Wilton Park

Image: CERN

Conference report

The Big Bang and the interfaces of knowledge: towards a common language?

Monday 15 – Wednesday 17 October 2012 | WP1180

Held in Nyon, Switzerland

In partnership with:

CERN

In association with:

Sir Halley Stewart Trust

Wilton Park

Conference report

The Big Bang and the interfaces of knowledge: towards a common language?

Monday 15 – Wednesday 17 October 2012 | WP1180

The Big Bang theory is the prevailing cosmological model for explaining the genesis of the universe. To date it has the wide support of the scientific community because if offers the most accurate and comprehensive explanation for a broad range of observations. It leads to a dating of the universe as 13.7 billion years old.

The purpose of this conference is to enable scientists from a range of disciplines to dialogue with philosophers and theologians from the world religions about the nature of the Big Bang Theory. What understandings might scientists and theologians share in common? How are their paradigms shaped and developed? Is it possible to develop a common framework or language?

Key Explorations

- The nature of what it is to claim to know something in various disciplines.
- Current scientific thinking about the origin and evolution of the universe.
- Understandings of the origins of the universe inherited and developed by different religious traditions
- The relationships between faith and empiricism and the role of knowledge in different communities.
- The possibility and limits of a common language to discuss these matters?
- How we handle new discoveries and incorporate them into existing approaches alongside questions about limitations to human knowledge.

The following enumerated paragraphs represent contributions from a wide range of viewpoints. These are respectfully anonymous in the spirit of Wilton Park discussions. Earlier and often longer pieces are more likely to be prepared presentations. Shorter paragraphs to the end of each major section usually represent comments made in plenary discussions.

Philosophy, religion, and the nature of scientific knowledge

How do different communities hold knowledge? What are the legitimate aims of scientific endeavour? How should scientific results be interpreted? Is it scientific to make truth claims? What is the relationship between faith and reason? How are religious truths claims knowable? What do religious and scientific paradigms have in common?

1. The physicist and Catholic priest, Georges Lemaître proposed the Big Bang theory. The Pope honoured him. Soviet Communism condemned him. So much for the naïve conflict metaphor. Reason and religion are complex terms and we should reject simplistic accounts of their interaction. Records of fruitful interactions of reason and religion are as old as Aristotle. All disciplines benefit from engaging in dialogue. That said, there are many naïve utterances from philosophically careless physicists and scientifically illiterate theologians.
2. Time should not be conflated with our mathematical representation of it. Thus physics must be silent about t=0 and 'before'. Furthermore, we can speak of time in ways other than as a 'space-like' abstraction. Teleology can appear, even in mechanics. From a photon-centric point of view, time and space are 'experienced' rather as Boethius described eternity. Quantitative sciences cannot deal with essentialist questions at all well, whether mundane or metaphysical.
3. Faith can and probably does shape the context within which facts are understood. History seems to indicate some kind of correlation between cultures shaped by certain grand narratives of faith and corresponding scientific fruitfulness. Such cultures have a strong sense of covenant with God, an 'I' to 'Thou' in Buber's terms. The contemporary loss of this can be illustrated in art where our perception of order, and of an Orderer, in the world has been diminished.
4. The history of thinking about science includes those who believe that science is about pursuing truth claims and those of a more instrumentalist mindset who renounce such an approach in favour only of calculations that result in useful outcomes. Osiander, in the preface to Copernicus' 'De Revolutionibus' renounced the idea that scientific hypotheses should seek the truth. Most practicing scientists though, are critical realists, as are most theologians. The central premise here (cf. Putnam) is that mature theories are highly confirmed and make strong predictions. How can this be if they were merely instrumental calculating devices? The 'inference to the best explanation' is a point of similarity between science and theology here. There remains however the question of the relationship between predictive success and truth. Fred Hoyle famously criticised Big Bang theory for being 'rubbish' at making predictions, unlike his own Steady State Theory!
5. Clearly there are a range of views in the scientific community with some explicitly seeking closer approximations to the truth 'out there' and others who eschew metaphysical questions and merely calculate to control the (presumed) independent reality they investigate.
6. The Islamic tradition has included a form of secular science, separate from theological considerations. Faith and emotions will influence what questions we find interesting and valid even if that faith is positivistic.
7. There is non-realism in some accounts of both science and theology. Duhem and van Fraasen, Braithwaite and Cupitt, defend non-realist science and theology respectively. Is this where post modernity inevitably leaves us? Post moderns do not care about truth about unobservables, only about true predictions.
8. Competing worldviews should not be underestimated. Do not confuse faith and the Faith. Careful use of language is important. The same terms can mean different things in different disciplines. In practice though, doing science usually does not involve explicit connections to one's Faith. Scientific truth questions are usually in

relation to experimental data.

9. There are likely to be deeper motivations for the pursuit of science. Neuroscience and psychology may offer important insights here.
10. There are important questions of the public funding of science. Recent utilitarian motivation among funders is less sympathetic to science for its own sake.

Contemporary understandings of Big Bang Theory

How does contemporary cosmology understand Big Bang Theory? How does particle physics inform contemporary understanding? Higgs Boson – Where does the 'God Particle' fit in? Current experimentation and data from LHC at CERN.

11. Creation myths throughout history characteristically have a dark, featureless 'before', and act of creation and the appearance of light and order, after which humankind enters into a friendly environment. The Big Bang theory is similar.
12. The BB is not much different: some, yet to be accounted for, initial state was suddenly ignited, leading to the creation of space, time and matter and to an (almost) perfectly symmetric expansion. Within a billion years galaxies and stars formed, processing the original protons and electrons into the multitude of elements that were needed to create planets and, ultimately, life.
13. This picture surpasses any ancient creation myths! Epistemologically it is very different. 'Predicting' the Big Bang was based on backwards extrapolations from known mathematical laws of physics applied to data about the recession of the galaxies. Traces left in the evolution of the universe can be detected and analysed such as cosmic microwave background radiation and made sense of in Big Bang cosmology. We are pretty certain that the universe came from a small dense volume about 13.7 billion years ago.
14. We can only speculate about what happened before T=Δ~10–11 sec, the time when we believe the Higgs field appeared and particles acquired mass. We can envisage at least three different scenarios for what might have happened before this. The universe may evolve back to a point origin; there may have been a change of state from a pre-existing system; there may have been an expansion following a 'Big Crunch' as part of a periodic cycle. Whatever developments may allow us to go to smaller and smaller T=Δ's, with CMB ripples related to 'inflation' and the like, we cannot provide a complete explanation of the BB itself. This is the terrain where the discussion between science and religion acquires its most fascinating and engaging dimension.
15. Quantum Mechanics may well allow nature to explore its options close to a point like singularity at T=0, but the question remains as to the origin of the laws of physics themselves and of the so-called quantum vacuum, which is something rather than nothing.
16. In the Standard Model of Particle Physics, the Universe and its evolution can be understood in terms of twelve point-like fermions acted upon by forces carried by bosons. They can be classified into two distinct types: quarks, which feel all four of the forces and leptons, which do not feel the strong force. All of the material that we perceive with our senses and indeed everything in the universe except in rare and violent events is composed of just four of these particles, known as the "first generation". For reasons that we do not understand, Nature chooses to replicate this "first generation" with two other generations of four particles, each identical to their opposite numbers in the other generations in all respects except that they are heavier in the second generation and heavier still in the third generation. Indeed, the heaviest known elementary particle, the top quark, has roughly the same mass as an atom of gold. The paradox that a particle with no size can have a mass comparable with an object that can be resolved in the best electron microscopes is

still deeply mysterious. The final element of this so-called “Standard Model” of particle physics is the Higgs Boson, for more than 50 years sought in experiments and finally likely to have been recently discovered in the LHC at CERN.

17. There are other paradoxes and puzzles of the Standard Model. Why do quarks and leptons exhibit the pattern of masses we see in Nature? Why do the interactions have the strengths they do? Perhaps most obvious of all, how can Einstein’s Theory of General Relativity be incorporated into the Standard Model? The only way to answer such questions is to do experiments to investigate them and develop better theories.

18. The most important of these experiments is the Large Hadron Collider (LHC). The LHC proton beams collide 40 million times per second and each collision gives an average of around 20 interactions. Only about one event in every billion is of sufficient interest to be recorded for further analysis and which of these billion events it is has to be selected within about 0.000003 seconds. The data flowing around ATLAS and CMS is comparable to that of a large European country.

19. Although there are many theories to allow us to go beyond the Standard Model with its manifold open questions and arbitrary parameters, so far there is no sign of evidence for them from LHC data. One such group of theories is based around the only remaining so-far-undiscovered quantum symmetry of the Universe, Supersymmetry. This allows the construction of a theory, which has as its basis extended objects (although of unimaginably small length) known as Superstrings that exists in a 10 or 11-dimensional universe whose extra dimensions are curled up so tightly that they are invisible to our senses and experiments. Such theories may give rise to micro Black Holes, tiny analogues of the Black Holes that sit at the centre of most galaxies, which, if they are sufficiently light, could be produced at the LHC. Rather than sucking matter into them, they would evaporate into a myriad of particles almost immediately, via Hawking Radiation. So far there is no sign of any such phenomena. These theories are attractive since they allow Einstein’s Theory of General Relativity to be included in the same mathematical framework as the other interactions. Furthermore, such a theory would have the beauty, which Einstein prized so much in theoretical physics.

20. Feelings of awe are commonplace amongst physicists. Equations that work are seen to be beautiful in the sense of being economical and unifying, compelling and based on simple ideas; simple here in the sense of minimal and compact – “geometric, symmetric and compelling”. We strive for deeper, more accurate and beautiful understanding. A perfect theory would be one that we could not imagine being improved upon. But we should note that even a Theory of Everything may not add anything to the theological and philosophical debates we already have. Weinberg famously said, “With the discovery of the final laws, our daydreams will again contract. There will be endless scientific problems and a whole universe left to explore, but I suspect that scientists of the future may envy today’s physicists a little, because we are still on our voyage to discover the final laws.”

21. It is generally agreed by physicists that we have a clear concept of time within the standard model. Conceptually there are problems arising with both the Planck time in Quantum Mechanics and the breakdown of Relativity Theory at small space-times. Thus we cannot speak meaningfully of a singularity within known physics. We do not know what is meant by ‘time’ below 10 to the minus 45 of a second.

22. Physicists and philosophers need to be clearer in explaining how they use language about time, existence and the like. Science cannot extend its use of terminology beyond the domain of applicability without resorting to philosophical considerations. “Physics meets metaphysics.” Belief in things you cannot see is deeply entrenched in physics. Quarks or Inflation are not observables, but both make more sense of the data we do have than alternative ideas (at present).

23. Physicists need to be cautious at times, not least in their extrapolations. It may be hazardous to extrapolate from what we know at 10 to the 12 GeV at CERN to energies of 10 to the 15 beyond this! There is mystery at the heart of Quantum Mechanics, which is hard to spell out. From an anthropomorphic viewpoint this Universe is very strange and wonderful.

In the beginning from different religious perspectives

What are the implications of Big Bang Theory for religious or theological understandings of the genesis or creation of the world? In what ways might the Big Bang contradict or support traditional theological approaches? Are there any religious elements inherent within some scientific understandings of Big Bang Theory?

24. If you reject the notion of Non-Overlapping Magisteria (NOMA), then the historical evidence is that many have suggested that there are religious reasons for and against general cosmogonical outlooks. Hoyle, Bondi, Maddox and Hawking saw that Big Bang theory could imply a creator. Penzias said he would have predicted BB from the Torah. Aquinas with Augustine spoke of God causing the Universe to be, with time, not in time. Worldviews can and do shape our selection of possible explanations. Historians of science have done a lot of work showing how this mattered in the history of chemistry in the West.

25. The notion of a self-creating universe from nothing is self-contradictory whoever says it is possible. Mathematics does not have creative power in a Platonic sense. The role of agency is important as one type of explanation for those open to religious understandings of the universe. It is denied, a priori, by those already committed to atheism. But agency and mechanism are complementary and should not be confused. God as Agent explains why science can explain mechanistically. There is no need for a God-of-the-gaps mentality.

26. Some argue that preferences between a universe and multiverses in the light of fine tuning issues has more to do with it than just the relevant physics. Note that some theists support the idea of God creating multiverses. Others argue that it is not fine tuning that motivates multiverse speculations; rather, they emerge from considerations internal to cosmology such as inflation, dark energy and string theory. Others say God is irrelevant here.

27. Paul Davies has made the suggestion that we need to consider information as a key notion. IT from BIT? The tradition of a rational principle or Being behind all things is found in the use of logos in the Biblical record. That God is the ultimate, eternal source of all things implies a limit to scientific reductionist modes of explanation. There is a space forLemaître's embracing of more than one mode of knowing: "There are two ways of arriving at the truth; I decided to use both."

28. The Qur'an is not a structured narrative. But It does affirm God as the creator of all. 10% of the text points to nature as evidence for a wise and benevolent creator. Natural Theology featured in Islamic history as it did in Judeo-Christian thought. Philosophical theology necessarily attends to questions of God's relationship to the cosmos, past, present and future. Kalam theology in Islam was atomistic and picked up some Epicurean thought. It allowed for science to be done because God acted consistently, except when miracles took place. Aristotelian thought dominated 8th and 9th cc Arabo-Islamic philosophy and this essentially secular tradition can be contrasted with more overtly religious traditions. So Averroes and Avicenna interpreted scripture in the light of the science of their time. These two perspectives are found in contemporary Islam. Note too that Occasionalism has featured in a lot of Islamic thought.

29. In Judaism there is a strong tradition of keeping religion and science as delimited areas. In Jewish history Maimonides was pivotal in his response to the epistemic

challenges that Judaism met in the 9th century in its encounter with Islamic thought. Maimonides argued that we must accept truth revealed by science as an equally important source to Scripture. When there is an apparent conflict the interpretative principle is that one cannot contradict the other and we should employ metaphor and allegory rather than treat passages of scripture literally. In practice, science pulls rank, though its findings should not be accepted uncritically. That said, there is a full range of views in Judaism about the precise relationship between science and religion, but most intellectuals do not treat the Torah as a source of facts about the world.

30. The central affirmation of a Creator God is consistent with a number of cosmological models. There is a serious argument that a God of Love who wants a degree of independence in the creation will choose to use chance processes for a lot of the time. Simon Conway Morris argues carefully for this view. Theism affirms a Divine 'Whatmaker' not a Watchmaker; the latter is a somewhat deist view.

31. Many contemporary Christian thinkers have been influenced by neuroscience. In particular, in moving away from dualist understandings of the human person, realising that dualism is not essential to Christian philosophy.

32. In all of this it is important to note that questions concerning Origins are not the most important issues for religious people. Genesis was after all a relatively late composition, which was a polemic against Babylonian culture and thought, not primarily a treatise on cosmology. Minimally, and the Orthodox tradition affirms this, Genesis is saying that God is the Creator. It does not tell us details of 'how' in the scientific sense. Religious concerns are focussed on how we should live and this is a complex matter. Various parts of the Bible operate with different genres. Science has much to contribute to the human enterprise along with other human cultural creations. Facts and values cannot and should not be kept apart. Hence the importance of dialogue and the recognition that truth is bigger than any one community of discourse can know on its own.

The shaping of communal knowledge?

The relationship between faith and scientific empiricism

33. Faith in the New Testament is characteristically about trust in persons and in things unseen. After the Reformation 'faith' has tended to stand for a body of beliefs shared by a community. Barbour's 'Myths, Models and Paradigms' provides one of the best ways to grapple with the relationship between theological and scientific communities and the way they function with their ongoing 'research programmes'. It is based on Lakatos's subtle attempt to describe science's work as it really is - more successfully than Popper, Kuhn and Feyerabend. It is possible to examine the role of reason in both science and theology and in particular how groups come to rationally reject or reaffirm a particular paradigm. It is possible to show how both science and theology change, as their respective communities engage rationally with questions arising from new data. Arguably the Enlightenment project has failed to deliver in ethics and MacIntyre argues for a revival of Thomism as a necessarily theological account of ultimate reality. Large-scale traditions must be recognised in the discussion and networks of belief should include naturalistic ones as competitors with theistic traditions. Moreover, it is a mistake to focus on individuals. Knowledge is an essentially communal thing. Given the prominence of scientific naturalism, two questions may be posed. The first is whether science alone is an adequate source of knowledge. The second is whether it has the resources to settle moral disputes. In turn, secularists can rightly ask whether theistic traditions can accommodate the findings of the empirical sciences and interpret the same within their worldview.

34. Not all sciences work in the same way. The balance between data and its interpretation varies as does work driven primarily by observation or by theory.

Hypotheses to be tested have to be chosen. Some theories are easier to test than others; some cutting edge work is hard to test empirically, if at all. In theology, revelation features as well as experience. Different religious traditions have different understandings of knowledge.

35. Christian faith appeals to evidence, not least that of the resurrection. Communities are committed to ways of being as well as beliefs about what is the case. Commitment to respective endeavours is part of belonging. There are face saving aspects to each endeavour too.

The role of authority within a knowledge community

36. In a descriptive sense a community's knowledge is the body of beliefs or truth-claims that it confidently accepts as true. 'True' beliefs are thus normative for that community. Beliefs only deserve to be treated as knowledge in virtue of their epistemic justification however. Ideally, of course, a belief can only be relied upon as true when it is in fact true. But in practice we need accessible surrogates for truth and that surrogate is epistemic justification. What then is it to possess such epistemic justification? The standard answer is to ask for available evidential support for its truth. But the demand for evidential justification threatens a regress. A knowledge community worth its name has some truth claims that for it constitute foundational knowledge, accepted as basically evident rather than based on inferential evidence. This in turn presupposes a source of authority. In science, publically accessible sensory perceptual experience is taken as foundationally authoritative. Paradoxically, scientifically 'known' knowledge may turn out to be false and not knowledge at all! By contrast, it is commonly said that faith based communities rest on deference to specific sources of revelation and may not be falsifiable; indeed they rest on inadequate foundations for knowledge in the normative sense understood within scientific knowledge. But is this an improper conflation? Religious traditions do not in principle regard their knowledge as resting on such an empirical basis. The evidential method of science itself ultimately depends on untestable assumptions, which it regards as properly basic. All epistemologies are thus limited in what non-circular justification can be offered for them. Science needs a kind of underpinning faith, but one which is demonstrably reasonable given the body of well confirmed scientific beliefs. Its foundations seem secure. Under what conditions may we decide that a religious source can be authoritative? We should first ask what the domain of religious knowledge is? What is it authoritative about? We need a science of the good, a moral science, in addition to empirical science. Historically this has been the business of religion. There is a tension here between preserving unchanging traditions and being open to critical examination of the same. Moral knowledge is not the exclusive domain of religion. What is distinctive is its metaphysical grounding in God as the creator of a universe that exits to realise a supremely good purpose. Theological revelation has 'ontoethical' content. The divine purpose has salvific content. Such questions of purpose are beyond the bounds of science. Given that there are competing claims about special revelation in different religious communities a spirit of 'faith seeking understanding' will be needed; a critical rationality which is prepared to re-evaluate knowledge claims in dialogue with other interested parties. Total interpretations of the world need the best of science and the best theory of the good. Anti-realists, who seek to reduce religious knowledge to ethics alone do not do justice to the full gamut of what participants in the religious communities wish to claim as knowledge.

37. In both the history of science and the history of religion there are many examples of where both communities revise their core beliefs, eg. atomic theory, the Reformation. Communities can resist change and progress. When research is expensive, science needs a wider consensus and links to other communities of discourse who are rightly and sometimes democratically interested in asking about how we choose which research to do and what moral consequences these

decisions may entail.

38. There is a role for knowledge communities in managing progress and deciding what to pursue. Ontoethical issues are relevant; there are questions of value in deciding what science should do. Scientific authority has limited domains. Critical realism is widely shared as is the belief in laws of nature. We do need to make good judgments in society and there are helpful precedents such as the Royal Society to reflect on in discussing the relationship between science and religion in the public sphere.

The interfaces of knowledge – is a common language possible?

Where are the meeting points between religious approaches to the beginning of the world and contemporary scientific approaches to Big Bang Theory? In what ways might the different knowledge communities have already influenced one another's paradigms? Are there pointers to common language or new shared paradigms?

39. One view is to assert that there is only one language that is meaningful when speaking about Origins and that is the language of science. Religion thus has nothing to say; it is not only wrong, it is antithetical to science where talk of purpose is meaningless. Observation is the only reliable guide and pure thought gets us nowhere. The goal of science is to remove the need for God. Nothing has changed its meaning in science and now we can show how to get something from (the new) 'nothing'. Lemaître's brilliant idea of the BB was good science. His theology contributed nothing. It was a mere accident of history that a religious worldview provided the context for the emergence of science.

40. A contrasting viewpoint affirms a legitimate dialogue between science and religion without the former dismissing the latter's claims outright. Both have a concern to root their respective languages in reality. Ontology is unavoidable. Two theses: one is that there is a common rationality in science and theology; the other is that this rational approach to reality provides for respectful basis for dialogue. You cannot argue for rationality, but affirm that the 'logos' has featured in thinkers from Heraclitus to Einstein. Theologians speak of the Creation as the implementation of the mind of God, but the architecture of the creation cannot be deduced from first principles; it must be investigated empirically. We need to reaffirm the importance of rationality in the modern world. It is the important point of connection between difference discourses.

41. In Orthodox thought, experience is a basis for knowledge, both spiritual and material. There are limits: we cannot know the unknown substance of being itself, of the world or of God. Logos is broader than reason and the latter is not, in and of itself, sufficient to decide between theories. Faith is a condition of all knowledge. There are non-rational aspects to science too and a role for elegance and beauty. As science is a creation of human beings, there is a role for applied theology in conversation with scientists. The social dimension of science including the apprenticeship of practitioners is key. Knowledge is always related to ways of life and the love of persons is key to all of this in Orthodox thought, grounded in the love of God. Thus science is a gift from God to study His Creation. Symbols are important in helping to foster ways of speaking about, and approaching, truth. We should be careful not to jump to conclusions. Theology should hesitate to accommodate itself to current theories too hastily.

42. The position outlined in paragraph 39 ducks the fundamental question as to why there is something rather than nothing. These are questions that humans legitimately pose and are meaningful ones. The question for example of whether the quantum vacuum is basic or emergent is interesting, as is the same question about physical laws. It is more than science can handle.

43. The rise of modern science did not just replace certain Greek notions, it also overcame a sort of spiritual tradition that Calvinist maximalism objected to on theological grounds. God is not a constant meddler on this view and Boyle saw the absence of miracles as evidence for a greater conception of God. Bede in the 7th cc stripped out theological language from his 'De natura rerum' in order to explain the world in its own terms. He saw this as his Christian duty to do so.

44. Science needs ethical frameworks from somewhere other than itself. There is more to the social context in which science must operate than its instrumental role.

45. It is important to be a practitioner in order to be able to speak with authority about a particular field. The corollary of this is that one should be cautious about speaking about less familiar discourses. Scientists should be careful to distinguish between opinion and what science itself can say.

46. There are so many languages we use, such as Art, that we regard as legitimate. If there is a commonality of language, it will be necessary for all to attempt where relevant to accommodate their understanding of 'established knowledge' in other domains, not least science, without making science a controlling discourse in the variegated human endeavour.

47. Questions of value and its relationship to purpose are at the heart of the human enterprise. We need a common language here.

48. We can only answer the question as to how we should live if we get the right overall framework within which to operate. Given that the language of science cannot deal directly with issues beyond its remit, such as supernatural realities and morality, it cannot tell us what ethical standards are best for us. It may inform aspects of the debate however.

49. Learning from one another needs patience, sustained hard work and respect for one another. An experiment in Oxford of having a philosopher in residence in a science lab is proving worthwhile, but it has taken about a year to bear fruit.

50. It is helpful to distinguish between language and meta-language. Such questions are why the universe is intelligible and why there is something rather than nothing cannot be answered, logically, from within science. What is essential is to ask whether the limits of rationality coincide with the limits of science itself.

The shaping of communal knowledge?

How to handle revolutions in discovery/thought?

51. We need to distinguish between the elite scientists and theologians and the public at large, including the media and politicians. Sagan warned of a "combustible mixture of ignorance and power" blowing up in our faces. There is widespread schizophrenia even among the educated people on issues relating to science, belief etc. reminding us of Snow's 'Two Cultures'. Yet science is widely seen as having the final word. Secondly, there is a resistance to science when it is perceived to be a product of 'western culture'. Thirdly, scientific and digital literacy is not universal. Science has both transformed society profoundly and left no mark at all on many people's worldviews. Cosmology is seen as simultaneously fascinating and incomprehensible. There is a separation between the world of science and that of meaning and values. We need to develop images and symbols that better communicate across the divides. Mistrust of science is sometimes justified and shared by informed scientists themselves. Some success has been seen in communicating esoteric physics to the public; numbers studying physics in HE across Europe are growing. Science needs to keep politicians informed; there are funding implications in all of this.

52. The 'two cultures' issue is pertinent. Need for minimal numeracy in society as the knowledge gaps are widening. Big issue of funding being tied to outcomes with

immediate utility. It is reasonable to ask about impact but we should not lose sight of the quest to know and the creativity and awe and wonder in what we do.

What are the limits of knowledge? How do we work with what we don't know?

53. It can be argued that there are limits to what we can in principle know in terms of fundamental science. Three things suggest themselves as limiting factors. The first is the brain; why should such a limited device presume to be able to understand everything? Secondly, there are practical limits. We would need a galaxy-sized device to be able to detect the strings postulated by string theory. Thirdly, there appear to be areas where we may already have come to the boundary of the knowable, such as the problem of consciousness, free will and determinism, how we understand time and the existence of multiverses. How do we deal with this? Theology certainly has made progress over time in say its models of God – look at the chronological development of the Bible etc. Science is more obviously progressive. There are interesting parallels: Kierkegaard declared that when truth is objectively a paradox, then subjectivity is the truth. This resonates with Bohr and the paradoxical behaviour of electrons. There is a limit to our ability to know the essence on things, be it God or electrons. Epistemological limits should not faze us. We may infer things; there may be life beyond death, and the life of Jesus may count as evidence here. Similarly we may infer from what we see the possibility of other universes, which we cannot encounter directly. We can never hope for completeness; but we can have a sense of humility and incompleteness in the face of mysteries whilst rejoicing in what we can know.

54. Considerable interest in the question of the limits of thought. Will the brain further evolve? Can it be enhanced electronically? Is real thinking beyond machines?

55. Will there be a public backlash against Big Science? Will the LHC be the last of the Big publically funded Machines? Is incomprehensible science beyond public understanding, and if so why should the public wish to fund it? Good outreach work is being done in many places, not least at CERN.

56. Logicians have known for some time about NP incompleteness problems, which show clearly that there are insoluble problems in principle, at least in limited axiomatic systems. In addition to these Gödelian limits there are limits to what we can measure (Heisenberg). We can perhaps recognise the limit to our cognitive tools without necessarily putting limits on the tools we use. We may be able to develop AI machines that pass the Turing Test. But there will always remain questions that science cannot answer. According to information theory there is no known limit to what can be known in principle; there is no known law of conservation of information. But there are serious distinctions between information, knowledge, understanding and wisdom. We need to do work on the relationships between these.

57. There are different senses of knowledge too. Belief; institutionalised belief; true belief and justified true belief. Religions certainly have the first two. It is a contentious claim that they possess the latter two, but a lot depends on what the object of the claimed knowledge is. It follows that we need more liaison between different areas of discourse drawing on what others already know and where ground-clearing work has already been done.

58. We have much dichotomous thinking to deal with. William Blake's painting of the Ancient of Days is not telling the same tale as a symbolic representation of the Big Bang. The Jewish tradition tells stories often ones that challenge our preconceptions. It is a moot question whether science or religion fosters awe and wonder more successfully. Thinkers like Soloveitchik encourage us to apply the principles of Halakhah (Jewish religious law) to developing realities as has been done by rabbis through the ages, constantly reinterpreting texts. Soloveitchik distinguished between homo religiosis and homo scientificus and sought to meld

them into halakic man. Halakic man loves to create in partnership with the Almighty. We are to strive to be the noblest of creatures and not degenerative ones.

Closing Panel Discussion

59. Although it is possible to access a measure of common language this conference has shown that words like truth, proof and faith have divergent meanings in different disciplines. Nonetheless all participants seem to have a common passion for rationality and awe along with a sense that as a human family we need to address our common problems.

60. Barbour's famous four-fold typology of the possible relationships between science and religion is very helpful. The options he offers are conflict, independence, integration and dialogue. The final one has a 'messiness' about it, but fits best the aims of this conference. Five suggestions about where we might go next follow.

61. [1] We need to work at the dialogue between academic and popular languages. This has implications for education and cross-disciplinary dialogue. Some scientists go beyond their legitimate remit when presenting popular science. [2] We need a better dialogue between the theological academy and ordinary theology held by members of faith communities. Many Christians, for example, are deists in their understanding of creation and have a God-of-the-gaps mentality. Many see science not as a gift but as a threat. Churches need to redress this. [3] We need a better dialogue between philosophy and mathematics as well as facing the challenge of how any and every discipline can talk to others. Mermin's "shut up and calculate" does not encourage us to talk and listen to others. [4] There is important common ground in awe and rationality. Awe was basic to the Design Argument in the Age of Scientific Revolutions and the Enlightenment and is of interest to theology and science today. [5] There is a dialogue to be had between the general and the particular. Polkinghorne's 'bottom-up' approach has much to commend it in avoiding the danger of generalities which lose the texture of differences.

62. We have evolved different ways of reacting to our environment and overcoming our fears. We now see the world as not central to the universe and should be glad that we can know this. There are degrees of greyness in science and the '5 sigma' statements from CERN about the Higgs boson illustrate this limitation. We are never sure that we are correct, but this is a strength in science and ensures progress over time. A similar humility in religion would be a good thing and religion should be prepared to change its views in response to new discoveries. Humility on both sides of the dialogue is needed.

63. There is widespread ignorance of what religions really believe. Nietzsche's point that there are values at the heart of religious commitments that are more than metaphysical is noteworthy. More enquiry is needed here, not least into the deep religiosity of many secularists. We are unsure about the limits of science. If there are limits, where does religion fit into the picture? Is religion to be consistent with science and coeval with it? What counts as evidence in religion and what is religious knowledge? Is the notion of truth dispensable with? Is the pursuit of science a religious duty?

64. On Hawking's claim that philosophy is dead, his defenders point out that he meant natural philosophy that does not impact on science. It does not matter to some that Hawking is doing bad philosophy if it does not adversely affect his science. Others suggest Hawking should avoid things beyond his field of expertise.

65. Professional scientists need to know a little more about the history and philosophy of their own subject. Hitherto there has been little time in their training for such reflection. It can take a great deal of time to listen carefully to what may initially seem to be the impenetrably difficult language of another. Respect for the way

others think is an essential prelude to any attempt to dialogue.

66. Technical language within individual disciplines exists for a good reason and needs to be learned by practitioners from other disciplines if they truly wish to understand what is being said. The invitation to learn from the other, to welcome one another into particular spaces, also requires a willingness on the part of the visitor to spend sufficient time finding out how a language works as a necessary prelude to asking about meaning (cf. Wittgenstein).

67. The shared desire to know about reality from various points of view is the starting place for commonality. This shared need to understand the world and recreate meaning and purpose is because persons create purpose. Theologians see this as part of what it is to be in the image of God. This theological stance affirms the place and importance of science.

Conclusion

It is clear that the discussions that took place in this conference have done a lot of important 'ground clearing' work. The interfaces of language are complex and subtle and theologians, philosophers and scientists all need to work hard to firstly understand what other disciplines are saying in their own terms. The invitation to participate and begin to respectfully enter the worlds of other disciplines in a spirit of wanting to understand is fundamental in our search for better ways to further our joint human project for the common good. More work clearly needs to be done, both at the interfaces of the languages represented here, and in the public sphere.

Adrian Brown
Wilton Park | 2 November 2012