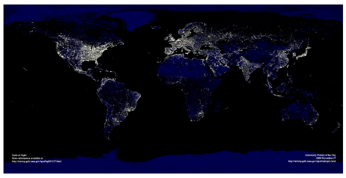
Does It End?

London is an amazing city but its not till well after sundown that many of its "places of interest" come to life. All tastes are catered for and there are some truly astonishing things to see and do. I'm quoting from the Rough Guide to London here, obviously, not personal experience. But one delight you'll never experience in London, no matter how rich, famous or important you are, is a truly dark night time sky.



Street lights, offices, houses, advertising, industry, traffic, dust, smog, humidity, all conspire to saturate the night sky with artificial light. Even when I was young, London never boasted a truly black sky. It wasn't until my family moved to the depths of the countryside that I can honestly say I even noticed the night sky. It turned out we were only ten miles from Luton airport, but to a seven year old from the East End of London, it might as well have been deepest Africa.

There were no street lights, no cars, very few houses and the nights were very, very black. Some nights you were afraid to walk in case you bumped into something. And you could not help but look up at the twinkling stars and the big heavy moon just beginning to rise over the frosty fields. But what really got to you after a while was the deep liquid blackness of space. And it's not too long before something does hit you right between the eyes - your first big mystery in life.

Does it go on forever or does it end somewhere? The question appears very simple and yet neither option seems possible. If the universe just stops, what's on the other side? And if it goes on for ever, and ever, if the universe really is infinite, well that seems even harder to get your head round, like holding infinity in the palm of your hand.

An over-rated ability of humans – in my opinion - is to stare into the conscious abyss for a while, mentally shrug, and move on to the relative comfort of life's daily grind - mum nagging about the state of your shoes, the endless cycle of lessons, homework, tests, yells of "tuck your shirt in" from Mr Sprague, the bitter-sweet teasing from the girl next door, and a million and one other pressures on modern youth.

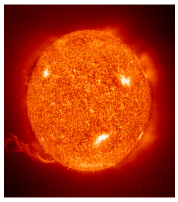
But there are some people who never lose sight of their first big mystery, people who seem driven to find out as much as they can about what's out there, where it's all come from and, possibly, where it's all going to. I'm not one of those people, but every now and then I try to catch up on their discoveries and ideas.

Take a powerful torch and shine it briefly at the moon and after about 3 seconds and you will be surprised to see a faint acknowledgement from a dark area of the moon known as the Sea of Tranquillity. Don't panic, its not some marooned astronaut frantically signalling for help nor the dreaded Clingons luring us into a cosmic trap. Actually, I do exaggerate a bit. To do this experiment properly you need an industrial laser and a decent telescope, but in principle, anyone can do this.

A pulse of light travels out from the laser, crosses the earth–moon gulf, reflects of a contraption of cat’s eyes left behind by one of the Apollo astronauts, then back to earth and into your eye, all in a breathless 3 seconds. And you can do this again and again. In fact students at University College just down the road do this routinely to measure, very precisely, the earth-moon distance in order to study how it is changing with time.

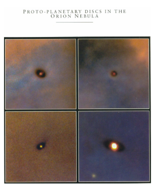
The point is that when we “look” at the moon we see it, not as it is now, but as it was 1½ seconds ago, when light left its surface and travelled into our eye. Now for something which has barely changed over hundreds of millions of years, 1½ seconds is no big deal. We don’t say, “that’s odd, the moon looks 1½ seconds younger than it actually is”, although maybe we should.

Nor is it such a big deal that we see the sun, not as it is now, but as it was eight minutes ago. If the sun disappeared this very instant, we’d be perfectly alright - for another eight minutes. Our Earth would even continue in its orbit around the missing sun for those remaining eight minutes. After that …well that’s something else.

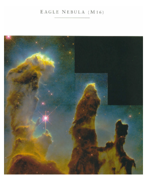


But for something like the sun, which hasn’t changed very much in a few thousand million years, eight minutes is a blink of the eye, a millionth of a second on a human timescale.

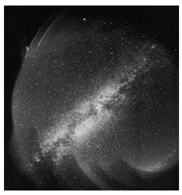
The nearest stars and planets in our galaxy are about 5 light years away (5 years light travel away) so we see them, not as they are now, but as they were 5 years ago. The slide shows four planetary systems actually in the process of formation, the central star has just ignited and the surrounding cloud of gas and dust will in another 500m years gravitationally condense to form a system of planets.



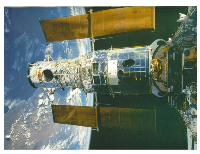
These “smoke stacks” of carbon, hydrogen, oxygen and sulphur in the Eagle Nebula region of our galaxy, we see, not as they are now, but as they were 7000 years ago.



And the most distant stars in our galaxy we see as they were 100,000 years ago. Looking out in space is looking back in time. But 100,000 years is still only a thousandth of a percent of stars lifetime so we do not notice any effects of ageing with stars in our galaxy.



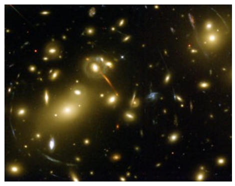
For fainter objects every photon is precious, so the best images are obtained at high altitudes. The highest observatory in the world is the Hubble space telescope, orbiting some 600 km above the Earth. Most of these images are from the Hubble telescope. It turns out our galaxy is just one of many millions of similar galaxies, and the further they are from us, the further in their past we are seeing them.



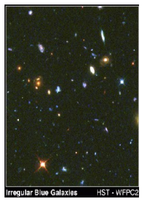
One of the nearest galaxies to our own is this, the Andromeda galaxy. As galaxies go, its pretty close, about 2 million light years away. And pretty big, almost a tenth of the size of its distance from us. Its also heading our way at about 300 km/s! Anyway, we see stars in the Andromeda galaxy, not as they are now, but as they were 2 million years ago, just about the time when humans got started here on Earth. That's still only a tiny percentage of a stars lifetime and far too small to notice any ageing effect between here and there.

Whichever direction we look in space we see millions of galaxies. There are about 1500 objects identifiable as galaxies on this one slide, which covers an area of the sky equal to about 1% of the moon. Scaled up to the whole sky, that's about 10^{11} galaxies in the observable universe, roughly ten galaxies for each human being alive on this planet. And each galaxy comes complete with about a million, million stars - and planets. There's an awful lot of stuff out there.

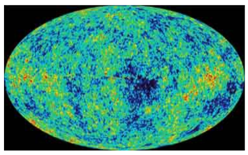
In fact wherever we look into the depths of space – and therefore time – we see the same familiar sort of stars and galaxies whether they're nearby in space and time, or far off in the distant past, right out to about eight thousand million light years. And yes those objects we see, not as they are now, but as they were 8000 mya ago, which is now getting on for the lifetime of an average star.



And here, for the first time, we do start to see a difference between the here and there, between the present and the past. At about 8000 mly out the number of galaxies starts to drop off. About 8000 mya the galaxies are fewer than they are now, and they get fewer still the further back in time we look. Those we do find are irregular in shape and an eerie blue in colour.



Beyond that we see - nothing. And lots of it. About as much nothing as there was something, if you see what I mean – another 6000 million years of nothing. And then, suddenly, at 13,700 mly out from Earth, we see it … the wall, the boundary, the end, the edge of our observable universe, the "Face of God" as some have called it.



Hovering in a very special stationary orbit on the far side of the moon, and shielded from all the microwave pollution of your mobile telephone calls, is a satellite called COBE. This slide is a mosaic of a large number of measurements from two years of COBE observations. Each pixel records the intensity of microwave radiation which started out 13,700 mya. Red is high intensity (warm), blue is low intensity (cool). The resulting contour map of the entire sky is a kind of thermal image of the wall, the wall as it might appear through sensitive night-sights. And the wall has very, very nearly the same temperature all around the universe, 2.7205 ± 0.0001°K.

While we measure its temperature as ~3°K (-270° Centigrade), it's actual temperature is more like 3000°K. It only appears 3°K to observers such as us who are travelling away from it at a significant fraction of the speed of light – the so-called Doppler red-shift effect. Now 3,000°K is the temperature at which ordinary atoms start to disintegrate into their constituent particles, protons, neutrons and electrons.

From another perspective, 3,000°K is the temperature at which an initially very hot soup of protons, neutrons and electrons has fully recombined to form electrically neutral atoms - a transparent gas. What we are seeing in this slide is the edge of an iridescent and opaque fireball, the universe at just 700,000 years after the big bang, when the soup had cooled sufficiently for the universe to become transparent to light for the very first time.

Whichever direction we look we see the wall, at 13,700 mly away. The wall seems amazingly smooth but when examined closely, we find tiny but definite variations in temperature and density of 1 part in 100,000, extending over significant areas of the early universe.

Like stumbling across a first map of the continents, we suddenly realise we are staring at the first condensations of ordinary matter, which in another six thousand millions years time, will cool and gravitationally condense to form the first galaxies, stars, planets and, ultimately, us. Because we are effectively looking at a complete map of the early universe, some people have rather fancifully called this image the “Face of God”. They’re probably not the first to get a little carried away by symbolism.

So does the universe go on forever? In the terms in which the question was originally posed, no. Our observable universe ends in a wall, a wall of searing heat and impregnable density, more impenetrable than any physical wall we can contemplate. But somehow that question seems less urgent now. Other questions clamour for attention - and funding.

While physically <u>we</u> may never reach and penetrate the wall, our equations <u>can</u>. The laws of high energy particle physics continue to describe conditions deep inside the wall where the temperature and density of the particle soup soars to unimaginable levels. The equations hold good right back to a hundredth of a second after time zero, the moment of big bang. What happens during that first one hundredth of a second? What happens, in fact, before time zero? These are the new questions of science, questions which maybe one day, you will be answering.

Does this discovery banish philosophical mystery and debate? No. As usual, answers only give rise to many more questions.

> **To see a world in a grain of sand**
> **and heaven in a wild flower,**
> **hold infinity in the palm of your hand**
> **and eternity in an hour.**
>
> **William Blake**

Does this discovery diminish our need to seek spiritual comfort to questions on life, consciousness, free will, love, morals, god? It offers little comment on these questions.

There seems an abundance of mystery and wonder for the human spirit to happily contemplate its role in the universe for an eternity. And as Woody Allen once said, eternity is a very long time - especially towards the end.

I’d like to end in the words of another gentle wit, the late Dave Allen, Thank you, and may your god go with you.