar of "nature" (and perhaps even Cabbalist/Rosicrucian, as Frances Yates argued).

[47] There are clearly links to monasticism here, and in an important way, modern science, in attempting to conceive of the noumenon, is attempting to conceive of the radically unknown;

between the modern and the pre-modern in science, but not in a way that denies science its manifest relative cultural and ontological autonomy. The scientific desire to "explore the noumenal realm, the real of the unknown," and to re-orient and redesign our devices in specific ways in order to do this, may represent a mere cultural-metaphysical mutation within extant western religious traditions, but it is mutation that is highly syncretic in this respect and also, essentially, *novel* in cultural-metaphysical form. Thus, overall, if we examine the nature of modern science, not through its history, but through its technological metaphysics, we can see that modern science does indeed orbit theological issues, although it is not reducible to them–to the extent that its sociological dimensions, contra Kuhnian thinking, are secondary to its metaphysical and theological ones, but in ways that preserve the need for philosophers to understand that the worlds of science stand as "worlds apart," and will remain so until philosophers can find a way of showing how the realms of the known and the unknown can be conceived as different aspects of a single world.

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to penetrate and circumnavigate the "cloud of unknowing" much celebrated by Christian mystics over the centuries. Thus the mysticism of science is a mysticism that stands in opposition to mysticism as traditionally conceived.

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