Case No: 10 or 11

The People

vs

String Theory

heard before

Judge Gauss-Newton

The Charges

1. That String Theory has failed in its self-professed objective to be the only suitable method for finding a unified theory of Quantum Gravity, or even to be one of the main viable methods. Moreover String Theory has failed in the past 40 years, to even to link itself with any experimental validation that might be possible in the short term.
2. That String Theory has built an edifice of control and undue influence in academic and research institutions, and through that influence has wasted valuable resources by encouraging research and analysis in their own area at the expense of other competing theorems

The Prosecution

Arguing the case for the Prosecution:

Attorney Mee Lomsin and Attorney Trip Wiot

Witnesses for the Prosecution:

Albert Einstein

Henri Poincare

The Defence

Arguing the case for the Defence:

Attorney Jed Twiten and Attorney Ryan Regeen

Witnesses for the Defence:

Paul Dirac
G H Hardy

Independent Experts

Richard E Feynman called by the Prosecution

Werner Heisenberg called by the Defence

Case heard before the Supreme Court and with an invited audience from the combined faculties of Maths and Physics of 50 universities, and held in a special session at the Institute for Advanced Studies in Jersey, United States of America. The Jury was made up of members of the public and carefully selected so that there was no scientific bias.

Record of Proceedings

Day 1

The Clerk of the Court: All rise, All rise. Judge Gauss-Newton has entered the Chamber.

Judge Gauss-Newton: Ladies and Gentlemen of the Jury. You are charged with the collective responsibility of deciding on the guilt or innocence of String Theory in the face of 2 charges bought against it through case no: 10 or 11, in the matter of "The People vs String Theory".

This is not a straightforward case and, as I will explain, the format that has been agreed does not necessarily fit the way in which cases such as this might have been heard in the past.

Regardless of the format for resolving this case, the prosecution have brought some very serious charges against String Theory. This is therefore not a trivial exercise and the decision you make will carry great weight and have a long-term impact on the future of scientific research around the world.

Before I comment on the schedule and format ahead of us let me introduce the lawyers who will be representing the two sides.

The case for the Prosecution will be made by Attorney Lomsin and Attorney Wiot.

The case for String Theory will be made by Attorney Twiten and Attorney Regeen.

Each side will call upon two witnesses. Additionally an independent expert has been provided by each of the two sides. The independent experts will present brief written statements that will be heard at the end of the trial, after you have heard the testimony of the witnesses, but prior to Counsels' closing arguments.

Detailed statements have been provided to the court ahead of time by each of the 4 eminent witnesses that you will hear from. The witnesses are not constrained by those statements, and the court hearings have been organised such that the second witness from each side has the opportunity, should they wish to take it, to comment on what has already been raised by their colleagues or the opposition. You should be aware that the witnesses that you will hear from were chosen freely, and no restrictions were placed on who was chosen or what they might comment upon – for so long as no rules of the court are broken. Equally

important, each witness has come to the court freely. No one was forced to appear as a witness.

It is also important for you to note that unlike the facility afforded to the witnesses, there is no flexibility of comment provided to the independent experts. Let me explain what that means. These experts, Professor Feynman and Professor Heisenberg, were chosen some time prior to the start of proceedings and each side had the right to veto the other side's choice. I am happy to report that no such veto was exercised.

The independent experts had to prepare and submit their written statements approximately 2 months ago, and their statements must be read as submitted. This means that the statements cannot be changed or altered in any way. Each expert will however be given a one minute period at the end of their statement to add something extra should they wish to do so.

There is therefore no requirement for either of the independent witnesses to say anything in addition to their statements, but should they wish to say something then they are aware that if I judge the comment to be inconsistent with their own prior statement I will ask the Clerk to strike those comments from the record and I will ask you to disregard them from your considerations.

My directions, indeed the requirements that have been placed upon both the Prosecution and the Defence, are to speak plainly and to speak clearly. Given the nature of the topic under discussion, there may, on occasion, be a need for some technical references. These however will be rare, and the work of this court will be aided, not hindered, by the use where possible of everyday language and common sense. If, however, despite these directions, at any time, you, the members of the Jury, require clarification or if you have any questions, then let the Clerk of the Court know. I understand that you have chosen a spokesperson that is aware of the process by which questions can be addressed to the clerk.

Once we have heard from both sets of witnesses and from the independent experts, I will provide a brief summation, as well as final directions.

The responsibility for passing judgement will then be handed to you, the jury.

I hope that all of this is clear and straightforward. Members of the Jury do you have any questions ?

(no questions were posed)

Thank you. If there are no questions, I call upon the Clerk here present to ask the counsel for the Prosecution to start the proceedings.

Clerk: Attorney Lomsin and Attorney Wiot please step forward.

Attorney Lomsin: Ladies and Gentlemen of the Jury. Your job today will be very straight-forward. My intentions are that together with my colleague Trip Wiot, and my esteemed colleagues who will be appearing as witnesses, we will present you with evidence that clearly shows String Theory to be guilty on both of charges that you have been called to pass judgement upon today.

Whilst I personally believe that String Theory is guilty of many other serious crimes and misdemeanours, these proceedings have, as their focus, two very specific allegations. Firstly that String Theory, being entirely without credibility as a scientific pursuit has failed in its self-professed objective of finding and proving a so-called "unified theory' of Quantum Gravity.

Secondly, the further charge that String Theory has wasted billions of dollars of resources and, by stacking faculty after faculty with their own kind and favouring research and scholarship in pursuit of erroneous and meaningless recursive discussions have wasted precious resources that would otherwise have been employed in rewarding areas of research.

We will present you with evidence that is simple, easy to understand, compelling and verifiable. In fact everything that String Theory is not.

Attorney Wiot: Members of the Jury. The defence will try to change the rules of discourse. They will try to confuse you with semantics. They will ignore, or try to ignore, the charges that have been laid against them. Their tactic throughout the years of scrutiny that they have faced has been the same – to obfuscate and to intimidate. Luckily they will not be allowed the latter tactic in this courtroom.

Members of the jury ! The defence team and string theorists in general remind me of the rogue and misguided gardener who grows a tulip but is convinced that he has grown a rose. He takes his tulip to a rose garden and insists to the head gardener of the rose garden that the errant tulip is in fact a rose. It doesn't look anything like a rose, but undaunted, the tulip-gardener decides that tulips should henceforth be known by another name – Roses. When no-one is fooled by his efforts to simply change the name of his tulip and call it a Rose, he then gets angry and starts to accuse the rose gardener and anyone else who disagrees with him, of being ignorant.

Just as the incompetent gardener fools no-one, String Theorists haven't fooled anyone and tonight it's our collective responsibility to show them up for what they are and to find them guilty as charged.

Clerk: Attorneys for the defence please step forward

Attorney Jed Twiten: Ladies and Gentlemen of the Jury. Let me firstly apologise. Let me apologise on behalf of all physicists and all mathematicians for the disgraceful waste of time that this case represents. The charges are false and I am confident that by the time this trial is over and all the evidence has been presented, you will dismiss the charges.

It is my view that our case, as presented by our witnesses, will not need to rely on any obfuscation. My opponent's, the counsellors acting for the prosecution, are confusing their own intended tactics with ours.

The facts, the manifestly evident facts that we present, will allow you to draw your own conclusion. Namely that the charges cannot be proven to be credible and that we have all had to waste time that could otherwise have been spent with our families and our friends on yet another wild goose-chase. It is our intention to allow the facts to speak for themselves. Thank you.

Attorney Regeen: My colleague, Attorney Twiten, is right.

The charges are not only false, but they have been conceived by people with a deep sense of insecurity. People who resemble that category of critic who wanted Christopher Columbus executed for daring to suggest that the earth might not be flat. The same people who constituted the worst of the band of luddites who saw the steam engine as the work of the devil. They are supported by physicists who simply have not made the mark, and want to blame everyone else for their failings rather than accept their own lack of competence.

Attorney Wiot: Objection ! Objection !!

Judge Gauss-Newton: Sustained. The Jury will disregard the last comments. And counsel for the defence will approach the bench

(the next comments are not taken from the official record of the court but are the recollection of a number of jurors who overheard the Judge, despite his attempt to shield the court's microphone. The comments are thus not to be relied upon as being a completely accurate record of what was actually said)

***Judge Gauss-Newton**: Mr Regeen. You will not use my courtroom as a platform to parade your personal attacks. If you cross the line again I will hold you in contempt and bar you from having any further involvement with proceedings. Do I make myself clear ?*

***Attorney Regeen**: Your Honour I apologise but I really do not think that I overstepped the mark. I simply stated the facts...*

Judge Gauss-Newton*: Enough Mr Regeen. Are you deliberately trying to get yourself banned before the trial starts. Now go back and complete your opening statement*

(the following remarks are again resumed from the formal record of the Court)

Attorney Regreen: My colleague, Attorney Twiten is a true gentleman, and moreover a lawyer who will present facts and let them speak for themselves. I am afraid I don't possess his patience and therefore I hope that this court will forgive me in advance if the conceit of the Prosecution becomes too much to bear and I allow my emotions to come through. But when the most important questions facing humanity are at stake I think you will agree that emotions are allowed.

Attorney Regreen (resuming after a pause): I am not overstating what is at stake Ladies and Gentlemen. Physicists and Scientists have been searching for the most fundamental answer to the key that will unlock the door towards a unification of Gravity with Quantum Physics. A "theory of everything" if you like. The theory that will bring to light evidence about our universe from its very earliest beginnings, and that will uncover the mystery of our existence.

String Theory offers us a path towards that theory and anything that deflects that aim has to be rejected, and rejected with brave force. I do trust that you will be brave enough to withstand the conceit represented by this egregiously conceived case, and careful enough to focus only the facts that are presented before you.

Thank you.

Judge Gauss-Newton: The structure of this hearing lays great emphasis on the witnesses and independent experts. We now move to that part of the trial where we will hear from a total of 4 witnesses, two each presented by the Prosecution and the Defence. As is customary the first prosecution witness will speak first, followed immediately by the first witness for the defence. If there is time today we will then hear from each of the second of the two witnesses from each side.

There will be no cross examination, however Counsel will be provided with the opportunity of observation should they wish to exercise that right immediately prior to the calling of their Independent Experts.

Clerk: I call upon the first witness for the Prosecution. Henri Poincare. Monsieur Poincare please state your name and occupation for the record.

Henri Poincare: My name is Jules Henri Poincare. I am an engineer by profession, and trained additionally as a mathematician and as a theoretical physicist. I have been described as a universalist in terms of

my approach to mathematics and theoretical physics, and I consider this to be a fair description of my interests.

I do however hope very fervently that I am not proved by history to be the last "universalist". I am encouraged in that hope by some evidence in the early 21st century of what has been described as 're-convergence'. If this continues, then, notwithstanding the fact that there are towering silos of specialisation in mathematics, the greatest institutions of the world will soon produce fine scientists who cover both the disciplines of mathematics and physics with equal ease, and with great reward when it comes to discovery and progress.

Looking back at my work and my career, I personally benefited immensely by being born and active during a time of great progress.

(there are some smiles and laughs from the Jury and from the gallery)

Yes, you might well snigger at my understatement. The early part of the 20th century is not easily described in terms of scientific progress without descending into hyperbole.

In any event, however that period is to be described, I was fortunate to witness some of the most ground-breaking advances in mathematics and mathematical physics and I therefore believe I have some experience and some credentials when it comes to identifying issues in these areas.

And here I come to my first substansive point. Whilst I admire the evident intellectual skills and do not doubt the integrity of many of the key players in the area of String Theory, I am afraid that the field has become a self-supporting edifice that has run its course.

In this regard I have a significant problem with the subordination of creativity and diversity, to mere application within the narrow discipline of String Theory when it has come to academic positions and research resources awarded in the period from 1990 until very recently. So many String Theorists occupied positions of influence that only research projects that seemed worthwhile to them were supported with genuine rewards, and an unhealthy pre-disposition towards work in String Theory became the academic norm.

This is enormously negative – and for this reason alone I would have chosen to speak for the prosecution.

Additionally, as many of you know only too well, I have spoken and warned against the dangers of excessive formalism at great length. Whilst this danger is also evident within String Theory, there is however, another different issue that compelled me to accept the invitation of Monsieur Lomsin and Monsieur Wiot to present myself here today and that I wish to comment upon for the benefit of the jury.

As I believe Albert, Professor Einstein that is, will also comment upon, positing the existence of higher dimensions is not new. The problem is that for almost 70 years those who were working in the area were able to benefit from a healthy alliance between themselves and the discipline enforced by experimentation. It would appear that this relationship has broken, and with that break has come the arrogance of entitlement.

String theorists treat their critics with such sneering dismissal that they have made a philosophy, or perhaps even a belief system out of their work that not only negates the need for experimental confirmation, but which revels in the fact that for exactly the same reason that it cannot be proved, String Theory cannot be disproved. This is dangerous and damaging.

Science has some clear boundaries that differentiate it from philosophy, or metaphysics or art.

Scientists gather information or data about the natural world, or certain aspects or phenomena from the natural world.

Scientists then provide their colleagues, and the rest of the world, with a hypothesis or conjecture about that phenomena. That hypothesis must be testable.

Scientists then submit their conjectures to such testing that can prove or disprove the hypothesis. The only tests that matter are those that are repeatable, and in the process of sifting 'true' from 'false' the theory that emerges then has an influence or bearing on other new hypotheses.

And so it goes – except, apparently, not for String Theorists.

My concern about String Theory and the people who are engaged in the field, does not stop me from congratulating them for the great summits of amazing mathematical complexity that have been conquered by remarkable intellects. But my admiration for individual intellect does not mean that I accept that String Theory is the only possible solution to the core problems that have pre-occupied our best minds since the later 1920's.

By the way, I note with interest Richard Dawid's conjectural work on how evidentiary support might not be required in the traditional form for string theory. There is only one thing wrong with this view. There is no such thing as traditional or new evidentiary forms. There are experiments, and then there are results. Until something can be proven, it will remain, at best, speculative, and all the philosophical hand wringing in the world will not change that fact. Suggesting otherwise is to take String Theory from being a science into being a belief system.

Clerk: I call upon Mr Paul Dirac to now present himself. Please state your name and occupation for the record.

Dirac: My name is Paul Adrien Maurice Dirac. I am a university professor in the field of theoretical physics.

Let me firstly state what a great pleasure it is to be present here with some very dear friends who I have not seen for a very long time.

Beauty and utility don't always go together in many walks of life, but in mathematics and the related fields of theoretical physics, truth, beauty and utility do go hand in hand.

In the case of String Theory not only is the maths beautiful to those of us who admire the complexity of the structures, but from a personal point of view, some of the approaches to examining the intricacies of higher dimensions have enabled some core problems associated with exploding infinities in a critical area of theoretical physics to be tackled and solved. This essential utility is something I will refer to again in a few moments.

Let me start however by looking at issues that are somewhat less personal to me.

Some of the critics who have been so voluble about their issue with String Theory talk about the relative length of time that the field has been active without experimental validation.

I dispute this allegation on two grounds.

Firstly, and very obviously, these critics are ignoring the large and growing body of successes that are linked ineluctably to research in String Theory. Advances in mirror symmetry or the investigation of black holes are just two of the most obvious areas where such success is well documented. More particularly Strominger and Vafa's work in showing how to derive the Beckenstein- Hawking formula for some black holes is a good example of what I mean here. It is difficult not to be irritated by the selective nature of these critics who will decry the lack of progress within String Theory. From my point of view the benefits to Cosmology alone of the application of String Theory are good enough to counter all criticism and I would like to suggest that the jury use these facts to dismiss without too much consideration the first charge.

As some of you may know, I have a very great regard for the work of Pierre Ramond, who I am lucky enough to call a friend. When he generalised my approach to point-like particles for those that we now know as strings, I cannot admit to being much impressed. After all, what is the point of mathematics, or for that matter any theorem, unless it provides some sort of accounting of nature? However Pierre and his colleagues harnessed the tools that accompanied a branch of

mathematics that I refer to as projective geometry and from those beginnings have emerged a great many new insights that have helped both mathematicians as well as physicists. By way of further example, in discovering super-symmetry in two dimensions Pierre also created a route-map for super-symmetry in 4 dimensions. Over time, and to my great relief, String Theorists found a method of avoiding the dreaded spectre of re-normalisation that had haunted and dogged the pursuit of higher physics since the later 1940's. For this achievement alone String Theorists are to be applauded and congratulated. Higher physics, the sorts of work that will eventually lead to a unified theory, can only be possible when we rid ourselves from the shackles of renormalisation.

It would be remiss of me to finish without mentioning the work of Gabriele Veneziano. It is entirely possible that the modern study of String Theory might not have come about were it not for Veneziano. He was recently awarded a prize that embarrassingly carries my name, but he was not only the pioneer that led the way in the late 1960's but he has been a catalyst for exactly the point that I have made in connection with Pierre.

Veneziano worked on the interaction of strongly interacting particles and uncovered a deep link between something called the Euler-Beta function that shed new and confirmatory light on how the laws governing these physical interactions work. The resulting measure, known as the Veneziano amplitude is a vital part of the landscape of theoretical physics and Veneziano has continued to work on important revolutionary ideas throughout his still active career. He and Ramond are exemplars of why String Theory is made up of beautiful structures, and why important real results have come from the work of amazingly talented scientists and form the second of my rebuttals to the argument that String Theory has not been successful.

I am aware that my distinguished friends who are pursuing the prosecution of String Theory have chosen two very specific grounds for highlighting what have been some wide-ranging misgivings some of which I might recognise, but many of which have no basis in reality. The charge that relates to some fictive conspiracy is too far fetched for me to do anything other than suggest that almost all senior positions of influence within the best universities are awarded on the basis of merit. To suggest otherwise is not worthy of our consideration.

I would, before I finish like very quickly to suggest to Henri that he might be too hasty in dismissing the recent approach of Mr Dawids with respect to phenomenology as a means of validating research areas such as String Theory. I understand that this is not the time or place to expand on these points, and so I offer my observation with respect.

Finally, my own approach to science has always been to focus only on the specific, and I can say without fear of contradiction that neither of the charges is capable of any serious scrutiny. You, members of the

Jury, should therefore have little difficulty in finding String Theory not guilty on the first and the second count.

Clerk: I now call upon Albert Einstein to come forward. Please state your full name and your occupation for the record.

Einstein: My name is Albert Einstein and I am a scientist.

Like my friend Henri, I have two fundamental problems with String Theory.

Before I expand on those objections may I take this opportunity of reminding people that I was a very early admirer of the work of Theodor (or Teddy as I called him) Kaluza and of Oskar Klein. I believe that I am on record as embracing the intuition that accompanied Teddy's work in particular, and, if we are going to talk about beauty, then the spare almost austere beauty of his work should be mentioned. However the underlying weakness of applying those developments in higher dimensions simply became void through a combination of well-known advances in other areas as well as computational failings when Teddy and Oskar looked more carefully at their own work. My point in mentioning this is that String Theory is not new. Its antecedents go back quite some time. I do agree that many of the mathematical techniques owe a great deal to progress in disciplines such as geometry and topology in the period after 1950, but in substance, the work of Kaluza and Klein first broached the issue of higher dimensions being applied to quantum physics.

The spooky edifices that been built, brick by flimsy brick, supporting conjecture with yet more conjecture, leaves me worried at the core integrity of String Theory. It is not necessary for me to repeat what Henri has already said except to agree whole heartedly with him that when scientific endeavour starts to resemble a 'belief' system, and when scholarship and work in physics stops being tested by real world proofs, or at least being open to those tests, then that is where problems start to multiply.

Being unproven for 40 years is not a short period of time. I am afraid that String Theory during that period has not delivered on its own pronouncements. It is one of a number of speculative approaches to unifying Gravity with Quantum Mechanics, but it is neither the most likely to succeed nor, now, credible as a vehicle for research. Someone told me that there are literally an infinite number of actual solutions within string theory (or was there a number that is so large as to be effectively infinite). It is when I hear such things that I come to the conclusion that String theory is simply one of many ideas and should not be so dominant as it has become.

It is lamentable that as a result of this, string Theorists have forced their agenda onto the rest of the scientific academic community and in

doing so does not allow other research projects to have access to the resources that would otherwise be more fairly distributed.

Before I close my comments, I wish also to touch briefly on the much-discussed issue of beauty in mathematics and in physics. As a theoretical physicist I am not only familiar, but deeply influenced by the conviction that beauty in mathematics and in physics is a key arbiter of truth. However the truths that I speak of and that I recognise have a beauty so simple and clearly discernible that no-one can deny it.

We are not here talking about a beauty that might lie only in the eyes of the beholder. In fact in order for something in mathematics – a formula for example – to be considered beautiful, it must be simple. One of my colleagues who will be appearing in this trial with a prepared statement, Richard Feynman once said that it is sometimes difficult to convey to a non-mathematician or a non physicist a real feeling for the deepest beauty of nature. Feynman went on to say that there is an invariance in beauty in its connections between mathematics and nature and I think that not only was he correct, but that equally, at least amongst mathematicians, if not between mathematicians and physicists, there must be an instinctive and shared opinion of such beauty. Our beauty must be simple, obvious and easy to identify and agree upon.

I am afraid that when it comes to String Theory that common view is very sadly lacking, and this fact alone would undermine the claims of String Theory to be the inevitable or even dominant method to be backed in the search for a unified theory of quantum gravity.

Such a great reliance on the argument that String Theory is so beautiful that it must be true is also dangerous from another standpoint. We must not allow ourselves to be entranced by beauty and elegance alone into allowing too much leeway to what is after all an untested approach. A 20th century mathematician of great note who I have sadly not had the chance to interact with, Sir Michael Atiyah was very right in my view when he said

"the mathematical take over of physics has its dangers, as it could tempt us into areas of thought which embody mathematical perfection but might be far removed or even alien to, physical reality"

It seems to be a good place for me to close my comments.

Clerk: I call now the final witness, Mr Hardy. Please state your name and profession.

G.H. Hardy: My name is Godfrey Harold Hardy. I am a professional mathematician.

Ladies and Gentlemen. I note with appropriate humility but also a degree of apprehension that along with Monsieur Poincare, I am the

only non Nobel Laureate amongst the group of witnesses and experts that are assembled here today. I would also say (and this with equal if not greater humility) that I am the only professional mathematician since Monsieur Poincare is recognised as being as eminent and valuable a contributor to theoretical physics and other areas as he was in mathematics. By this I mean that I am someone who has spent a lifetime studying, teaching and researching mathematics and it is a great honour to be called here today and being a witness in support of String Theory.

Whilst I have introduced myself as the lone professional mathematician who will address you today, that is not to say that there are not some extremely talented mathematical intellects here on display. I don't need to name any names, but suffice to say that each and every one of the other witnesses and experts who will speak later could have forged a career marked with equal success in mathematics. In fact I might even say that mathematics is poorer for their choice to become dedicated theoretical physicists. Our loss as mathematicians however is rather small when compared to the riches that we have reaped overall by the contributions of Einstein, Heisenberg, my colleague Dirac, and therefore the net gain, as we might say, is wholly positive.

Those of you who know me will not be surprised when I say that mathematics is pure and its effectiveness is not to be judged by any application. Whilst it is true that the ways in which beauty might be judged in mathematical terms might differ from the beauty apparent to a theoretical physicist I doubt that there could be any fundamental differences, and from a personal standpoint I can certainly see why some people will also consider the formalism that supports so many aspects of string theory as being beautiful. On balance therefore, where, in String Theory, simplicity has been lost to complexity, the price that has been paid, in my opinion, is worthwhile.

My principle question here is therefore this. Since when have we started to force mathematics to submit to these false strictures? From my perspective I admire, hugely, the mathematical endeavour that is represented by String Theory and that is why I had no hesitation in agreeing to be present today.

However I also cannot believe that the recent divergence between theory and experimentation by my friends working in physics, will last for much longer. As the notable physicist Claud Lovelace pointed out, we cannot simply criticise String theorists for the lack of experimental support in their work. They have to do what they do, and we must let them get on with it. If other theories come along, or if experimental support is found for an alternative theorem then that can only be positive. In the meantime we cannot deny that exceptional mathematicians and visionary physicists owe their livelihoods to their passion for string theory.

A physicist that I admire greatly is the Chinese Nobel Laureate Chen-Ning Yang. In an interview that I enjoyed very much he was asked to comment on whether String Theory has passed the test of beauty when considered by Mathematicians since Mathematicians might have a different view of 'beauty' than physicists. In his answer Yang said that Geometry and Mathematics in higher dimensions is extremely intricate and very beautiful. He went on to state what we now know to be true, namely that intuitive and non-rigorous 'proofs' that have emerged from String Theory have subsequently been proved by mathematics. Yang described some of the mathematics emerging from String Theory as being deep and possessed of what he described as a "strange beauty" that due to the passing of the more rigorous tests imposed by mathematicians, have earned their respect.

When it comes to mathematical rigour therefore, String Theory passes any and all tests that might be imposed by mathematicians, and passes with the highest distinction. The truth, members of the jury is that when it comes to looking for the common ingredient in successful physical theories, one must look first and foremostly for mathematical consistency. If that is lacking, one may as well move on, but conversely when there is such great mathematical consistency as is the case with String Theory, then success in an experimental context is not usually very far behind.

I would like to close my comments by providing the jury with what I hope will be an important example of why we must not be hasty in passing a negative judgement with regard to the first charge.

During my own lifetime I saw how a simple experimental answer to the question of why the boiling point of water is 100 degrees Celsius went from being largely a fictional expectation to one that was proven in real life. This process took more than a century. Even though one could hardly describe this proof as being pivotal to human knowledge it shows just why we must be patient in certain matters, and the fundamental truths being pursued through String Theory may take some time to become naturally obvious through practical proofs. If that time scale be measure in a decades, then so be it. You should not allow yourselves to be brow beaten into making a hasty and potentially damaging decision at this stage.

Clerk: This statement is the last event of this session of court. The court is adjourned until tomorrow morning. We will re-assemble at 10.30am.

All rise, all rise as His Honour Judge Gauss-Newton leaves the courtroom.

Day 2

Clerk: All rise, all rise. His Honour, Judge Gauss-Newton is entering the court room.

Judge Gauss-Newton: I call upon the Independent Experts to now read their brief written statements. I remind the jury that these written statements were provided to the court ahead of these hearings. Whereas the witnesses provided by the Prosecution and Defence have worked closely with their respective counsel, and whereas a statement made by the witnesses was provided to the opposing counsel, no such prior opportunities have been given to the independent experts. In this respect everyone in the court will hear these statements for the first time.

I also confirm that neither Counsel have elected to exercise their prerogative of challenging the witness who testified yesterday. Mr Wiot and Mr Twiten have confirmed that any comments they wish to make in order to take into account the testimony of Messrs Einstein, Dirac, Poincare and Hardy will be incorporated into their summation.

Clerk: Will Werner Heisenberg please step forward to read his statement and please start by stating your name and your occupation.

Werner Heisenberg: My name is Werner Karl Heisbenberg. I am a scientist.

Your Honour, Judge Gauss-Newton I understand that we were asked to stick to our prepared statements. May I respectfully ask for your permission to very briefly veer away from that direction and take this opportunity of acknowledging the presence here of a great many friends colleagues and collaborators who I have not seen or met for a very long time.

(Judge Gauss-Newton was seen to nod in assent)

Werner Heisenberg: Thank you your Honour. Having stated my gratitude and also my joy at being re-united, however fleetingly, with people who were an important part of my life, I will now move back to the contents of my written statement.

I have been asked by Counsel for the defence (that is the defenders of String Theory) to write a statement that might be read out briefly at the end of a trial that I understand has been arranged to be held in about two months after this statement has been submitted. The only guidance I have been given is a copy of the official charge sheet, and I can confirm

that I have had no other contact with members of the defence team and that my statement has been prepared and submitted to the courts directly. I can also confirm that at no time have I discussed or divulged any aspect of my statement with the defence team.

Being called the father (or in my case the grandfather) of a whole school of science is not something that's sits easily with me. My work in the area of quantum physis came naturally to me as a result of the progress that was made in an astonishing period of 20 or 30 years at the start of the 20th century. In this respect I have a great deal of sympathy with all theoretical physicists and mathematical physicists who work in the current environment. The relatively sparse ground for breakthroughs since 1945, and the positively barren landscape since the 1970's cannot have been easy.

There are some encouraging signs that this might be changing, especially on the experimental side. Engineering has made great strides and along with everyone else in this field I have been very excited to see how first the Higg's Boson and then, more recently, gravitational waves have been discovered or confirmed. These are important steps, and whilst not quite in the same category of the fundamental changes that revolved around the work of Albert Einstein, I would say these are encouraging positive signs.

When I started to work on what is known as S-matrix theory, and a little later on symmetry groups, I had no idea that these, together with the work of Kaluza and Klein would become foundational in terms of String Theory. As I say it is not easy to know that one is seen as a founding father of a whole school within theoretical physics, but if that is how people now see me with respect to String Theory, then I regard it as an honour.

The charges that have been bought against String Theory are not easy for me to appreciate. Nevertheless I have to accept that there might be people, educated people no less, who subscribe to the views expressed in these charges strongly enough to bring such a matter to such an eventuality. When I considered the charges therefore, I tried to see how and why anyone who is reasonable might feel so moved that they would accuse String Theory of being a failed enterprise, and one that has effectively conspired to exclude the efforts of scientists involved in competing areas.

No matter how hard I tried, I could not find any circumstance or confluence of a number of circumstances where any reasonable person could find even the most remote evidence upon which to base the charges. To be specific, the first charge cannot be justified due to the fact that the evidence is not complete – and there is a reasonable chance that experimentation could provide the basis for the proof that is being demanded by String Theories critics. The second charge is baseless due to the simple fact that many of the very critics who have bought about

these charges are themselves employed in senior roles in established institutions. They have published articles without apparent conflict, and they have taught and supervised students from the undergraduate level all the way through to Phd. On that basis alone the second charge is invalid.

I wish to close my statement by offering the court a simple observation. History has shown us how easy it is to criticise methods of discovery that are hard to understand. I believe that with the single exception of quantum mechanics, String theory is the hardest and most complex area of research that we as humans have ever encountered.

We were extremely lucky that incredible people such as Albert Einstein and Henri Poincare, Schrodinger, Dirac and Bohr. Rutherford, Maxwell and Planck all lived and worked together. Competed together and collaborated together. This array of talent was barely sufficient to enable us to fathom the unprecedented mysteries of the quantum world. We existed at a time when mathematics was also benefiting from the presence or near presence of gigantic intellects. Hilbert, Ramanjuan, Hardy, Godel, Turing, Cantor and Von Neumann are just some of the names active during the period I refer to.

The current leaders of String Theory include some impressive names. But what we lack is that almighty coming together of expertise and skill that is not only world class, but historically important. It is my hope that such people are coming through the system. As they emerge and take over the mantel from String Theory's current leadership, perhaps that is when we will see the advances we all now crave.

I understand that I have been granted the privilege of commenting on what I have heard from prior testimony in the last minute or so of my statement. I will not take up this privilege since I believe that I have made all the points that needed to be made, and nothing I have heard has changed my mind.

Members of the Jury please do not make the mistake of damaging progress in an area of study that in my opinion, in my expert opinion, has the best chance of finding a unified theory of everthing.

with respectful regards,

W. Heisenberg

Clerk: I call upon Richard Feynman. Please address the court and start by confirming your name and occupation.

Richard Feynman: My name is Richard Phillips Feynman. I am a University Professor.

Whenever I encounter the word “independent expert” the hairs on the back of my neck rise in some intuitive primeval note of caution. As some of you will know I have some experience of proceedings of this nature. Legal or judicial processes that seek to bring in technical experts are inherently biased, in my view, so my first reaction was one of suspicion. However, as is evident, I am here, which means I decided to respond positively to the invitation and I was able to overcome my initial misgivings. I can assure you that I have done everything in my power to be objective and careful in putting together my prepared statement.

Before I go into the detail I also want to very quickly jump off my prepared text, as Werner also did, in order to acknowledge my pleasant surprise at being in the presence of people here today who are my friends and also in some cases colleagues whom I have not met for some time.

Turning back now to the matter in hand.

There are two charges that the court has been asked to pass judgement on. Both are serious. Neither can be trivialised and I have therefore devoted some considerable time to a review of the issues.

I would like to comment on the second charge first. Institutionalised arrogance and bullying (by which I mean of the intellectual type) are inherently part of the legacy that our universities and research institutions have inherited. Any system that piles laudatory acclaim on its highest office holders will perpetuate through the system of advancement and through the related activities of research publication controlled by peer review, a sort of cronyism that creeps into being often without intent but always with extremely negative results.

Many of the great architects and designers of String Theory in its early days when it was the “outsider’s” gig, the new kid of the block, or the ‘rebel’ if you will, are my friends and colleagues. Lenny Susskind is notable amongst that number. None of these people could be at all accused of trying to build empires and all of them were possessed of a brilliance when reaching out beyond the accepted norms in trying to imagine a world that is beyond that which we inhabit. Trust me it takes a special kind of craziness to think about more than the usual 3 spatial dimensions no matter how small you try to make them.

Being creatively brilliant is one thing, and fighting to achieve the resources that are necessary to conduct long term research is another. What has happened in the past 3 decades very clearly with String Theory is that brilliant minds have become conflated with a dark and worrying tendency to do exactly what they themselves fought against when they were young. They have become the very enemy that they fought against in order to establish a foothold. By promoting only their own kind and by being arrogant and at times quite viciously so when

dismissing other competing theories, String Theory has become a horrible caricature of the worst of academic control.

As the court will know I have little truck with the establishment. I spent my own career ensuring that I kept at least one foot outside the tent ! When I was called upon to work with the Presidential Commission that investigated the awful disaster of the Challenger Shuttle accident I saw first hand how malicious vested interests can become and how perfectly reasonable and honourable people are able to accept being part of a compromise that they would normally never accept. And that, I am afraid, is exactly what has happened with String Theory. Those who have benefited from their career 'within the tent' will never accept this charge – in fact they will rail against those of us who dare to whisper that things have to change – but it does not alter the truth.

I feel I should say something about the first charge. I am afraid however that my comments are going to be extremely bare.

The reason for this is that the facts support the charge – String Theory has failed in its efforts to prove itself as the unifying theory for quantum mechanics and gravity, and for all the promise and expectation, I cant see anything on the horizon that will change that. Well I told you that I had very little to say – the charge, as levelled, is true.

In closing I would like state something else that should be manifestly obvious. Science is about reality. It is not about mythology and it is certainly not a belief system such as religion.

My advice is that when scientists start to act like a religious order, then its time to either run for the hills or to give them a wake up call. This trial could well be a wake up call that String Theory needs.

We need to remind everyone that science is about results and not about posturing. You, the members of the Jury who are listening to this statement, really have no choice, I am afraid but to convict String Theory of the charges that it faces.

In doing so the Jury will also be doing all string theorists a favour. I don't mean in any negative or malicious way. If even a reasonable fraction of all the talent and all the money and resources that go into String Theory then goes somewhere else, who knows, but that another Heisenberg or another Dirac will emerge. This will only happen when the system changes. The system that determines phd grants and allocates tenure, the system the controls the editorial boards of journals and the system that awards prizes, made up, judge and jury, of the very same people who decide on the nominations in the first place. This cannot go on.

Can I just say before I walk back to my rather uncomfortable chair that it pained me very much to note that I might be speaking on the opposite

side of the fence as my friend Paul Dirac. On this Paul, you are mistaken, but I still love you.

Clerk: The court calls upon Attorney Ted Twiten to give his closing address.

Twiten: Members of the Jury. If, like me, you have sat through the past two days wondering when, if ever, the Prosecution will produce anything that remotely resembles an evidentiary case, then we have learnt that the answer is that they will never get there. The reason is not that they have not tried, but that it is impossible to produce any evidence in the first place.

The most telling way of summarising their approach is through an analogy. The prosecution are effectively people who criticise String Theory for having won only 5 olympic gold medals when people expected them to win 8. Is that a failure ? By what standard is that negative ?

I ask this question not to challenge the integrity of the witnesses and experts that you have heard from through the Prosecution. Henri Poincare, Albert Einstein. Richard Feynman. These are not only scientists who have affected the nature of knowledge but upon who's shoulders we all stand as we do our own work. My respect for them, and that of all of us, should stand undiminished as a result of their participation in the misguided adventure that took place in this courtroom in the past two days.

In seeking to present a view that is an alternative to those articulated by the three scientists I have mentioned, my team and my own witnesses speaking on behalf of String Theory offer no criticism of anything that has already been created or discovered by these great men. However, in the narrow but clearly defined parameters of this trial, their evidence and testimony, though well meaning, falls short of any standard required for you to return a judgement other than that of "not guilty" on both counts.

Ladies and Gentlemen of the Jury, String Theorists are talented and dedicated people. They represent in many many cases the very finest intellects that we, the human race, have produced in the last 50 or so years. That they have given their all in the pursuit of the ultimate truth cannot be denied. When I talk about the 'ultimate truth' here I refer to the goal of unifying quantum mechanics with the theory of gravity as discovered and described by one of our eminent witnesses here today, Albert Einstein.

Members of the Jury, String Theory not only confirms gravity, but in some senses anticipates it and I look forward at some point, hopefully sooner rather than later, to the time when the largely (but not exclusively) mathematical route maps that we have used, can be

confirmed experimentally. This fact alone means that at least on the first charge there is more than reasonable doubt. I would argue that in fact String Theory could be described as having achieved its objectives and I do not doubt that experimentation will vindicate these achievements.

However whilst we await the time when experiments might probe the higher dimensions that String Theory foreshadows, a number of seminal discoveries that have arisen out of String Theory have already been described by our witnesses and our independent expert.

A very good friend of mine, and an eminent mathematician, Shing-Tung Yau, in a wonderful book that he wrote just a few years ago, highlights just how important the theoretical method has been for science over the ages. In a passage towards the end of the book Yau quotes one of our witnesses, Paul Dirac, on the suitability of a measure of mathematical beauty as being an essential criterion for selecting the way forward in theoretical physics.

As we all know, in the case of Dirac it took many years after suggesting the existence of the positron as a result of his work purely on mathematical reasoning that experiments proved the existence of that particle.

The number of scientists who have made much the same point as Dirac is very long, far too long to try and list here. I would however like to pay homage to someone else that we are all familiar with, Eugene Wigner, whose quotation about the 'unreasonable effectiveness of mathamatics in the natural sciences' has entered common conversation and which should provide you with further confidence that you will be on the correct path when you dismiss the charges. Even the fiersest critics of String Theory acknowledge its rigour and consistency in mathematical terms. This, along with the sheer beauty of what has been created, should be more than enough to guarantee that String Theory is very valuable, and that its scientific fraternity are on the right track.

As we have also heard, in addition to progress in showing how gravity can be quantised, String Theory has been responsible for many other examples of tangible progress in the physical world that came about as a result of theoretical work that was largely mathematical.

I would like to take the opportunity provided to me in this summation to add one more example to my very short list you have been told about – that of the Yang-Mills equations that describe the force between particles and that, to the great surprise of Chen-Ning Yang, bore striking resemblances to bundle theory in mathematics that had been developed literally decades earlier. According to Yang, when he asked his colleague S S Chern about the coincidence, Chern replied with great matter of factness that it was no coincidence and that the concept of bundles were not 'dreamt up' but were natural and real. That strikes me

as a very apt example of the contribution and the confirmatory nature of the work done by String Theorists and shows, Ladies and Gentlemen of the Jury, just how String Theorists feel. Their constructs and their work is real, and experimentation will ultimately prove this to be the case.

I would like to close by thanking you for your patience and forebearance. Some of the concepts and the work that has been referenced or described are not immediately clear to the layman. Mathematicians and theoretical physicists spend their whole lives working on these matters. In fact they are professionals in the area – paid to spend all their time on mathematics and theorems. I have no doubt that many of you, if you spent the necessary time, would easily come to appreciate the concepts being described. Before I sit down I would like very much to share with you a quotation from one of the very great professional scientists of the 20th century, the Russian physicist and Nobel Laureate Lev Landau. He said, and I quote

"A method is more important than a discovery, since the right method will lead to new and even more important discoveries."

This is how String Theory ought properly to be judged. I have no doubts, members of the Jury, that as experimental capacity by which I mean better technology and better methods in the laboratory, in the accelerators that have been assembled, or in cosmology, improve in the years ahead, String Theory will emerge as the most important scientific initiative of modern times. String Theory is not only too beautiful to be wrong, but it will then appear as if a 22nd century construct had fallen into the 21st century.

I have no doubt that you will return the correct verdict and find String Theory NOT GUILTY on both counts.

Clerk: I now call upon Attorney Lomsin to provide his closing remarks.

Lomsin: (approaches the jury whilst applauding). Wow, that was good. That was some closing speech Ladies and Gentlemen. Amazing rhetoric and delivered with the skill of a Hollywood star. Cary Grant at his best, or Gregory Peck, would be proud of that delivery. Well done. Well done Mr Twiten.

However, much as I am sure we all admire his passion and his strong words, my honourable and much esteemed colleague has perhaps forgotten that we are not being judged on our acting skills or even our rhetorical flourishes. This is not about tugging on your heart-strings. This is about making a judgement based on the facts as they have been presented, and in making that judgement, bringing an end to the abuse of scientific privilege that we must guard against with every method at our disposal.

Counsellor Twiten included in his wonderful exposition a reference to the great Lev Landau. I was reminded when hearing Landau's quote, of another wonderful Russian, the mathematician Vladimir Arnold. I am afraid I did not come prepared with the exact quote, but I am sure you will forgive me if I paraphrase from memory.

Arnold is recognised as a mathematician who has influenced literally dozens of areas of research, and who's pedagogical style has been responsible for creating at least two new generations of mathematicians with the skill and rigour to go out into the world and discover amazing new theorems.

Arnold's comments went something like this "in the beginning of the twentieth century a self-destructive democratic principle was advanced in mathematics, according to which all axiomatic systems have equal right to be analyzed, and the value of a mathematical achievement is determined, not by its significance and usefulness as in other sciences, but by its difficulty alone, as in mountaineering. This principle quickly led mathematicians to break from physics and to separate from all other sciences. In the eyes of all normal people, they were transformed into a sinister priestly caste"

Now I truly did not come to this summation with a view to quoting Arnold to you, but in that quote he captures some of the central problems with String Theory. As Arnold says, when technical prowess, like the example quoted of mountain climbing, becomes more important than usefulness or significance, then we start seeing enormous cracks developing between science and mathematics, and that is exactly what has happened with String Theory. String Theory wants us to reward it because it has been involved in "hard work" that is "complex". I am sorry, but that is not what we are here to discuss and debate, and ultimately pass judgement on.

At this point it behoves me to repeat, very briefly, a point that has been made by some of my esteemed colleagues already.

It is important for me to reiterate that we have no issue with the individuals who are employed in researching String theory. Many of them are wonderful, dedicated, hard working and talented scientists. However when those very people start to declaim that only String Theory matters, then something has gone terribly wrong. The pressure to conform then starts to become pernicious and the ruthless and slippery slope of academic ambition brings out the sinister side of people who would otherwise be perfectly pleasant.

We have resisted here on this side of the court in parading before you the dozens and dozens of early believers in String Theory who have either become disillusioned with the field or who have expressed serious doubts about the increasingly dizzyingly complex structures that have been created to try and extend the relevance of the

approximately 10 to the power of 500 number of possible solutions. String Theory far from being beautiful has become an ugly and mind bogglingly complex discipline with virtually no chance of having any bearing on reality or of ever being proven through experiment.

My first witness, Henri Poincare delicately but carefully explained that String Theory has become divorced from the healthy checks and balances provided by experimentation.

My second witness, Albert Einstein reminded us of the fact that String Theory is not actually all that new or novel and that he first came across the core concepts when thinking about the implications of the work of Theodor Kaluza. Albert Einstein acknowledged the linkages between some of the work that String Theorists have done and the impact on cosmology, but warned us against becoming too comfortable when a system of science starts to resemble a system of beliefs.

Finally, our independent expert, Richard Feynman, spoke passionately and stirringly about the dangers of institutionalised bias and why he believes that String Theory is guilty as charged.

The testimony and statements of these three scientists should be sufficient to have convinced you of your duty today. All that remains for me therefore is to ask that you are brave enough to stand up to the status quo and not be taken in by the theatrics of great speeches, but find String Theory guilty on both counts.

In closing I wish to share with you a memory that was bought to me when the Professor Hardy, a witness for the defence, invoked Chen-Ning Yang. I recall that Yang's partner, Robert Mills, the other half of the Yang-Mills theory was quoted as saying "Beauty cannot guarantee truth nor is there any logical reason why the truth must be beautiful". The full quotation is a little longer than this, but like Mills I believe that the expectation of finding beauty at the heart of any deep understanding of nature is not false on its own, but dangerous if relied upon as a justification.

All of the people who have tried to defend String Theory have called either upon the strength and formidable complexity of the mathematical rigour that goes into the system, or the beauty of the mathematics that describes that system. These are not, and cannot be defences for the charges that have been laid against them.

Ladies and Gentlemen of the Jury, you must do the correct and proper thing and find in favour of the prosecution. String Theory is guilty as charged.

Thank you.

Clerk: His Honour Judge Gauss-Newton will now make his closing comments.

Judge Gauss-Newton: I would like to congratulate both the prosecution and the defence for conducting themselves in a thoroughly professional manner. It is rare for an issue that incites such passion and which divides people so clearly, to be argued by both sides with forebearance and courtesy. In this regard I think Science is the winner, and I want to thank the witnesses, the independent experts and each of the two attorneys for this achievement.

I admit to being somewhat uneasy when I was asked to take on this case, but I can see that those worries were misplaced.

I now turn to the members of the Jury.

Your job is to weigh the evidence that has been presented and agree amongst yourselves on the two charges that have been laid. I would remind you that although the charges might be linked, they are separate and it is not necessary that both must carry the same judgement. I would also remind you that there need only be a majority vote in favour of a judgement and since there are 11 of you I would hope and expect that you will come back to this court with a decision on both counts.

A written transcript of everything that has been said, and a copy of the references that have been made is awaiting each of you in the room that has been provided for you to retire to as you debate your decision. I am expecting that this decision will not take more than a day, however should you require more time then arrangements have been made for you to be sequestered overnight. In that eventuality the Clerk of the Court and his assistants will provide you with the details and also a copy of the very strict rules that demand no contact with the outside world whilst you are still undecided.

If you have any questions that need to be asked by way of clarification then you will have the opportunity to do so through the Clerk. I must remind you that you should only ask questions based on what you have heard.

Finally, I wish to give you some guidance on the matters in hand. No matter how many novels you might have read or films that you might have seen, a good lawyer or a good case is not won or lost on the flourish of a speech. You must look, if you can, beyond the words and how they are delivered. It is my view that the charges that have been laid against String Theory are easy to understand and therefore it is axiomatic that a decision can be made. That decision, in our judicial system, is your responsibility, not mine. I wish you well in your deliberations and I look forward to hearing from you in due course.

The proceedings then ended. This transcript does not cover the events that occurred after the Jury returned from its deliberations.

Transcribed by : Ilyas Khan, May 2016

Cationary Note for the reader: The preceding fictional proceedings are true events.

Certain names may have been changed for obvious reasons. Readers are further cautioned to avoid getting overly excited. If you think you recognise yourself or one of your quotes then please smile broadly and accept the compliment. If you recognise the made up names then pat yourself on the back ☺