

## 13.7 BILLION YEARS

### Dr. Yervant Terzian

David C. Duncan Professor in the Physical Sciences,  
Cornell University; Director, NASA NY Spacegrant

I was born in Alexandria, Egypt, and later I attended The American University in Cairo. As a young boy in Egypt looking at the unforgettable amazing night sky I was captivated on why there were stars and planets, or anything at all !

At an early age I left for the United States where I devoted my life to scientific research and teaching. I have learned that the universe has had a beginning some 13.7 Billion years ago.

13.7 Billion years ago there was nothing. There was no universe. No galaxies, no stars, no planets, no light, no space and no time, nothing at all. Suddenly, for reasons that we still do not understand, an astronomical explosion took place and space and time began.

This explosion was incredibly hot and part of the energy of this inferno was converted to primitive matter of quarks and electrons. The quarks quickly combined and within microseconds formed the first protons and neutrons in the baby universe, the elementary particles that form all of the atoms in the universe. As the new superhot universe continued to expand, it also continued to cool, and within about 100 seconds it had cooled from trillions of degrees to millions of degrees in temperature, and that, enabled some of the protons and neutrons to fuse and form the first light elements like helium, beryllium and lithium. This early universe was very symmetrical, wherever it was, it looked about the same.

This fast expansion continued and the universe began quickly to cool. Within 380,000 years it had cooled to a few thousand degrees and it had cooled enough for electrons to combine with protons to form the first neutral hydrogen atoms. Today we have been able to map how the universe looked like at that early time with our man made powerful space telescopes.

What is amazing to me, is that from such hot and explosive beginnings, the universe after 13.7 Billion years, evolved according to the laws of physics and made it possible for you and me to be here today in this corner of the still expanding and now cold universe.

It appears that in its long journey the universe evolved precisely according to a few laws of physics that spring only from the nuclear force, the electromagnetic force, the weak force and gravity.

How did all this happen and where is the universe racing to?

Recently a US space mission, the Wilkinson Microwave Anisotropy Probe, made unprecedented precise observations of the entire sky from which we have deduced the accurate age of the Big Bang as 13.7 Billion years old, accurate to 1%. These observations also determined that only about 4% of the mass of the universe is made up of ordinary matter of the familiar atoms, and about 23% is made of dark matter, which, though we know it is there, due to the gravitational force it exerts on other matter, we still do not know what it is made of. The bulk of the mass/energy of the universe, the remaining 73%, is made up of some yet not understood dark energy, a mysterious concept, something like an antigravity force of repulsion that can explain the observed accelerating expansion of the universe.

Within less than a billion years after the Big Bang, due to gravitational instabilities, matter in the universe broke up into pieces that formed the billions of galaxies we now see. Trillions and trillions of stars formed in these galaxies, many with planets around them. One such galaxy was the one we inhabit, the Milky Way galaxy, where our star the sun is now one normal middle age star. The tiny planet earth has been gravitationally attached to our star since its birth some 4.5 billion years ago. We seem lost in space in this vast universe.

We have learned that stars evolve and change, and our sun will be there for us for another 4 billion years. After that it will expand and eject about half its mass into the interstellar space. By that time if humans still exist, they would have found better places to inhabit in the galaxy.

Eventually, all stars will die and the visible universe will become dark, filled with black holes and cold dark rotating spheres. Would life find a way to survive under such conditions? Would we, in the mean time, find other intelligent creatures living on other planets, to share our knowledge, and learn to live in peace in the universe?

The most important asset this century for the world is education. Educate all people or we will be in ominous trouble in the future. Most people believe in superstitions, supernatural entities, horoscopes - no better advice than from a fortune cookie. These people all have votes and elect our political leaders and our school boards. The illusion of knowledge does not promise a happy future.

I'm amazed to hear that educated people say "If the Sun is a star, why can't we see it at night?" or "Professor I promise you, I'll graduate on time no matter how long it takes", or "Infinity gets to be too long near the end."

I am often asked 'why study science and its resulting technology'. I think it is the thrill to explain nature and to understand the unknown, and also for the romance of discovery. To understand how nature works and use this knowledge to build useful tools and to survive. To solve problems of security, environmental dangers, and to have a comfortable survival.

In spite of the amazing progress we have made in understanding nature, most people are not friendly with the sciences. New ideas and understandings of the universe have always had a long time constant. It takes a long time for people to accept new revolutionary discoveries.

-Aristotle accepted that the earth was spherical more than 2000 years ago, and today there are 'Flat Earth Societies' paying dues.

-Copernicus 500 years ago, (and Aristarchus of Samos in ancient Greece), demonstrated that the sun is at the center of the solar system, and it took a few hundred years for people to accept this.

-Darwin explained biological evolution some 150 years ago, and today most people do not know what he tried to explain.

-Today, science is saying that we are only a marvelous complex pack of neurons that has an emergent property that we call 'consciousness'. I do not know how long it would take for people to accept this.

I suggest : We must devote more time to science education.

We must devote more resources to science education.

We scientists should be actively involved in improving the scientific literacy of the public.

We must promote the importance, usefulness, and benevolence of science.

We need qualified, enthusiastic, and well-paid science teachers.

We must seek ways for colleges and universities to work more closely with primary and high schools.

Science's great value is that it provides evidence-based arguments in finding the truth about nature. It provides hard facts that cannot be denied. Such understanding should guide all to make sensible decisions.

The aim of science is to discover how nature works, by searching for verifiable truths. Verifiability through measurements and observations is regarded as the cornerstone of discovery. This confidence that scientists possess have enabled them to develop super fast computers, instant communications, nuclear energy, space flight, genetic engineering to name a few of the modern applications of the laws of physics. This is the same physics that we use to understand the universe.

It is indeed fascinating to be able to contemplate the universe of billions of light years across and of billions of years in time. Yet our conscious minds have lifetimes of only a few decades each, a mini tiny drop in the vast ocean of time. In a super hi tech world of the future, would we develop immortality? Today we know of nothing else in the universe that rivals the complexity and ability of the human brain. This precious gift of the universe should be treasured and protected for generations to come.

The greatest scientist of the 20<sup>th</sup> century, Albert Einstein, once said 'The most incomprehensible thing about the universe is that it is comprehensible'.

It has been a long time since I gazed at the enigmatic stars shining like diamonds on the Egyptian sky. These first steps opened an ocean of knowledge.