Poetic Reality

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Abstract

In the Tagore-Einstein conversation, Tagore makes the obvious point that physics itself is a human enterprise as with any other human creation such as music, poetry, painting and sculpture. What effect does this fact alone have on the issue of realism? The suggested "humanness" of physics cannot by itself lead to anti-realism about entities and theories proposed in physics; otherwise realism cannot even be formulated. It follows then that the realism-antirealism options must be framed within the suggested "humanness". One way to conceptualise the problem is to examine Immanuel Kant's proposal that a sense of (independent) reality is itself a part of the human cognitive apparatus: the "Galilean Style" is a product of this apparatus.

Keywords: *realism, idealism, human reality, design, Galilean Style, truth*

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1

During his conversation with the physicist Albert Einstein, the poet-novelist-playwright-painter-composer-educationist Rabindranath Tagore stated that “truth, which is one with the universal being, must be essentially human; otherwise, whatever we individuals realize as true, never can be called truth”. “The truth which is described as scientific”, he continued, “can (only) be reached through the process of logic” which itself is “an organ of thought which is human” (In Marianoff 1930).

The point of interest in these statements is that Tagore is concerned with truths of physics, scientific truth. For him, scientific truth is one with Universal being; in other words, truth is universal. While claiming that truth is “human”, there is no emphasis on social norms, cultural forms, historicity, artistic variation, etc. In particular, he is not proposing that truth is subjective, whatever that problematic notion amounts to. In that sense, truth is objective; maybe *all* truths—not just truths of physics—are objective!! He seems to be upholding the concept of objective truth *while* asserting its essential humanness. In fact, he suggests that humanness is a *necessary* condition for objective truth! As we will see, this ‘poetic’ notion of truth lends a new dimension to the classical debate in philosophy of science between realism and anti-realism.

As noted, Tagore was a great poet and a humanist. As a humanist thinker, he also lectured and wrote on a variety of topics of general human interest such as the character of human existence, the play of nature on human creativity, and the role of values and

religion in human societies. Such concerns abound in much of his creative work too, especially in his poems, plays and paintings. His Hibbert lecture at Oxford University (*Religion of Man*), the Harvard lecture (*Sadhana*), the Kamala lecture at Calcutta university (*Manusher Dharma*), and some other writings—such as the collection of addresses given at the weekly prayer at Santiniketan (*Shantiniketan*) and other writings (*Personality, Creative Unity*)—were more self-consciously and directly concerned with these topics.

In one broad common sense of the term "philosophy", the writings just mentioned may well be characterised as philosophical insofar as they are general reflections on the human condition. In Tagore's case, these reflections are often accompanied by short citations and commentaries from the classical Indian tradition such as the *Veda*s, *Upanishad*s, *Gita*, and the like, which also may be viewed as philosophical in roughly the same broad common sense of the term.

However, these reflective works are not philosophical in the narrower, more academic, sense. Broadly viewed as systematic reflections on the nature of language, thought and reality and the relations between them, academic philosophy can be safely identified, as with other academic disciplines, with its textual lineage (Mukherji 2002; 2005).

Consider the classical problem of realism opened by the Greeks, especially by Plato: does the world consist of the entities that correspond to the concepts humans employ to form a view of the world? In other words, is the human view of the world real? With the overwhelming fact of Newtonian science in hand, the problem took a particularly sharp

form in the philosophy of Immanuel Kant, as we will see. Newer, more foundational, issues emerged as Newtonian physics gave way to relativity theory and quantum theoy in early twentieth century. By the time the discussion between Tagore and Einstein took place in 1930, philosophy of science had already emerged as a significant area in philosophy with the realism/antirealism debate at its core. There is no evidence that Tagore was familiar with the technical literature. To emphasize, there is no evidence that Tagore was familiar with the technical literature in the philosophy of science as developed in the works of, say, Ernst Mach, Henry Poincare, and Karl Popper. To say this is not to deny that Tagore took intellectual—even if semi-popular—interest in aspects of modern science.

Tagore's views on physics and science, therefore, need to be viewed not as technical comments, but in terms of general humanist reflections of a literary mind. Even then Tagore's 'outsider' view carries much intellectual interest. A work of art, including the writing of poetry, is not merely a play of form. Somehow the artist has to relate the emerging forms in his aesthetic imagination to stable aspects of human experience for the forms to have an irresistible interpretation. In that sense, an artist constantly struggles with the elusive reality of artistic depictions. An artist and poet of Tagore's genius was likely to have reached a satisfactory reflective understanding of his own artistic expressions that might have interesting philosophical implications. Elsewhere (Mukherji 2012), I have discussed how Tagore's poetic contemplation of bird-songs [*pakhire diyecho gaan, gay sei gaan* (*Balaka* 23)] illuminates an emprically-viable conception of

human musical ability. I wish to adopt a similar strategy for Tagore's 'poetic' views on science and truth.

Albert Einstein also was not an academic philosopher in the sense outlined above. However, his philosophical location with respect to the issue of scientific realism was far more intimate than Tagore's. Not only was Einstein the greatest physicist after Newton, his work was central in the new debate on scientific realism. In particular, he directly intervened in the post-quantum debate in scientific realism to suggest that quantum theory is an 'incomplete' theory of nature in that it fails to reach (genuine = objective) scientific truth. Thus, both for his outstanding role as a practicing scientist and a reflective thinker on the nature of science (specially, new physics), Einstein's remarks on the nature of reality carry intrinsic significance.

2

As we know by now, at the time of the conversations, Tagore was a very familiar name in Germany as some of his literary works had been translated into German and millions of copies were sold. Tagore visited Germany several times between the two world-wars. During these visits, he met many leading German intellectuals such as Rainer Maria Rilke, Albert Schweitzer, Thomas Mann, Stefan Zweig, Hermann Hesse, and others (Kampchen 1991). Einstein was perhaps the most famous German intellectual of his time. It is reasonable to assume that Einstein was familiar with Tagore's poetry and other writings. So, it is not surprising that the two might have sought each other out during Tagore's visit to Germany.

What is surprising is the topic of their conversation. We know that both Tagore and Einstein were deeply concerned with the rise of fascism and threat of war in Europe. Romain Rolland and others were actively engaged in organising world-famous intellectuals against the war. It would have been a stellar topic of conversation for Tagore and Einstein. Instead, as recorded in the truncated published versions, they chose to discuss the character of science in the first meeting and music in the second (Marianoff 1930). For reasons of space, I will focus only on the first without denying that the second may have some bearing on the discussion of reality as well.

Even there, the Tagore-Einstein conversation does not really have the form of a debate. Rather, it has the form of repeated assertions by two minds reflecting in parallel. And it is not very clear what these assertions were about. For example, from some parts of the conversation it appears that the conversation was about whether there is a mind-independent reality. Dmitri Marianoff, who reported these conversations in the *New York Times*, titled the first dialogue, "Thoughts on the possibility of [truth's] Existence without relation to Humanity". It is suggested that Einstein says 'yes', Tagore says 'no'. It is not clear that there was in fact such a direct opposition.

Consider the issue of the table. While Einstein clearly holds that the table continues to be there even if no one sees it, Tagore does not quite say that in that case the table won't be there. He says instead that it will be there but under the gaze of a universal mind. So Tagore does not deny the existence of the table when no individual human is present to perceive it; he ascribes the existence in that case to the presence of a universal mind. Similarly, in his *Three Dialogues between Hylas and Philonous*, George Berkeley

held that since sensible things may exist independently of human beings, “there must be some other mind wherein they exist” (Berkeley 1713). For Berkely this ‘other’ mind is God; Tagore called it variously “Supreme man”, “Universal being”, and the like.

The standard criticisms against Berkeley thus apply to Tagore as well. The postulation of a constantly and universally aware universal mind does not seem to have more explanatory power than the simpler postulation of the table itself. The universal mind will need the table for a veridical perception of it in any case; if that perception is non-veridical, the table won’t be there which is a consequence both Berkeley and Tagore deny. So Tagore needs to postulate all of (a) universal mind in the form of all-pervasive consciousness, (b) ability of the human mind to grasp the universal mind *and* (c) veridical perception, just to say that the table continues to be there. Even though Einstein does not offer any further realist argument in favour of his view that the table continues to be there (“I cannot prove my conception is right, but that is my religion”), his robust and simple common sense seems to outweigh Tagore’s complicated idealist thrust.

Philosophical difficulties aside, for the case under study, humans do seem to have a preference for the simpler option of settling for the reality of the table because that sense of reality is in fact withdrawn in some special cases. For one, even if, other things being equal, we robustly believe that the table continues to exist when I leave the room, we do not believe that my shadow—which also I can see among other ‘thing’-like stuff—will continue to exist in the room if I leave the room. This is because other things are not equal; unlike the table, the continued existence of my shadow is tied to my presence in

the room. So, there is a clear distinction beween things to which we do or do not ascribe reality even if they are perceptible.

To pursue the topic of shadows a bit more, it is interesting that humans not only make a thick distinction between independent objects like tables and mountains, on the one hand, and 'dependent' objects such as shadows, on the other, they make grades of distinction between the reality of shadows as well. For example, humans ascribe reality to shadows of individual persons even if the person is not present in the frame; they withhold such ascriptions if bottles are so arranged to generate a shadow-outline of a human face. These distinctions cannot be made sense of without a prior distinction between what is real and what appears to be so, *both* for the human mind.

Consider another—more classical—example requiring the appearance-reality distinction. When setting out in the dark in a snake-infested area, we take a torch along even if there is some moonlight. If I see what looks like a rope, I switch on the torch to double-check that it is in fact a rope, not a snake. Under those unfavourable conditions of light, we do not generally ascribe veridicality to the perception of rope without further examination. Since the 'universal mind' works throughout without getting affected by specific circumstances, a Berkeleyan has no further resources to explain these special cases. Einstein's realist conviction is thus ratified by robust common sense.

This is not to deny the appeal of Tagore's basic assertion that "the truth which is described as scientific and which only can be reached through the process of logic—in other words, by an organ of thought which is human." However, Tagore's own explanation of what he means is not very helpful, as we saw. For Tagore, scientific truth

obtains when the human mind forms a ‘universal harmony’ with the ‘supreme being, *Brahman*’. Such an explanation seems unnecessary because the basic claim is obvious as scientific theories are unfailingly human products. Furthermore, the postulation of a universal being takes the explanation away from the *individual* human being whose perception of the table and the conception of scientific truth *are* the relevant phenomena. In that sense, Tagore in fact loses his grip on the ‘humanness’ of the issue.

3

It is not clear how this obvious point that scientific theories cannot fail to be products of the human mind touches on the classical issue of realism of scientific theories. We cannot take this point itself to lead to an anti-realist position because then the realist position cannot even be articulated. I don’t think people such as Einstein, and more importantly philosophers of science like Karl Popper, who advocate the realist option even for (a completed) quantum mechanics, will want to argue for non-human origins of scientific theories. So the realism issue must arise, if at all, within the human enterprise.

I think a brief discussion of the realism issue is needed at this point basically to set it aside because there is a growing tendency, even among physicists, to view the ‘debate’ between Tagore and Einstein in terms of the realism debate around quantum theory. Tagore is said to be more inclined towards the uncertain, non-deterministic, subjectivist view projected by quantum theory in contrast to Einstein’s classical determinist, universalist view of the physical universe. I hope to show that Tagore’s concern was equally classical, different from the realism issue, and more fundamental.

Both the realist view of quantum mechanics via hidden variables, multiple worlds, implicate order, or whatever, and the anti-realist, instrumentalist Copenhagen view are to be understood within the undeniable idea that quantum mechanics is a human product, just as relativity theory and string theory are. The realism issue has to do with the character of particular scientific theories, not with the identity of the species that constructs those theories; there is just one species. As argued above, the issue has to do with whether we view the terms of a scientific theory to *refer* to mind-independent objects such as tables and trees or whether they are more like shadows.

For thinkers like Noam Chomsky (2000) the concept of reference in fact gets its salience from the over-riding scientific norm that scientific thinking aims to discover real joints of nature, notwithstanding the use of elaborate instrumental means such as mathematical models, approximations, artificial experimental setups, etc. This norm was the primary source of Einstein's stubborn realist conviction, as we saw, which was prepared to over-rule even as sophisticated a mathematical theory as quantum mechanics simply because it failed to indicate the required distinction between tables and shadows. This is because, on some popular Copenhagen-type interpretations, quantum phenomenon, such as defraction of electrons through a double slit, is irreducibly explained in terms of a local observer. According to Einstein, the presence of the observer introduces the element of 'shadow' in quantum theory. Einstein concluded that such a theory must be 'incomplete'. For Einstein, the suggested humanness of all science does not thereby validate quantum theory. To emphasise, *humanness of science does not necessarily endorse subjectivism*.

The postulation of a mind-independent world is thus a human ideal—a 'norm', pace Chomsky—which some scientific theories may fail to meet on occasion despite extensive use of the human cognitive apparatus. On that count, quantum theory is puzzling and problematic, according to Einstein and his followers (Popper 1992), precisely because there are scientific theories, such as Newtonian mechanics, falling under the so-called Galilean Style, that *do* meet the norm (Mukherji 2009). In effect, the human mind is such that, given a choice between general relativity and astrology, one is prone to ascribe truth and reality—and thus reference—to the former while denying them for the latter because astrology is contaminated with the (undesirable) 'human' factor—shadows. Again this asymmetry in ascription of reality is something that the anti-realist finds hard to explain.

There is no contradiction between the essential human origin of scientific theories and the adoption of a realist norm. In fact, as Tagore insisted (as noted), a realist norm is not available unless scientific theories have a human origin: "truth … must be essentially human; otherwise, whatever we individuals realize as true, never can be called truth". We may safely conjecture that higher animals such as the great apes do form sophisticated views of the world in order to find strategies for survival. If these views (in fact) 'fit' the world, the apes survive, otherwise they perish. For the ape, there is no further reflective issue of *whether* the view fits the world. The ape, not unlike the postmodernist, need not have a concept of (objective) truth.

4

Earlier, I mentioned the value of Tagore's poetic conceptions of how things are such as the character of bird songs. Naturally, then, Tagore's deeply reflective views on the

nature of reality is likely to be represented more effectively in his literary work, rather than in occasional philosophical pronouncements of dubious value as we saw. Consider the first two lines of his very popular lyric—*mahavishye mahakashe*—set in *raga* y*aman kalyan* (I am not using the rest of the devotional part of the song; all translations from Bangla are by me):

> In the cosmos, the endless sky, the boundless time
> I, the human, travel alone in wonder.

The first line depicts what philosophers call the "space-time manifold" consisting of all that is there in the universe located in the universal space-time framework. The second line 'humanizes' this manifold. I have access to the *entire* manifold for further reflection because I can be *there* at every possible point of this manifold as apart of my travel-itinerary. Tagore emphasises the idea of *traveling in wonder*; he mentions it twice in succession. Perhaps he means that, if the manifold were to be my *construction*, an effect of my conscious imagination, then there is no travel, no wonder. I travel in wonder because the manifold is there independently of my reflection such that I *experience* the manifold just as I experience the table out there. Yet, this independence is meaningful just because I *grasp* it in wonder.

I think Tgore elaborates on the notion of a humanized cosmos at many places in his creative work. Consider another very popular lyric—*akashbhora surjyatara*—in *raga mishra kedara*.

1. The sky is full of the sun and stars, the world is full of life
2. I have found my abode there,

3. Thus my song comes alive in wonder.
4. The waves of eternal time that cause the ebb and tide
5. Also guide the rush of blood through my veins,
6. Thus my song comes alive in wonder.
7. When I walk on the grass on the forest-path,
8. The scent of the flowers startle my spirit
9. The gift of joy is scattered all around ...

In line 1, Tagore begins to describe the cosmos as a skyful of sun and stars, but it also includes the life in the universe. In line 2, just as in the earlier poem, he locates the I, the poet himself, amongst the elements of the cosmos. Line 3 says, this wonder of self-realized cosmos gives rise to the poet's song. In lines 4 and 5, Tagore highlights the unity of the cosmic order—in terms of gravitation—by noting that the reason why my blood flows is the same as why ebb follows tide for eternity. In lines 7 and 8, the idea of the cosmos is expanded to include blades of grass on the forest-path (7) and the smell of flowers (8), both giving rise to the joy and wonder (lines 6 and 9). Similar sentiments can be found in dozens of other poems and songs.

How do we interpret this image of a human universe? In some literary and philosophical circles, Tagore's colourful 'animated' conception of the cosmos is often over-interpreted to suggest parallels with the Upanishadik tradition, or the primacy of artistic (fictional) imagination. In both cases, the emphasis is placed on the subject, the I, as *constructing* the cosmos. In other words, the cosmos is viewed as *dependent* on the solitary self, the cosmos *disappears* if the self does. Tagore is thus viewed as a classical

idealist. As noted, some of his inadequate philosophical arguments do suggest such a picture—wrongly in my view.

Tagore, as noted, did not develop his complex world-view with professional philosophical rigour. There is no doubt that his conception of the universe is a fallout of his artistic wonder; it is not a systematic product of cold analytical reflection. Tagore's conception of universe is scattered in a large body of artistic work whose meaning changed sharply throughout his life; in some cases, he did leave the impression of an idealist's universe. For example in one of his much-cited poems—*amar-i chetanar ronge*—he seems to assert that the emerald gets its colour due to my consciousness, the sky is lit up when I open my eyes, etc. Authors cite these lines with glee to emphasise Tagore's 'subjectivism' and affinity with quantum theory:

But it is routinely missed in the literature that, in this poem, Tagore carefully keeps to what philosophers call 'secondary qualities' after the 17th century British philosopher John Locke—qualities of matter that seem to manifest only under human observation and are not intrinsic to matter. He also mentions aesthetic properties such as 'beautiful'—*golaper dike cheye bollam 'sundar'*—which of course have intrinsic reference to the beholder. However, there is no evidence that Tagore thought that the so-called 'primary qualities' such as size and density of objects—proper subject matters of physics—are also products of the beholder.

Be that as it may, let us assume that Tagore might not have been fully consistent in his world-view through his varied artistic expression. Yet, as explained in some detail above, a central part of his artistic work seems to project the conception of a human

reality which is metaphysically independent of the human mind, but gets its entire epistemic significance via human experience. This is the sense in which the universe is at once familiar and unfamiliar—*chiradibaser vishwa ankhisammukkhei*:

> The perennial universe in front of my eyes,
> I have seen a thousand times
> At my door.
> This timeless familiarity of the unfamiliar
> Has filled the deep recesses of my heart
> At ease.

So, the human universe is an *experienced* universe. Only in human experience does the universe carry its full significance since human experience is interpretive—'stimulus-free', to use a term from contemporary cognitive psychology. The universe appears to us in all its variegated complexity because humans—only humans—are endowed with "organs of thought" that transform the experience into a symbolic conception. And an experienced universe has the self as the interpreter of experience at its cognitive center. As Tagore puts it: the grand-designer works on the canvas of human ego—*manusher ahankar-potei*.

5

The idea that humans are experienced interpreters is an ancient one, although it was stressed with much force in the Western rationalist tradition. These philosophers pointed out that humans are not just passive receivers of external stimuli. The human mind actively contributes from its own inner resources to organize and interpret sensory information. The rationalist philosopher Ralph Cudworth called these resources

'cognoscitive powers' which enable the mind to raise 'intelligible ideas and conceptions of things from within itself'. The 'intelligible forms by which things are understood or known', Cudworth held, 'are not stamps or impressions passively printed upon the soul from without, but ideas vitally protended or actively exerted from within itself.' For another rationalist philosopher Rene Descartes, the human ability to form conceptions of things from chaotic and often-impoverished experience is akin to 'a statue of Mercury contained in a rough block of wood'. The rationalists held that these cognoscitive powers, held together by human language, marked the basic distinction between humans and animals. The suggestion is that humans have a distinct (mental) design that generates the conception of a mind-independent reality.

Although the rationalists inaugurated the discussion, Immanuel Kant studied the design-factor with much ingenuity. He opens his masterwork *Critique of Pure Reason* with the following suggestion:

> But though all our knowledge begins with experience, it does not follow that it all arises out of experience. For it may well be that even our empirical knowledge is made up of what we receive through impressions and of what our own faculty of knowledge (sensible impressions serving merely as the occasion) supplies from itself. (CPR, B2)

Thus, Kant postulated a "faculty of knowledge"—what Tagore called "the organ of thought"—to account for human knowledge. As an aside, let me note that it was quite possible that Tagore had some familiarity with Kant's work since Kant was vigorously

discussed in the intellectuals circles of Bengal during Tagore's time. Specifically, Tagore's elder brother, the philosopher Dwijendranath Tagore, studied and wrote extensively on Kant and the relation of Kant's work with some aspects of classical Indian philosophy. There is some evidence of long philosophical discussions between the two gifted brothers (Bijoy Mukherjee 2007).

An immediate consequence of Kant's conception of human knowledge is that, since knowledge is necessarily linked to human receptive and interpretive faculties—*sensibilia* and *understanding*, respectively—the conception of a mind-independent reality, the noumenon, is logically incoherent since, by definition, we cannot describe it. In that sense, our conception of reality is restricted to what is intelligible to us, and intelligibility is directly related to our phenomenal grasp of the world. I return to the issue of intelligibility in the next section.

In the absence of a coherent conception of mind-independent reality and granting the existence of physics, how is physics possible? What does it mean to say that physics unearths the fundamental principles of the Universe if there no Universe to inquire into in the first place? How do we explain the universal (*a priori*) empirical (*synthetic*) content of physics? How are *synthetic a priori* judgements possible? Notice that this is no longer a query *in* physics, but *about* physics. Tagore's emphasis on "an organ of thought which is human" to appreciate "the truth which is described as scientific" is, therefore, essentially a Kantian question.

Early on in his CPR, Kant poses the suggestion that a sense of mind-independent reality is a fundamental human endowment. There is no clear argument, but some hint

can be found in his treatment of space-time, two of the fundamental concepts of physics. For Kant, both space and time are *transcendentally* ideal, that is, human contribution to the possibility of experience; space and time thus are products of *sensibilia* where space is the outer sense and time is the inner sense. In other words, space and time are viewed as real since that is how we are bound to think about the world. For example, he gives the following argument for the conception of *empty* space and time:

> For if we regard space and time as found in things themselves, and if we reflect on the absurdities in which we are then involved, in that two infinite things, which are not substances, must continue to exist, even although all existing things be removed—we cannot blame the good Berkeley for degrading bodies into mere illusion. (CPR, B71)

So the only coherent solution is to "assert then the *empirical reality of space* as regards all possible outer experience" while at the same time we "assert its *transcendental ideality*—in other words, that it is nothing at all." (CPR, A28) Similarly, "Time is therefore to be regarded as real, not intended as object but as the mode of representation of myself as object. That is, I really have the representation of time and of my determination in it." (CPR, A37) Space-Time are empirically real because without the required manifold we cannot make sense of the notion of experience without which the enquiry on how physics is possible cannot begin.

Similarly, the transcendental ideality of objects such as table via the human mode of understanding must also project the empirical reality of the table because without this

endowment we cannot make sense of the content of our experience of tables, as Einstein insisted. The required resources for doing physics thus arise from the human design itself within the constraints that any design imposes on the product. Tagore's "Universal Mind" is part of the species-design of humans, and is thus located in each pathologically sound human mind.

6

The suggested humanness of science was also central to the issue of intelligibility and the conception of a Galilean science (Mukherji 2009). Galileo held that humans will never completely understand even 'a single effect in nature'. Chomsky suggests that Galileo's pessimism was validated by later developments in Newtonian science which 'not only effectively destroyed the entire materialist, physicalist conception of the universe, but also *the standards of intelligibility* that were based on it' (Chomsky 2000, emphasis added; also, Hinzen 2006). Thus Chomsky supports Alexander Koyre's remark that 'we simply have to accept that the world is constituted of entities and processes that we cannot intuitively grasp.' The force of the expression 'intuitively' seems to be that we cannot have direct knowledge of how the world is like; the knowledge has to be routed in terms of resources available to our theory-building abilities—the Kantian view, as we saw.

Thus, any conception of the universe is restricted to what is intelligible to us; as standards of intelligibility fall, so does our grasp of the universe. The restriction gives rise to the old irony that the world which undoubtedly gives rise to our knowledge of it can

not be sufficiently grasped by the only means available to us. Chomsky suggests that, in a way then, we are compelled to adopt David Hume's position that Newton's discoveries reveal the 'obscurity' in which 'nature's ultimate secrets ever will remain'. The perspective seeks to question what is taken for granted, namely, that 'the natural sciences seek to discover basic truths about the world.' Clearly, these remarks apply to the whole of science including the most ingenuous proposals in theoretical physics. Notice that the skepticism arises due to the humanness of science.

If science cannot explain 'a single effect in nature', how do we explain the sense of deep understanding, of genuine scientific explanation in some selective domains? How is it that some instances of science, say, theoretical physics, convey an abiding sense of truth, a view of 'the real properties of the natural world'?

The answer is located in the idea of mathematical physics. The mathematical formulae of physics are not only empirical in character, they also signal vast generalisations: Newtonian mechanics, relativity theory, quantum theory, and now string theory are often viewed as theories of everything. So, the really puzzling feature of the fundamental laws of physics is that they are at once mathematical in character and representations of large aspects of the universe.

This primacy of mathematical physics as the ultimate form of human knowledge was recognized since the beginning of modern physics. Johannes Kepler (1609/1858) held that "nature is always able to accomplish things through rather simple means, it doesn't act through difficult winding paths." Galileo Galilei (1632) thought that "nature generally employs only the least elaborate, the simplest and easiest of means … nature is perfect

and simple, and creates nothing in vain." Isaac Newton (1687) suggested that "we are to admit no more causes to natural things than such as are both true and sufficient to explain their appearances … for nature is pleased with simplicity, and affects not the pomp of superfluous causes." Albert Einstein (1954) said that "nature is the realization of the simplest conceivable mathematical ideas."

Authors such as Steven Weinberg (1976; 1993) in fact trace the *realistic significance* of physics to its mathematical formulations: 'we have all been making abstract mathematical models of the universe to which at least the physicists give a higher degree of reality than they accord the ordinary world of sensations' (Weinberg 1976). Weinberg and others (Chomsky 1980) have called this form of explanation in physics the 'Galilean Style'. The style, according to these authors, works as a foundational methodological principle in science, especially physics.

The discussion of intelligibility and mathematical physics brings out three salient aspects of a humanized conception of reality. These aspects may be ascribed to the emergence of Galilean style:

(A) Abstracting away from "ordinary world of sensation", "most of what we find around us in the world of ordinary experiences is unhelpful for determining the real properties of the natural world", Chomsky (2000);

(B) Assuming the universe to have a 'simple', 'perfect' design. Nothing else can be studied!

(C) Prioritizing mathematics which is totally *a priori* and, hence, an exclusive product of the human mind.

7

When (empirical) physics is mathematised, the realist norm is recaptured within human intelligibility itself. In a very significant sense, then, the Galilean style essentially constructs an imaginary world. Yet, the amazing thing is that it actually works! The world does seem to obey simple mathematical principles. I will discuss two popular examples briefly.

The Fibonacci Sequence, discovered by the 12^{th} century Italian mathematician Fibonacci, is the series of numbers: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, ... The next number is found by adding up the two numbers before it: 2 is found by adding the two numbers before it (1+1); Similarly, 3 is found by adding the two numbers before it (1+2); And the 5 is (2+3); and so on! The sequence is generated by a very simple *recursive* function that imposes the same order repeatedly at progressively higher levels: $x_n = x_{n-1} + x_{n-2}$. The series was also described by Indian mathematicians working on syllabic and metrical structure of speech hundreds of years before Fibonacci (Singh 1985). Indologists suggest that "the sequence Fn had already been discussed by Indian scholars, who had long been interested in rhythmic patterns... both Gopala (before 1135 AD) and Hemachandra (c.1150) mentioned the numbers 1, 2, 3, 5, 8,13, 21 explicitly".

The interesting aspect is that this progress of numbers maintains a constant rario, the 'golden' ratio:

A	B	B/A (Golden ratio)
2	3	1.5
3	5	1.6666…

5 8 1.6
8 13 1.625
and so on.

When the numbers are plotted figuratively, the golden ratio generates a systematic spiral. The amazing thing is that the Fibonacci spiral is observed in many forms in nature, most notably in the organization of seeds, leaves and petals in flowers and other flora. For example, it is observed in yellow chamomile head showing the arrangement in 21 (blue) and 13 (aqua) spirals.

The second, slightly more difficult, example comes from the study of fractals, self-replicating geometrical shapes. A simple and small geometrical shape such as a triangle or an open section of a curve may be repeated at different levels and scales to generate some of the most complex phenomena in nature. The "self-replication" or "self-similarity" can come in a variety of forms: exact self-similarity as in some snowflakes; quasi self-similarity noted usually in artificial mathematical figures such as Mandelbrot sets; statistical self-similarity as in shape of coast-lines, and so on.

As with the Fibonacci sequence, fractals can be mathematically generated from simple recursive functions such as $z = z^2 + C$ as in the figure below. The figure shows a wide variety of fractals, both natural and artificial, that are generated repeating basic simple forms at a variety of levels and scales. From organization of leaves to snowflakes to coast lines to solar systems, fractals exemplify Galileo's statement that "nature generally employs only the least elaborate, the simplest and easiest of means … nature is perfect and simple, and creates nothing in vain."

To emphasize, fractals and Fibonacci sequences, among many other similar recursive forms, are products of the ingenuous human (mathematical) mind and, as noted, mathematical ideas, by themselves, are entirely *a priori*, that is they are independent of the sensibilia. Yet, these beautiful 'fictions' seem to fill all parts of nature. It in this specific sense of the mathematization of reality that we may understand Tagore's poetic idea that "the human mind forms a universal harmony with the supreme being," except that nature itself is that supreme being, no additional anthropolization in the form of *Brahman* is needed.

Needless to say, deep scientific inquiry into the order of nature, as in hundreds of years of mathematical physics, requires even more ingenuity, not only to describe nature, say, in terms of Fibonacci numbers, but to explain the inner structure of matter that gives rise to its surface systematic forms. That deeper inquiry, resulting in the postulation and discovery of fundamental laws governing basic elements and forces can only be "reached through the process of logic which itself is an organ of thought which is human," as Tagore emphasized in his poetic gesture. Humans, after exercise of ingenuity, come to grasp reality because reality, in that explicit sense, is human.

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