Summer School Lecture

Einstein, Buddha and Modern Cosmology:

Awesome Knowledge and the Search for Enlightenment

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The document is a transcript/lecture notes for the above lecture.. The lecture was illustrated by scientific and astronomical images as well as portraits. The numbers refer to the image number. The images are too large to include here but are available from the author.

An English country parson told a young curate how to give a sermon: "First I tell em what I'm gonna tell em, then I tells em, then I tell em I told em"

"First I tell em...
Ways of Knowing
Mundane to awesome
Search for The Answer
Answers by Contemplation and logic
The Answer from the Quantum world: the nature of reality
Beyond the Grave...Time, Genes and Immortality
The Disciple problem
The Synthesis ...I tell em I told em"

1 Introductory Quotes

Dalai Lama

When one puts the world under a serious lens of investigation - be it the scientific method and experiment or the Buddhist logic of emptiness or the contemplative method of meditative analysis - one finds things are more subtle than, and in some cases even contradict, the assumptions of our ordinary common-sense view of the world.

Buddha: Kalama Sutra

Do not believe in anything because it is written in your religious books.

Do not believe in anything merely on the authority of your teachers and elders.

But after observation and analysis, when you find that anything agrees with reason

and is conducive to the good and the benefit of one and all, then accept it and live up to it.

2 Ways of Knowing

There are 4 ways that people get knowledge

Stories: always the most popular…humans love stories.

Contemplation

Logic

Science

3 Awesome Knowledge

A hand grips a ceramic container containing hot water, milk and an infusion of plant leaves.

A hand: an appendage that evolved over 1 billion years

The owner: a result of a billion generations of successful reproduction…not one of us has a single instance of a sterile or impotent ancestor: every single ancestor over a billion generations sucessfully reproduced. Each one of us has a uniquely successful pedigree.

4. Cells

More than a billion cells make a hand. Each an intricate machine that vastly exceeds the complexity of a jumbo jet.

5. Proteins

The grip: an assembly of billions of cells created from 5000 intricately structured proteins, lipid membranes, and collagen.

6. DNA

All of these proteins are created by the transcription of genes encoded in DNA molecules found in the nucleus of each cell. The DNA consists of 3 billion pairs of precisely matched and patterned amino acid molecules, containing about 30,000 genes which are the codes for creating the proteins.

7 **DNA and X-chromosome** Every cell contains about 2meters of DNA. The hand itself is a structured collection of atoms, and yet those atoms are in a state of flux and have an average residency time of only about 3 months.

While the atoms in the hand stay around such a short time, the cells are also quite short lived, and the thing we call a hand exists for less than 100 years. Yet the genes, the patterns of information coded in the DNA are very very old, many of them only slightly altered in a billion years.

8 Supernova Remnant

Roughly one third of the atoms, mostly oxygen, carbon and nitrogen,(which flow in and out while preserving the structure) account for 90% of our body weight, and were created in stars more than 5 billion years ago and thrown out into space in enormous supernova explosions, often accompanied by the birth of a black hole.

9 Big bang

Roughly 2/3 of the atoms were produced in the first 3 minutes of the universe, 13.8 billion years ago.

The force holding the cup and holding the cells together is the electric component of the electromagnetic force. The atoms themselves are held together by a combination of the electromagnetic force and the vastly more powerful force called the strong nuclear force. The force opposing my hold on the cup is the due to the curvature of space created by all of the atoms in the universe, dominated by all the atoms that comprise the planet earth.

10 Looking back 10 Billion years

An awesome image, 11 days of light gathering by the Hubble Space telescope on a spot of sky 1/50 th of the size of the moon. The size of this image is about the size of what you would see if you looked through a drinking straw 4 meters long. The nearest galaxy's light set out before the birth of the solar system. The most distant light set out more than 2 1/2 times the age of the earth ago.

11. Looking back 13.8 Billion years
This photo is a 2-year exposure of the entire universe 13.8 billion years ago (three lifetimes of the Earth ago!) when it was 1000 times smaller and before the first stars were born.

CONCLUSION
Our hands carry with them the history of the universe and the history of life. An ordinary hand links us to the whole universe.

12. The Search for the Answer

How deep study found universal laws
hoping to know the mind of the lawmaker

13 Pythagoras 530 BC. Scientist and Mystic

The universe is number and geometry. He explored all the perfectly symmetrical solids (Pythagorean or Platonic)

14 Leonardo da Vinci picked up the same ideas

15 Carbon buckyball.

The most beautiful molecule: In the 1980s Carbon was found to occur in this shape…so Pythagoras's exploration predicted nature

16 Galileo

17 The Leaning Tower

The next great leap: zero difference in free fall between all bodies. The perfection of free fall.
Shock and Conflict: he was first to observe the worlds beyond, and realized that the Earth is not the centre of the universe

18 Maxwell
The great synthesis of electricity and magnetism: they are the same force

19 And God said Maxwell's equations
God said (maxwells four equations) and then there was light. (This is a T-shirt design.)
I prefer to change the last line to "and then there was television")

20 Einstein
Revolutionary synthesis of space, time and gravity

21 Equations of space-time and gravity
And God said "matter tells space how to curve, space tells matter how to move" and then there was gravity!

22 Diagram of curved space.
The curvature of space around a black hole. (other side of the T-shirt)

23 Curved space seen by the Hubble Space Telescope
Image of gravitationally lensed galaxies.

24 Gravitational lensing diagram
How it works: two paths of light past a giant cluster of galaxies.

CONCLUSION
We have found out many of the laws…we have uncovered many of the beautiful symmetries that underlie these laws, the ideas are awesome but are we closer to knowing the thoughts of the law maker?

25 John Archibald Wheeler

John Wheeler was a colleague of Einstein's. He is still active in his 95th year. He invented the term Black Hole and the poetic statement of Einsteins theory.

"Law beyond law. It is preposterous to think of the laws of physics as installed by a Swiss watchmaker, to endure from everlasting to everlasting when we know that the universe began with a big bang. This means that the laws are derivative, not primary. Events beyond law…they fabricate form."
We need to find the law for the laws or the creation process for the laws.
But Wheeler goes on to say: "There is no law other than the law that there is no law". He is referring to the idea that the universe is an emergent phenomenon, that what we perceive as laws emerged out of the complexity of the structure.

26 Contemplation and Logic

How contemplation and logic found surprising facts, deep truths later confirmed by science and states of bliss unfettered by knowledge.

27 Hindu Discoveries: atoms, cosmic time and worlds beyond.
One day and one night of Brahma =2 Kalpas=8.64 billion years
Smallest cycle=maha yuga 4.32 million years
The atom: 1/ 146,000 of the size of the smallest grain of dust in Benares
Worlds beyond: The Upanishads: Where do all these worlds come from? They come from space. All beings arise from space and into space they return.

28 Democritus 460-370 BC The laughing philosopher:
We are accustomed to speak of heat, of cold, of colour
In reality there are atoms and space.
The Milky Way: "In some worlds there is no Sun and Moon, in others they are larger than in our world, and in others more

numerous. In some parts there are more worlds, in others fewer; in some parts they are arising, in others failing."
Are these merely good guesses? Science fiction?What is the significance? Compare them with the Buddhist discoveries.

29 Buddha
"If there is only empty space, with no suns nor planets in it, then space loses its substantiality"
This is uncannily close to Einstein's general relativity: According to general relativity, space cannot exist without matter to shape it and give it form.

30 Buddhist Contemplation and Logic.
Two most powerful ideas emerged out of Buddhist contemplation and logic.
(1) **Sunyata**, the doctrine of interdependence of all existence. Because of the interdependence of all things we experience the universe as if in a mirror, ungraspable, it can't be pinned down, it is just out of reach, chains of causality spread outward like waves, and come back and change the very things we are trying to grasp.
(2) **Anitta**: impermanence , change and decay. This concept arises from observation of the world and observation of the mind during meditation. Nothing is constant, nothing is unchanging.
Both of these ideas are completely consistent with scientific view of the world. From Sunyata comes another idea:

31 Buddha: Truth cannot be cut up into pieces and arranged in a system. The words can only be used as a figure of speech.

32 Feynman.
This is echoed by the great physicist Richard Feynman: if our small minds, for some convenience, divide this universe into parts – physics, biology, geology, astronomy, psychology and so on – remember that nature does not know it!

33. Lao Tsu
Not all contemplative traditions are in tune with science. They have still made parallel discoveries but they seem to do so by avoiding

both knowledge and logic. Lao Tsu, Zen Budddhism and some Christian mystics such as St John of the Cross see knowledge as an impediment

"Mere learning is dangerous…it is a source of distraction, its multiplicity destroys the unity of being.

“Without looking out of the window one can see the way of heaven
The further one goes the less one knows"

34 Einstein

. I want to now use Einstein to show how philosophical traditions are important when it comes to science. My target is Western absolutism, a mode of thought motivated by the Biblical story of the single creation of an unchanging universe. The realm of the stars is called The Firmament. Absolute objective existence is implicit. In this cultural context Einstein made his "greatest blunder"
His equations predicted the changing universe. He said to himself: My equations must be wrong because a changing universe is impossible!

While he soon repudiated this mistake,…the evidence for the big bang was irrefutable…. his absolutism also saw him repudiate the Buddhist notion of the link between the observer and the universe that emerges out of quantum theory. Einstein used quantum theory to predict the long range entanglement of particles, something that he said was so absurd that it proved that quantum physics was wrong. Well this quantum entanglement is now a tool used by physicists to make gravity wave detectors and quantum computers.

So we see absolutism contrasts with Sunyata and Anitta. Now I want to show you how Sunyata emerges in quantum physics.

35. The nature of quantum reality.

How science discovered Sunyata and Anitta and the Awesome quantum paradox of duality and entanglement which links the observer to the whole universe

36 Shrodinger
Shrodinger, Heisenberg and Bohr were the main players in the development of quantum physics. Wave particle duality: matter acts sometimes as a wave, sometimes as a particle and how it behaves depends on how you measure it. The act of observing appears to change even the distant universe.

"Inconceivable as it seems to ordinary reason you – and all other conscious beings..- are all in all. Hence this life of yours which you are living is not merely a piece of the entire existence, but is in a certain sense the whole."

37 Niels Bohr
"For a parallel to the lesson of atomic theory, we must turn to problems which thinkers like Buddha and Lao Tsu confronted when trying to harmonise our position as spectators and actors in the great drama of existence
We must be clear that when it comes to atoms, language can be used only as in poetry."

I want to explain how these ideas are a consequence of simple observation. This is the hard bit: it is a month of Physics 100 concentrated into 5 minutes.

38 Light as a wave:
Interference when light of a single colour combines.

39 Water waves:
Absence of ripples where the waves cross is a sure signature of waves

40 Soap Bubbles
Colour in soap bubbles comes from wave like interference of light. Light waves of certain colours either add up or cancel to give us colours. It can only happen when waves following two separate paths coincide.

But there is a paradox: when I photograph light it registers as instantaneous clicks like bullets hitting a target. This tells us that light comes in particles called photons. So we try to reconcile the problem by supposing that the photons are sort of wavy bullets like the next slide.

41 Photon Identity problem

(cartoon of wavy photon…am I a wave or a particle?)

Now imagine these wavy photons illuminating my bubbles. The bubbles are lit by a light bulb, but I am going to move it far far away, so far away that only one photon every second reaches the bubble. Since light travels at 300,000km per second that means each photon must be very far…300,000km from the next. Interference should be impossible…one wavy bullet is far too far away to overlap the next. But experiments show that the picture is unchanged (except I have to do a long enough time exposure to get my picture) BUT you need two waves to interfere. The colours should vanish because there are never two anywhere near the bubble….this is the paradox…there are only two ways of describing it…one is by poetry, the other is by mathematics.

42. Gravitational lens

Return to the gravitational lens and it gets even worse. Remember that interference comes from combining waves. I can combine the light from that distant galaxy inside my telescope: if I do that there will be interference as if some wavyness had traveled down both paths. But I can do something else. I can choose to measure the light in each beam. Then I register a click, click, click as the photons arrive, and I can say a photon just arrived from the left, now one arrived from the right. However the moment I enable myself to know the trajectory the tell-tale pattern of light and dark interference vanishes. I turned the waves into bullets. What I did in one minute in my telescope changed the light from waves that went on both trajectories at once, into particles which went one way or the other for their entire 10 billion year trajectory! My observation changed the whole universe!

43. Heisenberg

Appearance is not reality In the microworld Listen to what some of the sages have had to say:

Heisenberg: structures are linked and entangled with each other

Cheng Chien: Every phenomenon determines every other phenomenon…all phenomena are interdependent.

Heisenberg: A further consequence of quantum theory is the non-objective reality of things: "Every particle consists of all other particles…We could not say that the proton consists of 3 quarks…it may temporarily consist of 3 quarks, but may temporarily consist of 4 quarks and one anti-quark or 5 quarks and two antiquarks, and so on.….the world appears as a complicated tissue of events in which connections of different kinds alternate or overlap or combine, and thereby determine the texture of the whole."

44 The observer is Inseparable

Michael Frayn in Copenhagen "We discover that the universe exists only through the understanding lodged inside the human head" What is out there are wavefunctions and fields…things that are immaterial in the normal sense.

RC Henry:The only reality is mind and observations, but observations are not of things. To see the universe as it really is, we must abandon our tendency to conceptualise observations as things

So Democritus's statement: "we are accustomed to speaking of heat, of cold, of colour….in reality there are atoms and space" needs to be rephrased:

- "we are accustomed to speaking of atoms, of electrons, of photons…in reality there are wavefunctions and fields"

45 Beyond the Grave

Doctrines of immortality and reincarnation have always bothered my scientific mind. These exist in religion but not in science. But these can be reconciled with science. Let us start with..

46 Richard Dawkins:
The great exponent of genes and evolution

47 The River of Genes
The river of genes flows through time from body to body, generation to generation. The genes are nearly immortal, bodies are their vehicle…reincarnation and immortality is a reality, but for the genes, not for the bodies. We even share 50% of our genes with primitive bacteria.
Reincarnation is indeed closer to reality: the person is not re-incarnated but the genes certainly are at the moment of conception.

48 Einstein
Einstein expressed this idea long before genes had been understood. "The old who have died live on in the young ones"

49 Time

The question of death would be thrown into confusion if past, present and future were meaningless concepts. Well this is what the sages have to say:

Einstein: People like us who believe in physics know that the distinction between past, present and future is only a stubborn persistent illusion.

T R V Murti : The past, the future,…are nothing but names, forms of thought.

DT Suzuki: the past and the future are both rolled up in this present moment of illumination

Richard Feynman: What we mean by right now is a mysterious thing which we cannot define…Now is an idea or concept of our mind: it is not something that is really definable physically

50 Alan Watts:
And yet we still all know we are going to die. Alan Watts, the great Western exponent of Zen used recognition of Mortality as a means of self realization.

“The point is only to know, beyond any shadow of doubt, that "I" and all other "things" now present will vanish, until this knowledge compels you to release them – to know it now as surely as if you had just fallen off the rim of the Grand Canyon. ….And then comes the hitherto unbelievable surprise: you don’t die because you were never born.
"Consider death as the permanent end of consciousness, the point at which you and your knowledge simply cease, and where you become as if you never had existed at all.

Consider the death of the universe at the time when all the energy runs out, when…the explosion which flung the galaxies into space fades out like a sky rocket. It will be as if it had never happened. Likewise, when you are dead, you will be as you were before you were conceived. So, there has been a flash, a flash of consciousness or a flash of galaxies. It happened. Even if there is no one left to remember."

Now as I am coming to the end of this talk I come to all the unpleasant bits that I have left until last. Does all that I have said mean that there is a wonderful synthesis? Is this a fairy story with a happy ending? Not quite.

51 The Disciple Problem
How truth can be distorted, and how doctrines and dogma emerge. How the Western idea of faith can be interpreted in accord with Eastern philosophy, but how science cannot find accord with the idea of the personal god.

52 Dyson

Freeman Dyson, one of Einstein's colleagues at Princeton says this in a recent book Science and Ultimate Reality in honour of John Wheeler's 90th birthday:
As so often happens in the history of religions…the disciples of the founder establish a code of orthodox doctrine that is more dogmatic and elaborate than the founder intended. Bohr's pragmatic view of quantum mechanics was elaborated by his disciples into a rigid doctrine.
When Bohr was accused of confusing people,… he replied that one should not speak more clearly than one can think
I find that the experts have a tendency to speak with dogmatic certainty….they tend to speak more clearly than they think.
The structure of science is always provisional, always growing and changing." Disciples freeze knowledge in a time warp.

Dogma and doctrine create empires, promote power. "Have faith in me" is a means of exerting power.
"Have faith in me and you will be saved" NO! "Have faith in me and we will create an empire."

53. Billiard balls
The disciple problem is manifest in our interpretations of quantum mechanics.

The parallels between Eastern philosophy and microphysics have been exaggerated by the disciple effect: they are not false but extrapolate only weakly into the macroworld that we live in.
Physicists find that the quantum world is fragile, easily blurred by "decoherence." This happens because everything is "observed"…things affect things, and there is not just one observer but many. For example, the sun is observed not just by people, but by trees which photosynthesise and the ground which warms up. Because there are too many observers, there is a blur of averaging.

Decoherence causes time to gain a more concrete form, things to be more objective. The microworld does not know the direction of time but the macroworld knows it. Consider the collision of two billiard balls. They fly together, collide, and fly apart: as a movie

played forward or backward it looks the same. But do the same with eggs…it is easy to tell forward from backwards. The microworld is simple like the billiard balls. Our macroworld is complex. so quantum effects are mostly small.

54 The Micro-Macro Paradox: a raging debate

There is a raging debate…here are some of the opinions. On the one hand people say the universe is a quantum entity. Steven Hawking is one of its champions. On the other are those like Marburger, a science adviser to the US President.

RC Henry "Physicists shy from the truth because the truth is so alien to the everyday world. We evade the mental universe by the claim that the environment introduces “decoherence” switching the reality from the mental one of the microworld to the objective one of the macroworld.

“the world is quantum mechanical: we must learn to perceive it as such"

John Marburger: reality at a human scale may be approximate..but that approximation is independent of human consciousness because intrinsic “detectors” and stable structures define a concrete, objective, if approximate reality.

I say go easy on the parallels…beware of attributing mysterious quantum behaviour to everything from atoms to people. But still interconnectedness exists. The Buddhist insight is unchanged. Causality still makes everything effect everything else, but not in quite the mysterious way that it does in the microworld

55. Faith

A moment ago I mentioned the issue of faith. Even the most atheist scientist has one faith: faith in the existence of the truth, and faith in our ability to understand it.

But faith is a poorly defined word. I alluded to faith meaning "let go of everything and believe exactly what I say." But it can mean "let go of **really** everything…prejudice, material baggage, ties to the world and fears of death." This meaning is entirely consistent Alan

Watts teaching about knowing your own death, and with the Buddhist idea of skepticism, believing only what you experience yourself.
I want to thank Michael Wood, who I believe is here, for this insight.

56 Einstein

Coming to the last difficulty…the question of the personal god I want to use Einstein's own description of his cosmic religion.

"I am a deeply religious non-believer…this is a somewhat new kind of religion

"I don't try to imagine a God: it suffices to stand in awe of the structure of the world.

"What I see in nature is a magnificent structure that we can comprehend only very imperfectly, and that must fill a thinking person with a feeling of humility. This is a genuinely religious feeling.

"The religious geniuses of all ages have been distinguished by this kind of religious feeling, which knows no dogma and no God conceived in man's image…..It is the most important function of art and science to awaken this feeling and keep it alive in those who are receptive to it."

"I do not believe in the immortality of the individual, and I consider ethics to be an exclusively human concern.

"A God who rewards and punishes is inconcievable…..Man would indeed be in a poor way if he had to be restrained by fear of punishment and hope of reward after death."

And yet the personal God who helps you pass exams, win lotteries, girlfriends and boyfriends, and cure disease seems to be a

universal degenerate form of nearly all religions, no matter how pure their underlying philosophy. Man **is** in a poor way!

57 Awesome Cosmology

I have only given you a glimpse of the awesome universe….but it is there, everywhere, whenever we look deeply. In cosmology I wish I had had time to cover more of the awesomeness more deeply:

- Space is not what we think…it is filled with a teeming mass of particles and energy. 97% of the universe consists of unknown forms of matter and energy called dark matter and dark energy.

- The sum total of the mass and the energy adds up to exactly zero!

- Inflation theory accounts for this….a simple piece of mathematics…..but the consequence is that it is vastly bigger, awesomely bigger. The universe we see is like a single atom compared with a galaxy.

- And still we don't know why, why, why?

58 The Synthesis

No one has found the Answer except Douglas Adams and he did not know the question!
I want to summarise in 5 points:
1. Science has found awesome beauty and some of the laws but it has not found the lawmaker.
2. Science and the fundamental philosophies of Buddhism are in remarkable harmony.
3. Philosophical foundations do affect the way we think and react as illustrated by Einstein's blunders.
4. Truth is approximate.

5. Knowledge of the truth affects the happiness of the world.

This is emphasized by the Dalai Lama :

59 Dalai Lama:

"One of the key factors [in the origin of ideologies that tend to divide humanity] is the tendency to perceive things as inherently divided and disconnected. From this misconception springs the belief that each of these divisions is essentially independent and self-existent."

Absolutist Old Testament disconnectedness still drives deep conflicts: the Middle East, cultural battles over evolution, the dishonest war of intelligent design.

The world would be a happier place if all cultures accepted the concepts of anitta and sunyata.

60 Text

Chuang Tsu: Once Chuang Chou dreamt he was a butterfly…suddenly he woke up solid and unmistakable Chuang Chou. But he did not know if he was Chuang Chou who had dreamt he was a butterfly or a butterfly who had dreamt he was Chuang Chou.