

Planetary motion, Newton, and Buddhism

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Background

I should begin by pointing out some of my background works to establish my perspective, and my entry point into this debate.

1. First, I have pointed out how a re-examination of Newton's views of time, and consequent correction, led to the special theory of relativity.¹ (The origin of special relativity had nothing to do with the Michelson-Morley experiment,² as Poincaré³ stressed; the sole question was: how can time be measured [in Newtonian physics]?)
2. Second, I have pointed out how Newton's views of time were conditioned by his religious beliefs.⁴ (Specifically, Newton did *not* define a physical measure of time, and dealt instead with "mathematical" or metaphysical time, just because he believed in God. Also, because Newton believed in apocalypse and prophecy, he made time "linear", compared to the two choices between "linear" and "cyclic" time considered by his predecessor, Barrow.)
3. Third, I have pointed out how the Western understanding of mathematics has religious roots,⁵ and how these religious beliefs entered into Newton's attempts to understand the calculus,⁶ which was the key part of his physics of planetary orbits. (Because Newton believed that God had written the book of the world in the language of mathematics, he thought mathematics to be perfect. He tried to reshape the Indian calculus to fit this perspective. This idealistic position on mathematics led him to his theory of fluxions, and to the belief that time is a continuum and not a discrete sequence of atomic instants. Although the theory of fluxions was rejected, the related idea of time as a continuum is still used as the basis of calculus today, for no clear-cut reason.⁷ This belief in time as a continuum has no practical or refutable consequence, since all calculations are done using discrete time.)

1 C. K. Raju, "Newton's time", *Physics Education*, **8**(1) (1991) 15-25. "Einstein's Time", *Physics Education* **8**(4) (1992) 293-305. "Time: What is it That it Can be Measured", *Science & Education*, **15**(6) (2006) 537-55.

2 C. K. Raju, "Michelson-Morley Experiment", *Physics Education*, **8**(3) (1991) 193-200.

3 H. Poincaré, *Science and Hypothesis* [1902] Eng. trans. Dover, New York, 1952. H. Poincaré, *The Value of Science*, [1905], Eng. trans., G. B. Halstead, 1913, reprinted, Dover 1958.

4 C. K. Raju, "Newton's Secret", chp. 4 in: *The Eleven Pictures of Time*, Sage, 2003.

5 C. K. Raju, "The Religious Roots of Mathematics". *Theory, Culture & Society* **23**(1-2) Jan-March 2006, Spl. Issue ed. Mike Featherstone, Couze Venn, Ryan Bishop, and John Phillips, pp. 95-97.

6 C. K. Raju, *Cultural Foundations of Mathematics: The Nature of Mathematical Proof and the Transmission of the Calculus from India to Europe in the 16th c. CE*, Pearson Longman, 2007. (PHISPC, vol X.4).

7 C. K. Raju, "Time Measurement in Classical Indian Tradition and the Present-Day Representation of Time as a Continuum", in *Proc. 2nd International Pendulum Conference*, ed. M. R. Matthews, UNSW, Sydney, 2005, pp. 225-248.

4. Fourthly, I have pointed out how a further change in the understanding of time, and rejection of the religious notion of causality is required by current physics, and how this leads to a new type of equation for physics: mixed-type functional differential equations.⁸ (The Christian doctrine of sin necessarily requires a notion of causality: God can pass a judgment only when causes of good or bad outcomes can be located in individuals. The above approach denies this notion of causality.)
5. I have shown how the above approach can explain the origin of quantum mechanics.⁹ (Denying the notion of causality has the non-obvious consequence that the idea of linear time must also be rejected, and replaced by the idea of structured time. It has the further consequence that the temporal logic corresponding to a structured time is not two-valued, but is a quantum logic.)
6. Finally, (a) I have explained how this new understanding of time, or “a tilt in the arrow of time”, involves both spontaneity and history dependence,¹⁰ and hence corresponds very closely to the Buddhist notion of *paticca samuppada*.¹¹ (b) I have explained how the consequent quasi-truth functional logic (which is a quantum logic¹²) relates to Buddhist logic.¹³
7. An item which would be of great interest to Buddhists, though not necessarily to astronomers, is the new system of ethics that flows from this new view of time in physics.¹⁴
8. On a somewhat different plane, I have contrasted *sunyavada* or zeroism with Platonic idealism or formalism and explained how this leads to a better philosophy of mathematics.¹⁵ There is an actual project going on to test the effectiveness of using this new approach (instead of the usual idealist/formalist approach via limits etc.) in teaching calculus in schools and colleges.

This is only some of the work, and there are other aspects that I am not going into right now, such as quantum computing, since those aspects do not relate to the background note that was circulated for this conference. I am sorry for citing so many of my own books and papers, but I have to do that since my point of view is so radically different from the common point of view.

I do appreciate that the technical difficulty of some of the references listed above, and the radical shift of position, makes it very hard to understand what I am saying. However, I do not appreciate when some people keep responding to me simply on the basis of guesswork, and without any serious effort to read or understand what I am saying. I do appreciate the difficulties involved; however, I have made every effort to explain things in a non-technical way, and I am sure any serious scholar, from any background whatsoever, can, with some effort, eventually understand most of what I am saying.

8 C. K. Raju, “Electromagnetic time”, *Physics Education* **9**(3) (1992) 251-265.

9 C. K. Raju, “Quantum mechanical time”, chp. 6B, in: *Time: Towards a Consistent Theory*, Kluwer Academic, Dordrecht, 1994.

10 C. K. Raju, “Time: Travel and the Reality of Spontaneity”, *Foundations of Physics*, **36**(7) 2006, pp. 1099-1113.

11 C. K. Raju, “Atman, quasi-recurrence and *paticca samuppada*”, in *Self, Science and Society, Theoretical and Historical Perspectives*, ed. D. P. Chattopadhyaya, and A. K. Sengupta, PHISPC, New Delhi, 2005, pp. 196-206.

12 C. K. Raju, “Quantum mechanical time”, cited above.

13 C. K. Raju, “Logic”. *Encyclopedia of Non-Western Science, Technology, and Medicine*, Springer, 2008.

14 C. K. Raju, “Reconstruction of Values: the Role of Science”, in: *Cultural Reorientation in Modern India* (Indu Banga and Jaidev ed), IAS, Shimla, 1996, pp. 369–392. What I called the “order principle” in “Revaluation of all Values”, chp. 12 in the *Eleven Pictures of Time*, cited above, has now been renamed the “harmony principle”.

15 C. K. Raju, “Number representations in calculus, algorismus and computers: *sunyavada* vs formalism”, chp. 8 in *Cultural Foundations of Mathematics*, cited above.

Response

If I may start with a general observation: I have often encountered a bad disconnect between physics and philosophy, especially among Indian philosophers, who still seem to be going by 19th c. *stories* and myths about science. Physics on the other hand is becoming more and more of a social science: where truth and value is decided by reference to the community, and not by reference to experiment or argument. Indian physicists are too insecure as members of this community to engage with philosophy, and those who do are rarely able to explain how their philosophy affects physics and its equations or experimental consequences. This disconnect is the consequence of bad management of our academic system, which has no place for history and philosophy of science, despite repeated requests to various bodies like ICPR, UGC etc. From that perspective, the present effort to bring the two together is most laudable.

Force: what is that?

Against this background let me respond to Gangopadhyay's comments in the background note. Gangopadhyay makes the point that it is the concept of force, missing in Indian tradition, which is the starting point of science in the West. I am frankly amazed that he has chosen as his starting point a concept—force—which has been discredited in current physics for nearly the past century. However, this is a good starting point for a debate, since this articulation provides a welcome opportunity to sort out some myths about science and astronomy in the West.

What is force? Although force appears in Newton's second "law", it has no other or independent definition. (It might appear that force has some immediate intuitive significance such as the "force" with which one throws a stone. But this colloquial usage of "force" should not be confounded with Newtonian physics where the distance that a stone travels depends primarily upon the initial *speed* with which it is thrown.) Newtonian physics does not provide a way to measure force independently of Newton's laws. Basically, therefore, Newton's second "law" at best *defines* force. This is, however, a *bad* definition.¹⁶ Why? A force is said to act on a body when it accelerates (in an inertial frame), and the magnitude of force is *measured* using the equation $\mathbf{F} = m\mathbf{a}$. However, a good definition of force, \mathbf{F} , which would allow us at least to measure force accurately, would require that the quantity on the other side of the equation, namely the acceleration, \mathbf{a} , should itself be clearly defined and measurable. What is acceleration? A body is said to accelerate when it covers unequal distances in equal intervals of time. So, a definition of acceleration requires first, a definition of "equal intervals of time". Newton's mentor, Barrow, recognized this need, and did attempt to give such a definition.¹⁷ However, Newton undid the good work, and took a step backwards.¹⁸

What is not so widely understood is *why* this definition of equal intervals of time is missing—just because Newton took a God's-eye point of view about time and space, since he was so deeply influenced by Christian theology. Briefly: Barrow's definition of equal intervals of time was that "the same causes produce the same effects in equal times". Barrow explicitly rejected the attempts to make

¹⁶ See references at 1 above.

¹⁷ I. Barrow, "Absolute Time [*Lectiones Geometricae*, lecture 1]", in M. Capek (ed.), *The Concepts of Space and Time: their Structure and their Development*, Boston Studies in the Philosophy of Science, vol. XXII, D. Reidel, Dordrecht, 1976, p. 204.

¹⁸ Also, a good definition of force would also require a clear identification of an inertial frame, and Newton freely admits in his *Principia* that such a frame may not exist at all in the real world; but I will not go into this aspect.

time metaphysical; referring to Augustine's metaphysics of time (and especially his famous quote) Barrow calls physicists who resort to such theology as "quacks". His own definition of equal intervals of time was arguably a physical definition: for Barrow at least applied it to an actual physical clock such as a sand clock. Newton, however, avoided such a physical definition of equal intervals of time. Newton's overriding concern was with mathematical perfection—so he steps back to the metaphysical perspective—what he calls "mathematical time". Barrow's even tenor hypothesis applied to physical time, Newton applies "even tenor" to mathematical time.

Here is Newton's oft-quoted statement about time—usually quoted without understanding its meaning and purport.: "**Absolute, true, and mathematical** time, of itself, and from its own nature, flows equably **without relation to anything external,**..."¹⁹ [Emphases mine] One should note the three adjectives "absolute", "true", and "mathematical" all of which are intended to move the discussion from Barrow's plane of physics to Newton's plane of metaphysics. Just in case, somebody still missed the point, Newton makes things amply clear with the very next clause: "without relation to anything external". Obviously, something not related to anything external has nothing to do with physics. But that definition of equal intervals of time is the basis of Newton's definition of force!

No wonder, one needs to get rid of this notion of force to extract some physics from Newton's laws, in the Popperian sense of refutability. Popper pointed this out,²⁰ and I have explained this point earlier.²¹ Contrary to popular notions and the stock propaganda in school texts, Newton's laws of motion are, by themselves, not even physics in the Popperian sense: one can get refutable (or falsifiable) physics from Newton's laws only by eliminating this unphysical notion of force. For example, in a Newtonian calculation of planetary orbits, force is eliminated by putting together Newton's laws of motion and Newton's law of gravitation. It is only the combination of the two—laws of motion and law of gravitation—which gives physics, not either law individually.

Historically speaking, some serious physics emerged only after this religious notion of absolute time was eliminated from physics. This was what led to the special theory of relativity. And, eventually, this elimination of absolute time led to the elimination of force. That is exactly the strategy adopted in general relativity which explicitly has no place for forces of any sort. On the geodesic hypothesis a (test) particle moves on a geodesic, but not because of any sort of force: it does so by its very nature and the nature of the cosmos.

Before going further, I would first like to explain in more detail how Newton was pushed into this notion of time because of his religio-mathematical understanding of the calculus (or the notion of derivative with respect to time) that appeared implicitly in the notion of acceleration on the right side of Newton's second law, which defines force.

Divine laws and providence

Before looking at the deeper aspects, let us first look, in the manner of comic relief, at the easier-to-spot religious dimensions of Newtonian physics. There is, first of all the very notion of "law". The notion of law is not a physical notion, but a social notion. Laws are made by powerful people, kings, and

19 I. Newton, *The Mathematical Principles of Natural Philosophy*, A. Motte's translation revised by Florian Cajori, University of California Press, Berkeley, 1962. Reproduced in Capek ed., *Space and Time*, p. 205.

20 K. R. Popper, *Realism and the Aim of Science, Postscript to Logic of Scientific Discovery*, vol. 1, Hutchinson, London 1982.

21 See references at 1 above.

parliaments, and so forth, to enforce obedience. Where is the question about there being “laws” of physics? Who made them? How at all do we know that the cosmos is such that it is governed by physical laws? This is just an item of religious belief—a belief specific to the Western Christian religious world-view according to which there is a God who made these laws with which to control the world. In fact the priest made many moral laws which they related to a powerful God so that people should be frightened and become obedient to him. This constant propaganda naturally suggested the point of view that God had made laws also for the physical world. Obviously, such beliefs in God and the kind of world he made are no part of Buddhism. Nor should they be any part of any science, even if that is the sort of science that is done in the West.

Incidentally, the origin of this world-view of divine “laws” of God can be historically located in a theological dispute within Western Christianity. After the failure of the Crusades, the Christian priests tried attacking Islam by other means. They looked at the schism within Islam that had been generated by al Ghazali’s attack²² on the *falasifa*—philosophers—within Islam. Unabashed by their own earlier religious war with these very same “pagan” philosophers (Neoplatonists) in Alexandria in the 4th c. CE, this time the Christian priests chose to go along with the philosophers, and attacked al Ghazali’s notion (which I have called ontically broken time²³). This is better-known through the closely allied notion of Providence, in Western Christian theology: the idea that God intervenes at opportune moments to set things right in the world. (Such providential interventions are very much part of sufi thought, and one could easily see the analogous notions being played out in Hindi films until a couple of decades ago. Therefore, this requires no explanation.)

Providential intervention was also championed within Christian theology by John Duns and his followers, but it was rejected as the viewpoint of dunces (and all the negative connotations that today attach to that word grew from that rejection). Actually speaking the doctrine makes perfectly good sense—but with an immanent notion of God. The reasons for its rejection are simple enough: unlike al Ghazali’s (or the sufi’s) notion of an immanent God, Christian priests had established a transcendent God in the 4th c. This had been done to secure the priest’s own temporal power as representative of that powerful god. The idea of providential interventions did not mix well with the doctrine of a transcendent god. A transcendent god who also made providential interventions was so powerful, and man so helpless in comparison, that the doctrine of sin (the priest’s other weapon of behaviour control) stopped being credible.²⁴ Providential interventions had to be rejected to preserve the doctrine of transcendence in combination with the doctrine of sin. This theological compulsion led to theological consensus on rejecting Providence, a consensus which suited the priest’s temporal ambitions. It is this theological consensus which is reflected in this terminology of “laws”. In the absence of Providential interventions, how did god control the world? Through these “laws”!

Obviously this terminology about “laws” of physics and the related theological decision are so much nonsense from any serious scientific point of view. It is strange that neither physicists nor philosophers nor historians have objected to this nonsense in so many centuries, and we continue to mislead our children by teaching them about the “laws” of physics. This is how indoctrination is perpetuated! Sadly, those who preach science lack a scientific attitude, and accept such things uncritically. As far as I know, no physics experts in the last 61 years since independence has objected to the intrusion of this religiously biased viewpoint in Indian school texts.

It would be rather more appropriate and scientific to speak of physical models of the world. Newton

22 S. A. Kamali, *Al-Ghazālī, Tahāfut al-Falāsifā*, Pakistan Philosophical Congress, Lahore, 1958.

23 C. K. Raju, “Broken Time, Chance, Chaos, Complexity”, chp. 6 in *The Eleven Pictures of Time*, cited above.

24 For a quick account, see, C. K. Raju, “Benedict’s Maledicts”, *Indian Journal of Secularism*, 10(3) (2007) 79-90.

was aware of this possibility; he was aware that his propositions might only be in the nature of tentative hypotheses. But he thought himself to be a prophet. He thought that God had revealed to him a bit of his mind. Therefore, in his notes he cancelled the word “hypothesis” (*hypothesi*) and replaced it with the word “law” (*lex*). Anyway those divine laws that Newton thought he had found stand discredited today. Newton hadn’t read the mind of God, as he thought, and wasn’t quite the prophet he took himself to be. (Although Newton really was an outstanding theologian, and Bible scholar, this part of Newton’s work has been suppressed²⁵ in the persistently dishonest²⁶ history that British historians have told about him.)

Absence of empirical data

No Western historian, to my knowledge, has commented on the curious fact that the theory of planetary motion in the West developed *without* the availability of appropriate planetary data. To begin with, every purported observation in “Ptolemy’s” *Almagest* is fabricated, and obtained by back-calculation. There is not a single known exception to this.²⁷ (While this opinion is that of another Newton, I endorse it, and further argue that even the name of its author, “Claudius Ptolemy”, is fabricated! Please treat that as an open challenge.)

To move on to Copernicus, he simply translated the Arabic text of Ibn as Shatir,²⁸ so he needed no observations either. Of course, Western historians have invested Copernicus with that mysterious power of “independent rediscovery”—required so desperately by so many of their “revolutionary” scientists whose hagiographies they have written. (And this mysterious tradition of “independent rediscovery” by Westerners continues to this day with a person who is purportedly the greatest mathematician of the century having “independently rediscovered” my theory in my books published earlier, and mentioned at points 4 and 5 above!) But, as stated earlier, philosophers would be much better off if they were not taken in so easily by this kind of spurious history.

Post-renaissance, astronomical data was needed for navigation and the 16th c. Gregorian calendar reform (itself needed for latitude determination). Regiomontanus proposed a method of “ephemeris time” (found in Indian texts like the *MahaBhaskariya* of Bhaskara I from the 6th c²⁹) which obviously was a method he “borrowed” from the Arabs without acknowledgment. Once again, it is amply clear that, unlike Bhaskara, for Regiomontanus, theory preceded observation: this method did not work

25 Ref 4 above.

26 I. Newton, *History of the Church*, 7 vols., suppressed since 1732. After drafts of this suppressed material became public in 1950’s and again in the later 1960’s a revised biography of Newton was produced by Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton*, [1980], Cambridge University Press, paperback edition, 1983. However, in 800 odd pages, Westfall does not explain what it was that obsessed Newton for 50 years. (Newton thought the Bible had been distorted through forgery, and produced an enormous amount of evidence to prove that. That is the reason to continue suppressing his work.) Therefore, Cambridge historians, such as D. T. Whiteside, who edited Newton’s papers, seem to have thought they could merrily continue this long-standing tradition of utterly dishonest history, by striking poses, and abusing those who exposed it. See my responses to D. T. Whiteside at <http://mathforum.org/kb/message.jspa?messageID=1184739&tstart=0>, <http://www.mathforum.org/kb/thread.jspa?threadID=383956&messageID=1184740> and <http://ckraju.net/blog/?p=14> etc.

27 R. R. Newton, *The Crime of Claudius Ptolemy*, Johns Hopkins University Press, Baltimore, 1977.

28 Otto Neugebauer, “On the Planetary Theory of Copernicus,” *Vistas in Astronomy*, **10**, 1968, pp. 89–103. George Saliba, “Arabic Astronomy and Copernicus”, chap. 15 in *A History of Arabic Astronomy*, New York University Press, New York, 1994, p. 291. The heliocentric theory was one of the competing theories in Indo-Arabic astronomy for several centuries prior to Copernicus, and references to it may be found even in the poetry of Amir Khusrau, a 14th century CE poet of Delhi.

29 *MahaBhaskariya*, II.8.

because the observations (ephemerides) available to Vasco da Gama were of too poor quality to be actually used for navigation.

A century later, Clavius' calendar reform in the 16th c. was again based on data from *texts* since his astronomical observations were of too poor quality even to determine the length of the year—something known to Indians and Buddhist calendar makers in China from a thousand years earlier.³⁰ The pope admitted as much, in his bull announcing the Gregorian calendar reform, which claimed it was somehow based on the “Alphonsine tables”.

Tycho Brahe did try to do things empirically, but obviously he hadn't got very far, by the time of the 1582 calendar reform. His idea of copying the Samarkand observatory, by building large masonry instruments in Europe, failed because Europe did not have masons with the requisite expertise, so the masonry was not accurate enough. Obviously, Tycho did not go far enough with his observations even to be able to test the so-called “Tychonic” model before his untimely death. How, then, did he arrive at that model in the first place, in advance of his observations? (Obviously he borrowed it from a “pagan” source [Nilakantha], to whose translated works he had access through the Jesuits in Cochin, and whom he was not willing to acknowledge in view of the prevailing Inquisition, considering that he was Royal astronomer to the Holy Roman empire.)

Tycho's assistant Kepler decamped with Tycho's secret books, which he had been debarred from accessing before Tycho's death. Regardless of the truth of the recent accusation that he murdered Tycho for the sake of those secret books, and, of course, for Tycho's lucrative job, which he inherited, the fact is that Kepler was too shortsighted to carry on observations. Therefore, people need to reflect a little more on the real origins of the spectacularly accurate orbit of Mars attributed to Kepler. Was this just a fluke, yet another of those cases of “independent rediscovery” for which the great scientists of the West are especially notorious? Specifically, people need to pay a little less attention to the stories which came from this man who was an astrologer by profession, hence a professional liar³¹—being in the sort of profession that the Buddha clearly called an unethical means of livelihood.³²

Newton himself remained shut in a room for extended periods. He did not know how to calculate the size of the earth by observation, and his initial estimate of its size was off by 40%, compared to the 1% error in the 9th c. estimates of al Mamun, by direct observation, and the similar estimates of al Biruni, in the 11th c., based on Indian techniques.³³ It was only towards the end of the 17th c. (after Picard in 1672) that the value of this simple astronomical parameter could be determined in Europe. This is something that a child can easily do today.

So, it was only in the 18th c. that serious observational astronomy could be said to have started in

30 *Aryabhataiya of Aryabhata*, trans. K. S. Shukla and K. V. Sarma, INSA, New Delhi, 1976. Even many “experts” today seem to be unable to differentiate between the sidereal year used by Aryabhata, and the tropical year that is assumed by the Gregorian calendar, and hence incorrectly attribute a lower accuracy to Aryabhata.

31 “Planet fakery exposed. Falsified data: Johannes Kepler”. *The Times* (London) 25 January 1990, 31a. The article includes large excerpts from the article by William J. Broad, “After 400 years, a challenge to Kepler: he fabricated data, scholars say”, *New York Times*, 23 January 1990, C1, 6. The key background article is William Donahue, “Kepler's fabricated figures: covering up the mess in the *New Astronomy*”, *Journal for the History of Astronomy*, **19** (1988) pp. 217–37.

32 *Dīgha Nikāya*, *Brahmajāla sutta*, Hindi trans. Rahul Sankrityayana and Jagdish Kashyap, Paramamitra Prakashan, New Delhi, 2002, p. 5. Also, trans. Maurice Walshe, *The Long Discourses of the Buddha*, Wisdom Publications, Boston, 1995, pp 68–72.

33 S. S. H. Rizvi, “A newly discovered book of Al-Biruni: ‘Ghurrat-uz-Zijāt’, and Al-Biruni's ‘Measurements of Earth's Dimensions’”. In: *Al-Biruni Commemorative Volume*, ed. H. M. Said, Hamdard Academy, Karachi, 1979, pp. 605–80.

Europe. So, it is understandable why Newton's laws really proceeded more from theological motivation than from any empirical data related to planetary orbits, regardless of all the myths that we have heard about the methods of science.

The Indian approach to the problem of planetary orbits was far more scientific: there were these empirically observed motions for which people had invented various methods of calculation. The observations went on for thousands of years. Even alleged astrologers like Varahamihira explicitly preferred observations over the scriptural authority of the Veda.³⁴ This tradition was also carried by Buddhist monks to China, where they were responsible for calendar-making. The repeated revisions of astronomical models show that the calculations were being constantly checked against observations. That is how Nilkantha arrived at his "Tychonic" planetary model long before Tycho (and it had elliptical orbits, because the epicycles were of variable radii).

The religious roots of Western mathematics

Before going on to further subtler aspects of Newtonian planetary theory, let me mention in passing the question of the "unreasonable effectiveness of mathematics". I don't see what is the great mystery that is being made out about this. The prevailing theological opinion in Newton's immediate surroundings was that Nature was the work of God, and that this work of God was written in the language of mathematics. Why mathematics? Because mathematics was regarded as perfect, and mathematical truths were regarded as universal, immutable, and binding even on God.

The origin these religious beliefs about mathematics can be traced to another set of theological conflicts. I will not go here into too much detail regarding this. However, the very word mathematics derives from *mathesis*, meaning learning.³⁵ Hence, the Neoplatonists regarded mathematics as the science of the soul. Plato thought all learning is recollection of past lives.³⁶ That is why Socrates in *Meno* demonstrates the slave-boy's learning and claims that is proof of the existence of the soul (hence past lives). Similarly, Proclus explains that Socrates specifically used geometry for this process, since mathematics concerns eternal truths best suited to move the soul. (Hence, mathematics is called the science of learning, and means the science of the soul.) Proclus, in fact, thought the existence of eternal truths entailed an eternal cosmos. He explained why geometric figures or images served to move the soul (just as Porphyry had explained idols as books written in stone, which move the soul).

The deeply religious nature of these beliefs about mathematics and the soul is made even more evident by the way the beliefs were involved in the ideological conflict between philosophers and post-Nicene Christian theology. For example, the church declared Proclus a heretic, at about the time that Justinian shut all schools of philosophy in the Roman empire in 529. This is the same Proclus who wrote a commentary on the *Elements* (a passage from which is touted as the chief source of information about Euclid). The reason for declaring Proclus a heretic is found in the apology against him written by the priest John Philoponus, who objected to the idea that the universe exists eternally, as is clear from the very title of his book: *On the Eternity of the Cosmos: Against Proclus*. The reason is not far to seek:

34 Varāhamihira, *Pancasiddhāntikā*, III.21, Tr. G. Thibaut and Sudhakara Dwivedi, [1888], Reprint, Chowkhamba, Varanasi, 1968, p 18.

35 Proclus, *A Commentary on the First Book of Euclid's Elements*, trans. Glenn R. Morrow, Princeton University Press, Princeton, 1992, 47, p. 38.

36 Plato, *Meno*, 81–83. *The Dialogues of Plato*, trans. B. Jowett, *Great Books of the Western World*, vol. 7, R. M. Hutchins, ed. in Chief, Encyclopaedia Britannica, Chicago, p. 180.

Proclus' belief in an eternal cosmos, like the Buddhist belief, went against Augustine's doctrine of apocalypse, and the associated doctrine of sin which was a key source of temporal power for the priest. (Proclus' belief in an eternal cosmos, unlike the Buddhist belief, was entailed by the specific idea that the truths of mathematics are eternal, and *that* entails an eternal cosmos.)

Similarly, Justinian also cursed the belief in past lives (usually called the anathemas against pre-existence, or the curse on "cyclic" time)³⁷ But the belief in these past lives was implicit in the very name mathematics, derived from *mathesiz*, or learning, as we have seen. And so on. As is well known philosophy was banned from the Roman empire in 529 and it moved on to Jundishapur and then, eventually, Baghdad, where these religious beliefs about mathematics continued within what has come to be known as Neoplatonism.

In India, in contrast, mathematics was seen as purely utilitarian. (Although some incompetent historians have tried to suggest that the *sulba sutra* was related to "ritual geometry" there was no similar connection between geometry and religious beliefs in India, as there was among the Greeks. The *sulba sutra* were only used for the practical purpose of constructing brick structures.) The empirical was not regarded as inferior: mathematical proofs employed empirical techniques right from the days of the *sulba sutra*. Mathematics and mathematical proof were not a special aspect of metaphysics as they are in the West even today:³⁸ mathematical proof in India was no different from any other kind of proof (although, obviously, no one used *sabda pramana*).

However, through Plato-Kant-Hilbert, the West has a long history of regarding empirical techniques as less certain than metaphysical techniques (based on Western metaphysics): for example, empirical techniques involve induction which is regarded as less certain than deduction. These beliefs received strong theological support in the 12th c. because of the theological argument from creationism. The argument went that empirical facts did not bind God, who could create a world of his choice, but logic did bind God, and God could not chose to create an illogical world. This argument was accepted by both al Ghazali and Aquinas. However, there is no reason for scientists to accept this argument. Metaphysical techniques can never be more certain than empirical one's. For example there is no agreement even in the matter of logic: Buddhist logic differs from "Aristotelian".

Anyway, the point is that this long Western tradition of religious beliefs about mathematics coloured Newton's understanding of mathematics and through that his physics. Acceleration is the time-derivative of velocity, and to define this time derivative, in what he regarded as a properly mathematical way, Newton introduced his doctrine of fluxions and along with it, the idea of time as a continuum. Of course, as Berkeley pointed out, Newton was wrong, like Leibniz (and both those theories of fluxions and differences had to be abandoned). Nevertheless, formal mathematics has substituted them with the idea of formal limits within formal real numbers. As already stated, I have rejected this idea, and pointed out how calculus can be done better without limits, without the continuum, and using a philosophy of zeroism—very close to *sunyavada*.

37 For more details, see, C. K. Raju, "The curse on cyclic time" . Chp. 2, *The Eleven Pictures of Time*, cited above.

38 Specifically, the very idea of refutability is based on the belief that empirical observations cannot refute the deduction that connects a physical hypothesis to its empirical consequences. For more details, see C. K. Raju, "Proofs and refutations in mathematics and physics" , in P. K. Sengupta (ed) PHISPC, to appear.

Newton's law of gravitation

However, in this paper, I do not want to digress too far from the present topic which concerns astronomy. I want to return to the concept of force, specifically the force of gravitation which Newton is credited with having introduced. Voltaire made light of Newton's concept of gravity, by pointing out that if Newton had not used the word "attraction" to which a different connotation applied in France, he would have been taken more seriously by the French!

However, I want to ask more seriously about the origin of this mysterious force of attraction. Let us go back to the issue of empirical observation. Indians observed the sky. They observed that most of the stars go round in circles. To be sure there were different theories to account for this: whether it was the stars that went around or whether, as Aryabhata thought, it was the earth which rotated. However, the point is that circular motion was the observed norm.

Since circular motion was the norm, it required no explanation. What required explanation was the motion of the planets, which did not obey the norm. And that was explained by means of epicycles, which again involved circular motion (which needed no explanation). At any rate the epicycles enabled the calculation of planetary motion to a high degree of accuracy, and it was this calculation which was of practical value in timekeeping.

However, Newton's point of departure was the straight line. The most casual observation shows that straight lines are not natural. This is easily proved: some time ago, the possibility of straight lines on Mars was taken as evidence of the existence of life on Mars. So straight lines are naturally regarded as not natural (though they are a strong part of Western culture). What empirical observation then suggested Newton's first "law": that a body (whatever that means) naturally moves in a straight line? Obviously none. Newton conceded at the beginning of his *Principia* that there is no place in the world where one could say there is no force acting. So he would have conceded that bodies will *never* be actually observed to move in a straight line anywhere. It was just his religious belief that God had written the book of the world in the language of mathematics. And the fact that the mathematics that the West then knew was predominantly geometry—the sort of geometry which took the straight line (and triangles) as its starting point. Therefore, Newton took it for granted that God must have used straight lines while constructing the world! (Needless to say, Newton also used the corresponding notion of geometric points: when Newton spoke of a body, he was thinking of points—mass points to be precise.)

Anyway, the point is that just because Newton's point of departure was—axiomatically—the straight line, he needed to be able to explain circular motion. I should have clarified that in the preceding sentence, I used the word "Newton" somewhat in a generic sense, to refer also to Newton's contemporaries and predecessors. Descartes likewise thought that the straight line was the natural starting point of geometry, and he grandiosely opined that understanding the length of a curved line (in terms of a straight line) was beyond the capacity of the human mind³⁹—though this is a task that was done in India since the *sulba sutra*, and can be easily comprehended by a child, and was part of the traditional Indian mathematics syllabus. Western thought, because of its deep-seated theological moorings, revelled in making the simplest things look enormously complex, and it is this theological dross that has made a simple subject like mathematics so difficult today. Descartes' belief, like that of

³⁹ R. Descartes, *The Geometry*, (trans. David Eugene and Marcia L. Latham.) Encyclopaedia Britannica, Chicago, 1996, Book 2, p. 544.

Galileo, was in the context of the measurement of curved lines, using the calculus, recently imported from India, and avidly taken up by his contemporaries, Fermat and Pascal.

To retrieve the thread of the argument: just because “Newton’s” point of departure was the straight line, he needed an explanation for what other cultures regarded as most natural and not requiring explanation: circular motion. Of course, such an explanation was available also with Newton’s colleagues—particularly Hooke. This “explanation” took the form of an inverse square law force. Assuming straight line motion to be natural, circular motion can be “explained” by means of an inverse square law force.

To reiterate: what is naturally observed is circular motion, the circular motions of the multitude of stars for example. Prior to Newton this was not thought to require explanation. But if one insists, for reasons of religious belief, in asserting that the only “natural” motions are straight line motions (as in Newton’s first law), that straight-line motions are the only sorts of motions that do *not* require explanation, then it becomes mandatory to provide an explanation for circular motions. This explanation took the form of a postulated inverse-square-law force. Even a non-mathematician like Hooke could readily work out that for the case of circular motions this postulated force must have the character of an inverse square law.

Where Newton scored over Hooke was in being able to prove that the same force would work also for elliptic orbits. (Not to mention the parabolic projectile trajectories of Galileo.) Newton’s success in putting together the circle, the ellipse and the parabola was actually a matter of calculation, which depended very much on the calculus techniques imported from India, but people at that time seem not to have been able to pinpoint the exact causes of the success. The key difficulty that Europeans had with curved lines, and the calculus, related to *sunyavada*, but that is another story.