



God of Antimatter

Gerald Gabrielse

Overview

Prof. Gerald Gabrielse delivered the lecture "God of Antimatter" on 2nd March 2006 at Queen's Lecture Theatre, Emmanuel College, Cambridge. A transcript of the lecture can be view at:

<http://www.st-edmunds.cam.ac.uk/faraday/CIS/Gabrielse/>

The lecture was followed by questions from the audience and later a dinner/discussion at St Edmunds College. A transcript of the discussion follows. It was chaired by Prof. Bob White (Dept. of Earth Sciences, Cambridge) with introductory remarks from Sir John Polkinghorne. The other contributors are described at the end of the discussion.

Gabrielse Post-dinner Discussion – 2nd March 2006

Sir John Polkinghorne: I would like to thank Gerry for a very interesting and wide-ranging talk. I will try and pluck one or two things from it.

You started off by making a comparison between science and religion and, I think, essentially said that in science we know where we are, we have falsifiability. With religion, it's more complicated to figure out what we know and what we don't know. Up to a point that's right, but nevertheless I do think there is a cousinly relationship between them.

First of all, falsifiability is not quite so unproblematic a thing as one might suppose because theory and experiment intertwine in subtle ways. Moreover, there are questions that are deeply connected with physics but which can't be answered experimentally. Quantum mechanics is unquestionably probabilistic but is that because it's truly indeterminate, or because it's determinate and we are ignorant of some of the determining factors? Either of those theories can be made to work and fit all the experimental facts, so there are scientifically unresolvable issues here.

On the other hand, while on the religious side we can't do experiments with God: ("You shall not put the Lord your God to the test") but we do have motivated beliefs. I think that's the common thread between the two. Science and religion are both concerned with the pursuit of truth through motivated belief.

You went on to speak about God and pointed out that God is bigger than we can really think about. That's certainly true – God will not be caught in our sort of logical net. Yet we have to try to say something. Augustine, talking about the Trinity, said that while we don't know what to say, it's better to try to say something than to be totally silent. Then you,

wisely if I may say so, led us on to Job, which is a favourite book for me as well as for you – I think a lot of scientific people like the wisdom literature in the Old Testament. The wisdom writers look at the world with a sort of cold and appraising eye and the amazing thing about Job, as you said, is the answer given to Job at the end. Job has had this terrible experience because of an apparently amoral wager in the heavenly court – a short story in itself – and when the Lord does speak to Job out of the whirlwind what does he say? He says “Look up, and see what I’m doing elsewhere. Behold Behemoth whom I made, as I made you. You’re not the only one that matters, Job, and humans are not the only creatures that count.” You reminded us of this and I think it’s a useful corrective. A lot of contemporary theological writing is very anthropocentric; it’s very concerned with the human scene. When it talks about the world, it means the Earth; when it talks about history, it means the next hundred years. Scientists have a rather different perspective on both space and time.

Then you talked about our picture of the physical world. It is certainly not a mechanical world but something subtler than that, a world whose history is not the performance of a fixed score but is something much more like an unfolding improvisation. That’s really what an evolving world is like, and the world is like that because the Creator of the world is not a Cosmic Tyrant or a Cosmic Puppet-master who has to pull every string. God is the God of love and therefore God allows to all creatures some due kind of freedom to be themselves and indeed to make themselves, as you rightly suggested. This, in turn, is connected to a significant degree with the existence of evil and suffering in the world. Not everything that happens is God’s positive will, and that seems to me a very important point to think about.

And as time is limited, I’ll just finish by making one remark about Intelligent Design. The irony of Intelligent Design is that its hidden theological agenda is a mistaken theological agenda because it’s based on the idea that if nature didn’t do it, then God had to do it, but if nature did it, then God had no hand in it – which is of course absurd. If God is the sustainer and ordainer of nature, then God works as much through natural process as in any other way. I don’t know whether there are irreducibly complex systems and nor does Michael Behe. But if there are not, then that tells us something of the power that the Creator has given to evolutionary process. It is the way God has chosen to make the world, and I think we both agree about that, too.

Those are just a few thoughts but I’m sure there will be lots more from around the table, so over to someone else.

Bob White: Thank you. Before I ask Gerry to respond, does anyone else want to pick up on any of those as well? We’ll maybe take two or three comments and then ask Gerry to respond to them.

Rodney Holder: Could I bring up intelligent design again from a completely different angle? I think your criticism of ID is absolutely right but I wonder if another kind of design argument does come into play. For example, in terms of antimatter, the universe seems to have been endowed with one part in 10^9 excess matter over antimatter in the beginning at the Big Bang. If there weren’t that excess, as you described in your talk, the matter and anti-matter would annihilate totally, and if that happened the universe would never have given birth to stars and galaxies, let alone intelligent life. Is that something to do with the fact that the laws of nature which God has, as it were, endowed the universe with are very special – or is there a purely natural explanation which would somehow avoid the need for God being involved, so could I put a question along those lines?

To sum up, at the beginning cosmologically, in the Big Bang, the Universe seems to have been endowed with a very slight excess of matter over antimatter – and if that hadn’t been the case then we wouldn’t be here.

Bob White: Shall we get the views of a cosmologist – Paul?

Paul Shellard: Just to follow up that point, this is really the anthropic principle that we're talking about. The anthropic principle is often used as a sort of grounds for supporting belief in God and I wondered if you would discuss how you would distinguish that from these intelligent design arguments. Also, is the fact that we see this very special number of nucleons per photon, one nucleon per billion photons, a wonderful intricacy of our universe or is it just a selection effect on all possible worlds equally, or that we couldn't live in, basically?

Bob White: There's a small question to be thinking about!

Gerald Gabrielse: One of my wishful thoughts is that more scientists, philosophers and theologians would from time to time say 'I don't know', and that's what I'm going to say about your last question. I don't know. I'm sort of a hard core experimenter and I don't know how to tell whether we have multiverses or one universe. I just don't know and I would rather stop at that as I don't know how to answer the question.

I notice that among my colleagues there's a wide variety of opinions about some of these notions; some won't even talk about them because they don't think they are testable – and some will write books about them because they hope they'll get rich!

I talked about the question of antimatter in my lecture yesterday in the Physics department. Indeed it's hard to understand how a Big Bang, which from the physics that we know would produce equal amounts of matter and antimatter, why most of that didn't find each other annihilated and yet here we are. And I always chide the cosmologists a bit because I ask some of them why this isn't a big, burning issue in cosmology and the answer I enjoyed the most was "Well, we don't understand dark energy within 200 orders of magnitude, so we have bigger problems!" I think it's an open question.

What I do know is that I agree essentially with what John Polkinghorne said. I was relieved about that, because I am an amateur in this and you write these books about it and think about it carefully, so I'm relieved. On the question about verifiability, I don't really have a quarrel with what you said. Certainly there are some elements of similarity: we are humans, of course, in culture and in God and our science and maybe that's what helps pull it together. What I meant to say is occasionally I have gone to a science and religion conference because people hear that maybe I would be good after dinner entertainment at such a place, and what I call the verifiability quotient of the talks I hear there is quite different than at physics conferences. It strikes me that even if there are similarities you can point to, and I think your new book explores that, I always find that I'm at a loss at those conferences because when I hear something that I think is preposterous I have no idea how to reel it in. Probably that's just the frustration of my own ignorance, so that's what I was referring to.

John Polkinghorne: Can I make a very quick comment on that? I think the science to compare with theology is not physics and things like that, but the histories - observational sciences which don't have 'testability' in the same sort of sense as experimental sciences do, but which make *sense* of fragmentary evidence. I think that has quite a cousinly relationship to the way theology seeks to motivate religious belief. A lot of my scientific colleagues think that religion is based on unquestioning submission to authority. I don't think that's right. I think I have reasons for my Christian belief, different reasons of course from my physics beliefs, but nevertheless a fitting part of a rational discourse about reality.

Bob White: Three cheers for geology I think! Philip as a philosopher would like to comment.

Philip Clayton: I wonder if I can follow up directly on the last thing John says and tie in a comment he made earlier when he said he was going to use the term 'religious claims' as meaning everything that's not testable, and therefore include the things that a Christian would believe, but also on the other hand have those prejudices of an atheist which in a sense are also anti-religious claims. It strikes me, piggy-backing on John's last comment, that there are two questionable things about that. It seems to me that the Christian asserts something about the nature of the universe, something about its ground and cause, which is

different from the atheist, who totally denies, or the agnostic, who simply doesn't know. Somehow we need a way to do justice to that extra thing the Christian or members of other religious traditions claim to know.

Secondly, also following John, it seems that there's something that we claim to have reasons for this thing that we know. Of course they can't be physical reasons, they can't be tested in the same way, you're right about that, but I have to make sense of the call at all times to be ready to make a defence for the faith that is within me and it seems to me that I do that by finding a mode of argumentation which is not scientific, but it's also not just 'anything goes'. If you put those two points together, then isn't it true to say that there must be a kind of discourse which is about positive claims about the universe and its ultimate cause and it claims to have some form of rational discussion that supports it.

Bob White: Are there any other comments in the philosophical area?

Denis Alexander: I just want to pick up the question of proposing theories that are refutable. This depends very much on the discipline in question but I think if one's thinking of evolutionary theory, for example, then the theory provides the best explanation for a vast array of different types of data – one is trying to make a coherent story which draws on current genetics as much as it does on historical data. Evolutionary theory carries on absorbing new bits of data and it's wonderful the way that the human genome, for example, was easily absorbed into Darwinian theory without any effort at all, so that's why people keep on believing it. This is where the really big scientific theories become closely analogous to the kind of model, the theistic model, that you were proposing this evening. Such models are clearly refutable, but their power comes from the fact that they explain so much so well.

Gerry Gabrielse: I don't have anything more to say on that point so we maybe just don't see it in the same way. As far as whether the faith of the atheist is different from the faith of the Christian – well it's certainly different, there's a different god – and speaking as just a lab rat not a philosopher, it seems to me that every person has to make a decision as to what's worth living for, what's worth certain levels of pain and of exertion, and I like to say you are sort of choosing your god. Now maybe your god is the God of Job, maybe your god is yourself, which means you may call yourself an atheist but in one way of thinking you have chosen another important centre of your life. For politically correct enlightened types it's often serving the good of humanity, and that seems to me like a kind of god too. What do I mean by that?

I like to try and think of how it might have been if sin hadn't come into the world and then I imagine people just harmoniously living with their God and enjoying him even more deeply on a daily basis. Once that gets interrupted then something takes the place of what should have been and I see the faith of the atheist as finding their improvisations of things that fill in because they don't have a relationship with God of the sort that they could have. Now can I prove that? I don't think so. I think we can certainly have rational discourse but I see the point of that is not necessarily to persuade each other. I'm not sure people come to Christ despite C. S. Lewis's wonderful arguments or that they come to Christ because they're persuaded logically. I think it happens sometimes because they're persuaded that it's not *illogical* to be a Christian but in the end I think it's a leap of faith so I think what we can discourse about is, if I understand your starting points and you understand mine, I believe that I can help you spot the inconsistencies in where logic takes you from your starting points and you can help me with the inconsistency that my starting points and logic take me to and in that way we can serve each other.

I wish that Christians spent a larger fraction of their time trying to do that to the spirits of the time around them because I think that's a sensible thing. The thing I have a quarrel with is the notion that I can really go ahead and say I'll prove to you tonight over port – which is what you would do at this university from my experience here – that you should be a Christian and you must be a Christian. From my experience that can't be done.

Bob White: Does anybody want to open up something new?

Ric Whaite: I am going to be a little academic for a second. In my experience, sometimes current literature doesn't teach you a great deal as it may be unfamiliar, or it is a little simplistic or facile or whatever. Some of the better recent histories in science/religion are ones which proceed under the methodological assumption that if we drop preconceptions about good design and good order, and if you like God's dirty hand reaching in from the outside, and actually focus on the complexity and, say, the thickness of any given relation in science and religion, either across its history – whether it's Galileo or Copernicus or Darwin or Halley or some such – rather than trying to find specific relationships either in conflict or whatever, that we learn a great deal more about both.

As you were suggesting in previous comments, I think that actually scientists, philosophers and theologians ought to listen to each other a bit more. I am wondering whether, particularly with relationship to the intelligent design folk, and the necessary degrees of complexity – and I'm trying not to tread on two dozen toes of physicists and one geologist around the table who don't like the rather scattergun use of the word 'complexity' at the moment – if we chop the legs off the ID argument and rather than focusing on design and what it might look like with the designer, ask how you would proceed with theologising the complexity that you encounter? Because as a historian and as someone who teaches the history of science to undergraduates who always come in with a preconception – some of them are physicists but usually they are the better ones in terms of lacking preconceptions – I try to help them understand the complexity that occurs across history. I guess what I'm interested in, in terms of what you said, is whether there is something analogous that can be said about the present, that if we ditch an approach that looks at things as well-designed and well-ordered and accept some complexity, something richer could come out of it.. I am wondering how you think that might proceed.

Bob White: Any other comments on that general area of complexity?

Denis Alexander: I think in the context of the ID movement, it seems to me, speaking as a biologist, that everything in biology is complex. That's a definition of life. You can't get life without complexity because you have a lot of components that have to work together to make a complex system. That's why to me the whole ID idea is nonsense, because to identify something in biology that is more complex than something else in biology is missing the point: actually all biological entities are complex. The term 'complex' is used in a very loose kind of way by the proponents of ID and if anybody uses it they should be immediately questioned about what meaning it does have and what we are actually talking about. It would be interesting to know the meaning from a physicist's point of view.

Gerald Gabrielse: I really don't know, and I'm not a scholar of the ID movement to be honest. I haven't even been able to tell for sure what the ID movement stands for and I'm confused because I see different people representing different things. I went to hear Michael Behe recently and I was not very impressed with the notion of complexity as I thought it had no precision at all. He put up a mousetrap and asked if any of us thought that it had evolved. Of course not, you immediately recognised that it has complexity and it has design, and I thought we've all been living around mousetraps for how long, so of course his point had a complete lack of precision. He then claimed that things were testable because if you took away any of the crucial parts and the organism still worked and regenerated itself, his theory was disproved. I think that's nonsense, it's like taking the wheels off a car and asking if it still goes. Of course it doesn't. And certainly for higher order complex things there has to be a lot of self-assembly processes and all sorts of things that aren't described in very simple Darwinian terms, you know, this mutation and that mutation, there has to be something that triggers other things. I just don't see how you can work with that notion of complexity.

Studying the complexity, of course, is what a lot of us do in science. We study the complexity but with the goal of making it less complex, or in physics we try and figure out some simple principles. The biologists aren't there yet; although they're trying to do the

same sort of thing, I think they have a much harder and much more complex system of stuff to deal with and so they have to see a lot of analogies, similarities, classifications and so on between different things. I guess yes, they study the complexity, but I guess I'm having trouble figuring out exactly what to do in answer to your comment. I think scientists study complexity and will probably continue to do that.

Sakura Gooneratne: How active a role does your faith play in the way you do science and do you, unconsciously or consciously, find that you separate the two, your science and your faith? A lot of scientists would consider that bringing religion into any kind of explanation of their science when they are publishing would be a taboo.

Bob White: Indeed, it's more than taboo isn't it, because science only works without outside causes; that's the definition of science.

Sakura Gooneratne: But a lot of scientists are religious, and I just wanted to know how you feel about it.

Bob White: We have a biologist with us – Brian, I don't know if you want to say anything?

Brian Heap: I think it would be interesting to pursue your thought that we do science to make God happy, and enquire to what extent we have actually done our research with that motivation in mind. I suspect that quite a lot of scientists do science because of curiosity about discovering the way the world works. Of course these days some do it increasingly with the emphasis on commercialisation, the possibility of doing something that is going to be valuable and have humanitarian value. From a Christian point of view, we probably do research to make discoveries that may have a positive benefit for humankind in the context of love for neighbours and concern for the disadvantaged. I was rather taken aback by your thought that we do science in order to make God happy and would ask you to expand on that further; where did the idea come from and to what extent does it resonate with your own experience?

Bob White: Just to give you another breathing space I'll ask some of the younger scientists here why they do science. Does that resonate with them too?

Phil Christie: I'll put in a comment but I wouldn't classify myself as one of the younger scientists!

I was very impressed with your talk and one of the things that seemed to come out from what you had to say was your personal relationship with God. You used the word 'humility' quite a few times and humility in the face of the creator, who is the architect behind everything that we see and we're intrigued by motivates our study, so I really appreciated that. You turned this into a very personal relationship when you used the comment that well maybe God has chuckled because we finally unravelled the curve ball that he had hidden there waiting for you. I wonder to what extent or even when God started to chuckle in terms of his creation. So did it require the presence of the mind to come along with a consciousness and then he could take delight in that, in the way that parents might take delight in their children as they start to develop, and if it was for that purpose, why did it take so long?

Gerald Gabrielse: Well, here's where my fondness for saying I don't know will help you because I don't know when it started! I am working with the metaphor that works for now and it didn't work probably while everything was evolving, so I haven't thought about and I don't know the answer, although it's an interesting question.

[Bob White: Five times over in Genesis 1 alone, God is reported as looking at his work at the end of each day and pronouncing that he 'saw that it was good'. And then on the sixth day, after he had created 'humankind 'in his own image', he pronounced that he saw all that he had made 'and it was very good'. So there does seem to be something particularly special in humans and in their ability to build a relationship with God because they are made in his

image – a relationship that is pictured elsewhere in the Bible as like that between a father and his children.]

As far as the making God happy thing, I think it's a good question to ask if this is really for real. There are lots of motivations; of course some of us do science because we're geeks and it's the only thing we can do without embarrassing ourselves. I take this seriously though and it really comes back to your question too. I really don't know; in fact I think it empowers me to do pure curiosity-driven science. Now it seems to me easier than if I'm going to invent a drug that's going to cure cancer for me to see that that makes God happier. I never doubted that so I think a lot of those things that you mentioned, making something that's more productive, making something that benefits humanity, of course that makes us a lot happier as a rule. So that would fit in my thing, but what's harder to justify sometimes is curiosity driven research. Should I look at the difference between antiprotons and protons, even though I firmly believe that that's never ever going to have a technological application?

Bob White: Ah, but you don't know!

Gerald Gabrielse: I don't know, but that's what I believe now so can I go into that with good conscience, and the answer is yes, I do it not only with good conscience but with glee because I really do have this model that it makes God happy for us to figure this out. That's what it means for me.

Now as far as what my personal faith has to do with my science, certainly there are these issues of empowering you to choose your project and in that sense it does make a difference to me as I just explained. But science is a very limited game with a set of rules and some things are not part of that game. For example even if a miracle happened, and I'm very uncomfortable about miracles as a scientist because as they don't happen a second time they aren't verifiable, it's sort of off the table in some sense to me. I think when you view at least physics science as a kind of limited game where you have your methods and so forth for dealing with it, then because God holds the laws tightly we don't have trouble. Now it may be in some of the other areas that a lot of you know more about than I it's more complicated, and I don't feel qualified to answer there, so I'll duck off as far as all science is concerned.

Bob White: I thought that all science was physics actually and ultimately I thought that physics was maths.

Simon Mitton: In that spirit, all science is physics. In terms of personal belief I've got some night thoughts of a physicist for you to take home. I enjoyed the talk this evening enormously, Gerald, and I want to comment on the four forces of physics and also something to do with particle physics.

The four forces: the strong, the weak, the electromagnetic and gravitational force are, to use your expression, as it were, within the hands of God and it is interesting to me that from the point of view of human experience we have no direct experience of the strong force which holds together the nucleus, or the weak force which is responsible for radioactive decaying, but the two forces we do experience are the electromagnetic force and the gravitational force.

Now, the gravitational force is actually the glue that holds the universe together – the universe would still be held together if the other forces didn't exist. The electromagnetic force is really, really important for us as animate objects and beings and that's because your bodies contain 10^{25} atomic nuclei. The hydrogen nuclei in your body - think H₂O, eighty per cent of your body is water - were made in the Big Bang. All of the other atomic nuclei were made in stellar explosions, probably mainly in the first one billion years of the existence of the universe: the carbon, oxygen, calcium, potassium, everything. All of this had to be made in the interiors of red giant stars and super giant stars that exploded, so apart from the hydrogen that came out of the Big Bang, you are composed of close to 10^{25} atomic nuclei that were synthesised and made in stars. For any one of us we are talking zillions of stars,

we're not talking one star which kind of blew up in a nearby place in the Milky Way and then the Earth absorbed it. And then what is it that turns these inanimate atomic nuclei, which incidentally are immortal? We all came from stardust, we are all going to die, we are all going to turn back into dust. The atomic nuclei that we are composed of are immortal and they are not going to change. We are not made of radioactive atomic nuclei but of things that have existed for billions of years already and will endure, so the complexity here from the point of view of a physicist is that all of these atomic nuclei and their associated electrons have to be put together in some way. Of course, from the point of view of fundamental physics, what life and thought and all that is all about, it's actually the electromagnetic force. The gravitational force has nothing to do with you being human, it's the electromagnetic force which enables you to see and hear and enables your muscles and your nervous system to function.

Bob White: Simon, we only have a couple of minutes left so can we leave it with the electromagnetic force? Does anyone else want to say anything else before I let Gerry have the last word?

John Lister: May I divert on a complete tangent? One of the things I liked very much about Gerry's talk was that as well as talking about the physical laws which govern the universe, he also talked about the idea of moral laws and about the problems which are introduced when we violate them in terms of the pain and the suffering that are caused, in particular in the context of families, but I think more generally.

I would like to say that for me God is not just the God of Job and creation, the wonderful maker of all that is, but He's also the God of the gospels and of Christ and of redemption. Speaking personally, I struggled for twenty-five years, grappling as a mathematician and physicist, with the puzzle of how you could decide whether God existed or not by looking at creation: does the Big Bang require someone to light the touch paper or not? What convinced me eventually to become a Christian was not creation, but the overwhelming evidence that I myself was morally fallen. The Bible gave me a compelling account of why that was the case and what I should do about it! That experience of grace seems to chime very much with some of the things you said, Gerry, and your own experience.

Geoff Cook: You have just alluded to what I was going to ask you and that is how you as a physicist viewed miracles. I was very touched by the way you personalized the deep experience you had with your son's illness in the fact that you prayed as well as sought medical intervention. I wondered what you did with the prayer, was there a sense in which it was tied up with the concept of seeking a miracle? I realize it's very personal and you may not want to answer it but I just wondered.

Gerald Gabriele: I can try. When I talk about this it's sometimes hard for me still and this was some years ago, but again there's a lot of things I don't know and don't understand. For me it was a kind of personal wrestling with God asking him please, in this case, could the outcome be different than medical doctors were essentially certain it would be, and I didn't claim that we were special or we deserved it or any such thing.

While this was going on there was a young man one town away who was also a Christian and had a whole army praying for him and he died of a similar cancer. During this time someone about my age came to talk to me because he had heard my son had this kind of cancer and he had just learned he had the same kind. He didn't realise when he talked to me that as an adult the odds for him were much worse and he died only months later. He too was a Christian and he and his church were praying, so I'm not trying to make any simple answers here. All I can say is that I prayed really hard and it came through. I'm supposed to be a dispassionate scientist and it's not always so easy but I think one has to be really careful about glib formulaic answers about prayer. I don't think if my son had died that my Christianity would have been shaken one bit. That was never the issue, it was never that. I

really believed that even bad things could turn to our good somewhere but it doesn't mean I wanted it to happen.

Bob White: Thank you very much again, Gerry, we much appreciate your endeavours for us, particularly when you've got such a bad cold and a sore throat, and we hope you get a good night's sleep before you fly back to America tomorrow.

Who's Who

Professor Gerald Gabrielse has been Professor of Physics at Harvard University since 1987. Currently leads the international ATRAP Collaboration whose goal is accurate laser spectroscopy with trapped antihydrogen atoms.

Dr Denis Alexander, Director of the Faraday Institute and Fellow of St. Edmund's College, cancer and immunology research, The Babraham Institute; Editor of the journal *Science & Christian Belief*, author of *Rebuilding the Matrix* (2001, Lion).

Dr Phil Christie, Scientific Advisor to Schlumberger Cambridge Research on exploration geophysics, current Chairman of the European Association of Geoscientists and Engineers' Oil and Gas Geoscience Division, Associate/Deputy Editor of *Geophysical Prospecting* and *Petroleum Geoscience*.

Prof. Philip Clayton, Ingraham Professor at Claremont School of Theology and Professor of Philosophy and Religion at Claremont Graduate University; research in philosophical theology and science-religion connections; most recently editor of the *Oxford Handbook of Religion and Science*.

Rev Dr Geoffrey Cook, Vice-Master St. Edmund's College; Department of Anatomy, research in developmental neurobiology.

Dr Sakura Gooneratne, recently completed a PhD at the Department of Science and Technology Studies, UCL, titled 'The White Dwarf Affair: Chandrasekhar, Eddington and the Limiting Mass'; research interests include the history of astronomy and cosmology in the early 20th century and religion and intuition in science.

Prof. Sir Brian Heap FRS, formerly Master of St. Edmund's College and Foreign Secretary of the Royal Society; a member of the Nuffield Council on Bioethics and UK Representative on the NATO Science Committee, Brussels.

Revd. Dr Rodney Holder, Course Director of the Faraday Institute, former Priest in Charge of the Parish of the Claydons, Diocese of Oxford; author of *God, the Multiverse, and Everything: Modern Cosmology and the Argument from Design* (Ashgate, 2004).

Dr John Lister, Fellow of Trinity College and Reader in Fluid Mechanics; Department of Applied Mathematics and Theoretical Physics, research in theoretical geophysics, free-surface and viscous flows.

Prof. David J.C. MacKay, Department of Physics; reliable computation with unreliable hardware; communication systems for the disabled; sustainable energy; author of *Information Theory, Inference, and Learning Algorithms* (2003, Cambridge).

Prof. Emeritus Pat McKeown OBE FREng, high precision engineering, Cranfield, Founding President European Society for Precision Engineering and Nanotechnology; founder of several university and non-university companies; (awarded Faraday Medal of IEE, 1999).

Dr Simon Mitton, Fellow and Treasurer, St Edmund's College. Research area is the history of astronomy. Currently writing an intellectual history of our understanding of gravity. Author of the biography *Fred Hoyle a life in science*.

Miss Bekki Pearce, Marketing and Events Manager of the Faraday Institute. She read Physics at Oxford and completed a Masters in Science, Culture and Communication at Bath

in 2003. She has worked for the British Association for the Advancement of Science, NESTA and GridPP.

Revd. Dr John Polkinghorne KBE FRS, Retired president of Queens' college and formerly Professor of Mathematical Physics (elementary particle physics). Author of many books on science and religion. In 2002 awarded a Templeton Prize.

Dr. Paul Shellard, Reader in Cosmology, Department of Applied Mathematics and Theoretical Physics; research on the early universe, cosmic strings, inflation, gravitational waves, cosmic microwave sky; director of the COSMOS supercomputer.

Mr Robert Smith, Research Fellow at St Catharine's college, Department of Physics, researching emergent states of matter in strongly correlated materials.

Dr Sarah Smith has recently completed a PhD in astrophysics/cosmology, on the Cosmic Microwave Background radiation.

Dr John Stanton is a research consultant for a leading independent technology development company with particular expertise in printing technology. He read Natural Sciences at Trinity College, Cambridge followed by a PhD in Superconductivity.

R. P. Whaite, Lecturer in Science and Religion, Department of Science and Technology Studies, University College London; the contribution of sciences to philosophical approaches to matter, history of materiality and theology.

Prof. Bob White FRS, Associate Director of the Faraday Institute and Fellow of St. Edmund's College; Dept of Earth Sciences; volcanoes, earthquakes, climate change and other catastrophes; co-author of *Beyond Belief – Science, Faith and Ethical Challenges* (Lion, 2004).