Draft

Science and equity

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It is widely believed that science is value free—at least that the *content* of science is value free, and represents objective truth. However, to the extent that science is a human enterprise might one not expect it to be infected with a variety of human foibles? Today, most school children are first exposed science through "Newton's laws". Why are these called "laws" and not "Newton's hypotheses" for example? Newton, a deeply religious person, thought he had an answer to this question: he thought that the laws with which God controlled the world had been revealed to him. Therefore, in his notes, Newton cancelled the word *hypothesi* (hypothesis) and replaced it with *lex* (law). The rest of us blindly imitate that nomenclature, and many even regard Newton as some sort of prophet of science, for it is this belief in revelation and this religious view of the cosmos controlled by divine laws that is perpetuated by the terminology of "Newton's laws".

Of course, this example pertains to nomenclature. But can we say that the *content* of Newton's laws was similarly influenced by Newton's religious beliefs? Indeed we can. But it is hard to explain this to the layperson who has little understanding of science. It is equally hard to explain this to the scientist who has little understanding of theology—or indeed of anything beyond his own narrow field of specialisation.

Nevertheless, let me try to explain briefly how the theology of inequity has penetrated into the content of science. I will also point out the solution: how one can move towards a more equitable science. This is a highly condensed and simplified account of what I have explained in more detail in three books and several technical articles.

How could a hard science like physics, concerned with the empirical, be affected by religious beliefs? A prior this seems impossible. Would "Newton's laws" have been any different had they been formulated by someone other than Newton? The answer is: yes. How? The key issue here is the notion of time. Physics measures and quantifies, so it must also measure time.

But how is time to be measured? More specifically, how does one decide that two intervals of time are equal? Obviously one must use a clock. But which clock? Will any clock do? Can I use my heart-beats as a clock? Obviously no, for if my pulse races, the times declared to be equal by my heart-beats may not be "truly equal". It is not clear that a mechanical clock would do better: I must use a special sort of clock which understands "equal intervals of time". But, what exactly are "truly equal" time intervals?

Newton's teacher, Isaac Barrow, had suggested a principle of uniformity of causes as a way of measuring time: equal causes take equal times to produce equal effects. If a sand glass is inverted, nothing has changed, there is the same amount of sand in the glass, the size of the hole remains the same, so the times that the sand takes to fall through must also be equal. Certainly this gives us a way to measure times that are *approximately* equal. But how can we be sure that the time intervals in question are *exactly* equal? After all, over a period of time the size of the hole would increase, and the sand clock would run faster like my pulse. Newton conceded that he did not know of any physical process by which truly equal intervals of time could be measured. He allowed, for example, that the days and nights are truly unequal. He even conceded that there may be no "equable motion", no

physical way in which equal intervals of time could ever be measured. Nevertheless, he was satisfied by postulating a *mathematical time*.[1] He thought of this mathematical time as time known to God, and God knows how to decide equal intervals of time. So Newton's answer to the question of time measurement was this: whether or not humans had a way to measure time, God knew how to do it!

God has no place in physics; Newton's god was an intruder. We know that Newton's physics failed precisely on this point, and had to be replaced by the (special) theory of relativity. The guiding principle for the theory of relativity was that a definition had to be provided for "equal intervals of time", since the phrase had no meaning of itself as Poincaré emphasized. One cannot, for example, lay two time intervals end to end and compare them. Therefore, equality of time intervals is a matter of convention or definition. Poincaré also enunciated the principle of *convenience* to guide such a definition: one ought to define "equal intervals of time" in such a way as to keep physics as simple as possible. Therefore, Poincaré declared that the speed of light should be *postulated* to be a constant. Since the speed of light was postulated constant for all (inertial) observers, a particle of light (photon) bouncing between parallel mirrors would mark equal intervals of time. So one could now define a proper clock. (All this is, of course, far removed from the text book account that the Michelson-Morley experiment[2] proved the constancy of the speed of light, and that Einstein[3] built the theory of relativity based on that; however, the text-book story has little to do with facts, and I have been contradicting this account for so long now, that I am bored of doing it, and I am amused by the fervour with which people cling to their misconceptions without any basis.)

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1 Newton's quote from his *Principia* is well known. "Absolute, true and *mathematical time*, of itself, and by its own nature, flows equably *without relation to anything external*...". People, however, often fail to reflects on the parts I have italicised. Isaac Newton, *The Mathematical Principles of Natural Philosophy*, A. Motte's translation, revised by Florian Cajori, University of California Press, Berkeley and Los Angeles, 1962, vol. 1, pp. 6, 7–8.

2 The Michelson-Morley experiment was not performed to measure the speed of light. It was performed to discriminate between the theories of Fresnel and Stokes. It concluded in favour of the Stokes theory, which was mathematically incorrect. Hence, Lorentz rejected this conclusion. Miller later claimed to have found an aether drag, but as Synge points out, the experiment could not have told us anything about the speed of light, but only about the rigidity of the slab of stone on which the apparatus rested. E. T. Whittaker, *History of the Theories of Aether and Electricity*, vol. 1, Thomas Nelson, London, 1951. C. K. Raju, "On Time: 3A. The Michelson-Morley Experiment", *Physics Education* (India), **8** (1991) 193-200. C. K. Raju, "Time: What is it That it can be Measured" *Science & Education* (Kluwer/Springer BV), **15**(6) (2006) pp. 537–551. J. L. Synge, *Relativity: the Special Theory*, North Holland, Amsterdam, 1956, pp. 161-2.

3 As Whittaker further pointed out in the much maligned vol. 2 of his book, and in Einstein's obituary for the Royal Society, Einstein merely repeated Poincaré's ideas, using Poincaré's words. Whittaker regarded Einstein's claim to independent rediscovery as invalid, since Einstein even used Poincaré's word "relativity" for the theory. (Before 1904, Poincaré had used the phrase "principle of relative motion".) I have pointed out likewise that Einstein used the strange term "longitudinal mass" used by Lorentz, whose paper he denies reading. More importantly, like so many who copy without acknowledgment, Einstein made a mistake in understanding (the mathematics of) even the special theory of relativity. This mistake persisted in the physics literature, until M. Atiyah in his 2005 Einstein lecture claimed credit for having independently rediscovered *my* earlier published account about how Einstein's mistake ought to be corrected, and what the consequences were. (In this process, Atiyah, too, made a mistake, another mistake!) E. T. Whittaker, *History of the Theories of Aether and Electricity*, vol. 2, Thomas Nelson, London, 1951. C. K. Raju, "On Time: 3B. Einstein's Time", *Physics Education* (India), **8** (1992) 293-305. C. K. Raju, *Time: Towards a Consistent Theory*, Kluwer Academic, Dordrecht, 1994, chp. 5B "Electromagnetic Time". C. K. Raju, "The Electrodynamic 2-Body Problem and the Origin of Quantum Mechanics" *Found. Phys.* **34** (2004) 937–62 draft available at http://arxiv.org/abs/quant-ph/0511235. For a popular account, see "Einstein's mistake", C. K. Raju, *The Eleven Pictures of Time*, Sage, 2003, pp. 298-303. G. W. Johnson and M. Walker, "Sir Michael Atiyah's Einstein Lecture", *Notices of the American Mathematical Society*, **53** (6) June/July 2006, pp. 674–78. Available at http://www.ams.org/notices/200606/comm-walker.pdf. M. Walker, *Notices of the AMS* **54** (4) (2007) p. 472, available at http://www.ams.org/notices/200704/commentary-web.pdf. For Atiyah's mistake, see C. K. Raju, "Is this Ethical?" (unpublished) letter to the *Notice of the AMS*, http://11PicsOfTime.com/IsThisEthical.pdf.

God intruded into physics through Newton's mathematical time, which had no relation to anything external, and chasing out the intruder led to the theory of relativity. So physics *can* change (and has changed) in an important way by casting out theological beliefs. But the transition from Newtonian physics to relativity is not the end of the story. I have not yet explained how the theology which Newton cherished was inequitous and I have not yet explained how to move to a more equitable science.

So next let us understand how the theology which Newton cherished was inequitous. This again concerns the notion of time. Notice that Newton took for granted that time was a straight line. This decision, too, was *not* guided by physics. Newton's predecessor, Isaac Barrow had declared that time was either a straight or a circular line: for this was the limited understanding of time in traditional Christian theology. Newton, due to his theological predilections (prophecy, revelation etc.), took it for granted that time was a straight line.

To understand how time as a straight line relates to inequity, we need to go back a long way to Christianity before Constantine. Its chief exponent, Origen of Alexandria cherished equity. This belief in equity was related to the belief that time was *quasi*-cyclic. Origen thought that the cosmos went through a series of cycles. In each cycle of the cosmos events were roughly but not exactly the same. So, he thought that people were reborn in successive cycles of the cosmos. He thought that in each cycle, God rewarded or punished people by allotting to them appropriate stations in life. This is similar to the *karma-samskara* view so well known in India, and regarded as the basis of casteist inequity today. Origen, however, took it as the basis of equity on the following grounds. He said that God believed in equity and justice. The proof that God believed in equity was that he had created all people equal, and he demonstrated his belief in justice by rewarding or punishing people according to merit, in successive cycles of the cosmos.[4] The other aspect of Origen's belief in equity, and a key aspect, was that this reward or punishment (and for that matter ultimate redemption) did not depend upon whether or not one professed Christianity: all people were equal. In fact, Origen's God was immanent: all people were equal just because his God was *in* all—equally a part of all human beings.

After Constantine, church and state came together. The key problem was that the priest now wanted to rule, but had no weapons with which to strike terror in the heart of his enemies (or followers). The priest's only weapon was the advice he gave to the ruler. This was an insecure way to rule, for the advice could be rejected. This point was brought home when the Roman emperor Julian suddenly brought back all those whom the priests had earlier exiled under Constantius. Since the priests could not take up weapons, and no one was frightened by a doctrine of universal love and equity, the ruler-priests refashioned the Christian doctrine itself into a weapon that could strike terror in the hearts of people.

Augustine was a key architect of this change (though, of course, many others like Jerome and Justinian were involved, and the process of change took some two centuries). In summary outline, the key objectives of the changed were to ensure the following. (a) Those who professed Christianity should be offered the hope that they would derive a permanent and obvious advantage (both from Caesar and from God). (b) Those who disobeyed the priest might yet forfeit this advantage, and (c) there was an urgency to declare one's loyalties.

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4 Origen, *De Principiis*, Book II, chap. 9. Frederick Crombie, trans., *The Writings of Origen*, vol. X in *Ante Nicene Christian Library*, ed. Alexander Roberts and James Donaldson, T&T Clark, Edinburgh, 1895, p. 132. In the Catholic Encyclopaedia on Origen many more details are in Book II of *De Principiis*, Chap. III "On the Beginning of the World and its Causes", http://www.newadvent.org/fathers/04122.htm.

All this was achieved through a transformation of time perceptions. Augustine advocated apocalyptic time. He argued that the cosmos had been created a few thousand years ago,[5] and would soon end in an apocalypse, after which his god would judge people, sending some to heaven, and casting others into hell for eternity. Agenda point (a) was easily achieved: for Augustine's god the religion that the individual had professed was a key criterion to decide who went where. The inequity is made evident in painful detail by Dante: there were no non-Christians to be found in this heaven! Origen's conception of heaven admitted non-Christians, and was but a temporary place where the soul went for higher education, between lives on earth. (Agenda point (b) was achieved through the doctrine of sin, and agenda point (c) was achieved by giving a short life to the cosmos—doomsday was just round the corner.) Augustine destroyed the very basis of equity in immanence, by making his God transcendent, to be spellt with a capital G.

The exact connection between Augustine's apocalyptic time and Newton's straight line is the following. In a masterpiece of propaganda, Augustine misrepresented Origen's quasi-cyclic time as supercyclic time, and argued against supercyclic time.[6] Consequently, even today most people fall into the trap of thinking in terms of a dichotomy of linear time vs cyclic time, and hence cannot discriminate quasi-cyclic time from supercyclic time. Barrow articulated this same dichotomy of linear vs cyclic time, and Newton selected the linear version since apocalypse was the great hope in his life. Thus, the inequitous Augustinian theology of apocalyptic time crept into physics through Newton's religious predilections for time as a straight line. (Physicists are long accustomed to Cartesian plots which inevitably show time as a straight line, but in 3 centuries no one seems to have asked on what basis the local or global structure of time was decided.) In any case, it is clear that the theology which influence Newton was inequitous by design.

It remains to explain the last matter of how to move towards a more equitable science. The first step here is to examine more carefully exactly how physics has changed after relativity. The notion of equal intervals of time is also closely related to the notion of simultaneity—by changing the definition of equal intervals of time, relativity has also changed the notion of simultaneity. Newtonian physics admitted action at a distance, but Newtonian forces acted instantaneously. However, the speed of light can be constant for all (inertial) observers only if it is a limiting speed. Hence, distant forces need time to act, their action would be delayed or retarded. In mathematical terms, what this means is that, after relativity, we must replace the ordinary differential equations of Newtonian physics by functional differential equations. This point was noticed by Poincaré but overlooked by Einstein who did not know enough mathematics, and made a lifelong mathematical mistake in thinking that functional differential equations could be approximated by ordinary differential equations.[7]

The next step brings us face to face with another deep seated religious prejudice, often passed off as a physical principle and called the "principle of causality". Physicists often claim that influences can only travel from past to future, and not the other way around. Perhaps the world is actually like that, and one could make this claim on empirical grounds, but why on earth should this be a theoretical "principle"? One can better understand this as a religious principle. To send an individual to heaven or hell, God needed to identify that individual as the cause of some good or bad deed. In the absence of a

5 Augustine, *The City of God*, in *Augustine*, trans. Marcus Dods, vol. 16 in *Great Books of the Western World*, ed. R. M. Hutchins, Encyclopaedia Britannica, Chicago, 1996. 'Reckoning by the sacred writings, we find that not 6000 years have yet passed', XII.10, p. 402.

6 Augustine, cited above, XII.13, p. 404.

7 Specifically, Einstein, in his treatment of the many body problem, approximated delay differential equations by ordinary differential equations by expanding in powers of the delay, a procedure known to be incorrect. A. Einstein, L. Infeld, and B. Hoffman, *Ann. Math*. 39 (1938) 65. C. K. Raju, *Time: Towards a Consistent Theory*, cited earlier, p. 122. As explained in that book, the two types of equations have fundamentally different qualitative features.

clear notion of cause, Augustine's god would be lost, and would not know how to perform the task allotted to him by Augustine. In my view, the right way to proceed with regard to this "principle of causality" is to formulate a theory which does not respect it, and see what its empirical consequences are, and check whether they correspond to the real world.

Unfortunately, it is almost impossible to discuss the matter intelligibly in current physics because Augustine's trap—that old dichotomy of linear vs cyclic time—has created such an enormous amount of confusion. Take for example Stephen Hawking's arguments to support the chronology condition (which he needed to prove the existence of singularities).[8] Hawking's argument reproduces Augustine's. As stated above, Augustine first misrepresented Origen's position, confounding Origen's quasi-cyclic time with supercyclic time. Next, Augustine argued against supercyclic time that it would involve repeated crucifixion of Jesus Christ. Likewise Hawking talks of a spaceship repeating its history endlessly. This argument involves the worst sort of conceptual confusion imaginable, for it invites us to see the events in one kind of time from an out-of-the-world perspective where there is another sort of time! Like Augustine, Hawking rejects the repetition of history on the grounds of "free will" using (like Augustine) the quibble of "fatalism" to eliminate this situation (which he regards as undesirable) while retaining the usual determinism of science (or God in Augustine's case) which he regards as desirable. More recently, there are the attempts to resolve the grandfather paradox[9] and other paradoxes of time travel using similarly confused reasoning. I cannot go here into all the intricacies of these arguments. Suffice it to say that a simple resolution of these paradoxes is possible since allowing interactions from the future leads to spontaneity, the exact anti-thesis of determinism or fatalism. This is evident enough: if influences arrive in the present from the future, the past does not decide the present. Augustine's arguments, like those of some contemporary physicists, are much more accurate if we stand them on their head.

If we do allow influences from the future, this leads to a different mathematical model: functional differential equations with mixed-type deviating arguments. I have described this situation as "a tilt in the arrow of time", but I emphasize that this involves no new hypothesis. The equations involved are just t*he most general form of the equations of physics, after relativity*. It is causality that is a hypothesis, and the "tilt" simply refers to the rejection of this hypothesis. A reviewer aptly quoted Bohm on this point out that progress in physics is made by dropping hypothesis, not by adding them.[10] A "tilt" simply means that the hypothesis of causality has been dropped.

So we have a new scientific theory. Officially, the validity of this theory is yet to be established, but it seems to me that the most mundane observation corroborates the soundness of this theory. (Further, the theory anyway assumes nothing beyond current physics—only the hypothesis of causality has been dropped.) The key empirical consequence of the theory is spontaneity,[11] and we have ample reason to believe in this from repeated mundane observation.

(In deciding the validity of this new theory, we cannot go by the physicists' naïve idea that a theory must "predict the future": this idea of prophecy is another religious prejudice specific to Christianity;

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8 S. W. Hawking and G. F. R. Ellis, *The Large Scale Structure of Spacetime*, Cambridge University Press, 1974, p. 189.

9 Kip S. Thorne, *Black Holes and Time Warps: Einstein's Outrageous Legacy*, W. W. Norton & Co., New York, 1994. A more quantitative account may be found in M. S. Morris and K. S. Thorne, 'Wormholes in Spacetime and their use of Interstellar Travel: A Tool for Teaching General Relativity', *Amer. J. Phys.*, **56**, 1988, pp. 395–412. My account of of how the grandfather paradox should be resolved is explained for the layperson in C. K. Raju, "Time Travel", chp. 7 in: *The Eleven Pictures of Time*, Sage, 2003.

10 J. F. Woodward, "An Essay Review of C. K. Raju's *Time: Towards a Consistent Theory* (Kluwer Academic: Dordrecht)", *Foundations of Physics* **26** (1996) 1725–1730.

11 C. K. Raju, "Time Travel and the Reality of Spontaneity", *Found. Phys.,* **36**(7) (2006) pp. 1099-1113. Draft available online at http://philsci-archive.pitt.edu/archive/00002416/01/Time_Travel_and_the_Reality_of_Spontaneity.pdf.

science has nothing really to do with prophecy. Popper's criterion of refutability is on a sounder philosophical footing, but we cannot even go by refutability here, because that criterion itself involves the assumption of mundane time, which conflicts with the superlinear time of Newtonian physics. Moreover, without realizing it, Popper also assumed the absence of a microphysical structure of time which would change the 2-valued logic he took for granted. In this situation one could no longer assume, what Popper did, that mathematical theorems capture necessary truth. In fact, since physics is done using mathematics, the influence of theology on mathematics involves another dimension of the influence of theology on science. I will not however go into these questions here.[12])

However, setting aside the question of exactly how the validity of such a physical theory ought to be established, what does this new scientific theory have to do with equity? To understand this, recall that the value of equity historically derived from the belief in immanence. (This is a lesson that all Marxists ought to learn, especially in times when the value of equity is being fundamentally denied.) Newtonian physics made man mechanically obedient to the laws of Newton's transcendent god. The fate of the entire world was scientifically decided by Newton's laws, once one knew its state at any point of time. (That is, by solving the relevant ordinary differential equations, the state of the world at any instant of time, past or future, could be calculated from a knowledge of its state at present. The arguments about chaos etc. are little different from the medieval theological arguments which sought to reconcile the determinism arising from the supposed omniscience of the transcendent god with the "free will" required to justify the punishment of men in hell.) The new scientific theory breaks this mechanical tradition of physics, and restores spontaneity and creativity to human beings and to the world at large. The cosmos is not a giant piece of clockwork made by some god, it is built by us. The difference may be described thus: man can surprise God, and create a world that was not part of God's plan for the cosmos!

To that extent, the new scientific theory brings back immanence, hence equity. Creation was not the one-time activity of a transcendent god. Creation is a continuous process in which all of us participate. Each instant, each one of us willy-nilly creates something, and the future world at the next instant, is a consequence of all these creative efforts. This future world is not decided by a bunch of laws ("Newton's laws") put up by a transcendent god; nor is it decided by the entire past. Man can transcend both science and history. There is room for each one of us to decide something about what this future world will be like. Admittedly, the cosmos is a vast place, and each individual can make only a small contribution, but the future is decided by the totality of these small contributions. If creativity is the sign of godhood, each one of us is a small part of god. We are all equal because we are all equally a part of this god, in the sense that we all have equal potential to create the future.

In this situation where the future is created by us, the natural movement is towards equity and justice. People will remain dissatisfied with anything less, and will ceaselessly make attempts to create a future world in which equity, justice and harmony prevail, no matter how long that takes.

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12 C. K. Raju, "The Religious Roots of Mathematics", *Theory, Culture & Society* **23**(1–2) (2006), Spl. Issue ed. Mike Featherstone, Couze Venn, Ryan Bishop, and John Phillips, pp. 95–97. More details in C. K. Raju, *Cultural Foundations of Mathematics*, Pearson Longman, New Delhi, 2007. More related information can be obtained from http://IndianCalculus.info/.