
THE RACE
TO THE
BIG BANG
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THE BIG BANG AND THE FIRST ATOMS

(AS TOLD BY JACKSON)

On our final mission we reached the first second after the *Big Bang*, when the universe was very small and very hot. It consisted of *quarks* and electrons and nothing else. With these components, we had to build the first atoms in the universe. They were hydrogen and helium. Those atoms formed automatically in the intense heat of the *Big Bang*. But in the *Virtual World*, we were going to assemble them ourselves from the quarks and electrons as a learning exercise. We were going to use an *assembly sphere* where we would put the components in the right places and then join them together with the proper forces.

We started off with a *Room* meeting to plan the mission. First, we looked at the leaderboard.

"Wow, this is kind of a disaster for us," said Johari. "The *Cosmic Explorers* dropped from being the contest leaders to third place!" We had previously held the lowest total screen time by 0.17 hours. Now we trailed Milo's team by 1.08 hours.

BEST INVENTION: THE COSMIC KIDS

THE LEADERBOARD FOR AUGUST 7

TEAM	% OF RACE COMPLETED	SCREEN TIME HRS USED	BONUS TIME AWARDS (HRS)
SPACE PIONEERS	80%	11.50	-2.0
TIME TRAVELERS	80%	11.00	-1.0
COSMIC EXPLORERS	80%	11.08	-0.5
EINSTEIN'S GIRLS	80%	12.50	-1.5
JAPAN JOURNEYERS	80%	12.50	-1.5
THE SMASH	80%	13.10	-1.5
AUSSIE ASTRONAUTS	80%	12.80	-1.0
ENGLISH EXPLORERS	80%	13.00	-0.5
THE WOW	80%	13.20	-0.5
SPANISH SPRINTERS	80%	13.50	0

CONTEST NEWS: The Space Pioneers move into first place, the Time Travelers move into second, and the Cosmic Explorers drop to third place. The Cosmic Explorers have lost ½ hour of their bonus time award due to the insect infestation of their space station.

"Maybe we spent too much time trying to stop the bugs on *Planet Colorado*," offered Lizzy. "And we got penalized half an hour because the bugs made our space station unusable. We've gotta do really well on the next mission to catch up."

We spent an hour planning the mission. The plan was to split into three teams and attempt the assembly of hydrogen and helium simultaneously. Then each team did a practice run of our steps.

"I bet we can do the mission in 20 minutes if we're careful and quick," I proposed.

Once we felt confident that we knew what we were doing, we logged on and ordered two additional *assembly spheres*—where we would build our atoms—and two additional sets of all the tools we needed. We paid extra for immediate delivery to the ship. This cost us all of our remaining gold currency.

We went to work. First, we needed to collect the *quarks* and electrons. VC had already practiced that in the last mission. VC, Neddy, and I went up on the work deck, which had a heat shield to protect us. Using the *grab* tools, we collected several copies of the six different *quarks*, 3 colors of up *quarks* and 3 colors of down. That filled up the inventory boxes on the flight deck. We were going to use the *quarks* to build protons and neutrons which form the nucleus or center of each atom.

"OK, Lizzy and VC," I commanded, "you guys build a neutron."

Lizzy had to get a triangle template to assemble the *quarks*. Meanwhile, VC had to collect two down *quarks* and one up *quark*, each in three different colors. We don't know what they would really look like, but in the *Virtual World*, the *quarks* had different colors and arrows to represent up and down. VC needed to collect them, put them into the template, and then put everything into the assembly sphere. After that was done, Lizzy would hit the assembly with three *Gluons* from her *gluon gun* tool. The three gluons fused the *quarks* into a neutron.

VC put the finished neutron into the inventory and then repeated the process to make several more copies.

Scenes from "Building the First Atoms in the Universe," the STARDUST MYSTERY YouTube Channel

"OK, Neddy and Richie," I ordered, "now you guys do the same process to make a proton, except for protons, you need two up *quarks* and one down *quark*. Again, you need three different colors of each."

Neddy and Richie made 4 protons in 2 minutes, while Lizzy and VC made the neutrons.

As soon as the first proton was made, Johari and I started turning them into hydrogen atoms. We put the proton in the center of our assembly sphere, shot in an electron, and zapped the pair with the electromagnetic force gun. That created the attractive force between the proton and electron. The electron started circling around the nucleus in an orbit. It was kinda like how the moon circles the Earth.

When we finished making several hydrogen atoms, Johari and I started to make heavy hydrogens. For that, we used one proton and one neutron for the nucleus. We added a single electron and the electromagnetic force. We made a bunch and added them to the inventory. Then we made tritium which has one proton and two neutrons in the nucleus.

"OK," I said to Lizzy and VC, who had finished making neutrons, "now make helium atoms." A helium nucleus required two protons and two neutrons in the center of the assembly sphere. To make helium, they had to shoot two electrons into the sphere.

At first, the electrons bounced around wildly.

"Now Lizzy," I instructed, "add the electromagnetic force to make the electrons stick to the nucleus."

Scenes from "Building the First Atoms in the Universe," the STARDUST MYSTERY YouTube Channel

Lizzy did it, and it worked.

"Cool," said VC. "Now the two electrons are circling around the nucleus in orbits. It's like the two moons on that egg-shaped planet that Helen loves so much."

We did one final task for the mission. Neddy and Richie put all the hydrogen, heavy hydrogen, and tritium into the assembly sphere. Then Lizzy started cranking up the sphere's temperature.

"We are going to witness the nuclear fusion reaction that takes place on our sun to produce light and heat," I said. "It's the same reaction that actually formed the helium in the *Big Bang*."

The first thing that happened at several thousand degrees Celsius was that the electrons all detached from the nuclei. When the temperature reached 100 million degrees Celsius, each time a tritium nucleus hit a heavy hydrogen nucleus, the two fused to form a helium nucleus, and the extra neutron went flying off at a tremendous velocity. We were watching the nuclear fusion reaction take place.

We did all the experiments in just 19 minutes. We accomplished our mission.

GRANDPA'S GLOSSARY

The Big Bang: More than 2,000 years ago, humans looked at all the things in the sky and decided that the universe consisted of the Earth at the center with the sun, moon, and stars all revolving around it. In the fifteenth and sixteenth centuries, Copernicus and then Kepler and Galileo said that the universe has the sun as the center, and everything revolves around the sun. Then, in the nineteenth century, the picture changed to the sun and planets revolving around the center of the Milky Way galaxy. In the early twentieth century, the work of Henrietta Leavitt and Edwin Hubble showed that the Milky Way galaxy was only a small part of the universe, which has billions more galaxies like the Milky Way. What's more, Hubble's measurements, and the predictions of Alexander Friedmann and Georges Lemaître showed that the universe is expanding, with the most-distant stars moving away from us the fastest.

Based on the Theory of Relativity, Lemaître made a bold prediction. He reasoned that if you follow the universe back in time, it gets smaller. The further back in time you look, the smaller it has to be. So, if the evolution of the universe were a movie showing its expansion, and you played it backward, it would be contracting. The contraction of the universe would put it in one tiny, super-dense point about 14 billion years ago. Lemaître pictured the expansion of the universe from that point as the hatching of "the *Cosmic Egg* exploding at the moment of the creation." Other scientists call this the *Big Bang* theory. Lemaître gave lectures explaining his theory, including at Princeton University, where Albert Einstein was in attendance. It was reported that Einstein said, "This is the most beautiful and satisfactory explanation of creation to which I have ever listened."

How do we know that the *Big Bang* theory is correct? Well, scientists can calculate what occurred as the universe expanded from that first point. They can make predictions about the concentrations of elements in the universe and about the leftover radiation from the earliest times, which can still be seen as the cosmic microwave background. They can predict the size of stars, galaxies, and galaxy clusters, and the rate of the universe's expansion. Compared with these observations, the *Big Bang* theory is very accurate.

Quarks: Scientists discovered that besides the well-known building components for atoms (protons, neutrons, and electrons), there are over 200 other fundamental particles (photons, W bosons, Z bosons, gluons, Higgs bosons, gravitons, muons, and neutrinos). In 1969, Murray Gell-Mann and George Zweig independently proposed that just as atoms are composed of smaller particles, most elementary particles were actually composed of a smaller set of particles too. These are called quarks. There are six types, or flavors, of quarks: up, down, strange, charm, bottom, and top. Protons are made of two up quarks and one down quark. Neutrons are made of two down quarks and one up quark.

Electrons: All atoms are made of the same three particles: electrons, protons, and neutrons. Electrons are tiny particles that have very little mass and a negative electrical charge. They were formed in the *Big Bang*.

Atoms: Every solid, liquid, or gas in our world is made of atoms. Most things like water, people, trees, houses, and cars are made of combinations of different kinds of atoms. But some substances like silver, gold, oxygen, and carbon are made of only one kind of atom, and these are called chemical elements. The atom is the smallest unit that defines a chemical element. Anything made of atoms has mass, meaning that a force is necessary to make it go faster or slower, and it experiences a gravitational attraction to other masses. Atoms are very small. A single strand of human hair is almost 1 million carbon atoms wide. Atoms can be attached to one another in small units called molecules, in large crystals like diamond and salt, in mixtures of crystals, or in random arrangements in solids or liquids. You can see some of these arrangements in the animated science videos on the STARDUST MYSTERY YouTube channel. Milo, Lizzy, VC, Johari, and Neddy have starring roles in those videos. You can build atoms in the *Building the Universe* game available on Store.SteamPowered.com.

Some things in our world are not made of atoms. The most common is light, which consists of tiny particles called photons. Photons always move fast and have no mass. Some things are parts of atoms like a beam of electrons in an electron microscope or an old television tube. Then there are *dark energy* and *dark matter* that we think are out there in the universe but are not made of atoms. We are pretty sure they're there, but we don't yet know what they're made of.

Virtual World: Virtual worlds, also known as virtual environments, use computer technology to create a simulated world that a user can explore and interact with, while creating a feeling as if he or she were in that world. The representation of the user in that world is called an avatar. The user can even wear goggles to make it appear that he or she is surrounded by the 3-D virtual world. That is called virtual reality.

Room Communication App: A fictional internet communication software application that permits multiple users to hear and see each other and share their digital device screens. It is like the real app called Zoom.

Gluons: Gluons are particles that are part of the *Standard Model* of elementary particles. Like photons that travel back and forth between two charged particles to create the electromagnetic force, gluons do the analogous thing between quarks to create the strong force that "glues" the quarks together. Different quarks are glued in groups of three to form protons and neutrons.

Electromagnetic Force: The electromagnetic force is the force associated with electric and magnetic fields. It is the attractive and repulsive force associated with electrical charge that holds atoms and molecules together and participates in chemical reactions. It is the attractive and repulsive force associated with magnetism and all other electromagnetic phenomena. Like gravity, the electromagnetic force has an infinite range and obeys the inverse-square law. It is one of the four fundamental forces in nature, weaker than the strong nuclear force but stronger than the weak force and the force of gravity.

Protons, Electrons, and Neutrons: All atoms are made of the same three particles: electrons, protons, and neutrons. Electrons are tiny particles that have very little mass and a negative electrical charge. Protons have almost 2,000 times the mass of an electron and are positively charged. Neutrons have almost the same mass as the proton but have no charge. In an atom, the protons and neutrons are tightly bound together in the nucleus, attracted by the nuclear force. The electrons circle around the nucleus and are bound to it because of the electrical force of attraction between the positive and negative charge of the particles. Different kinds of atoms have different numbers of electrons, protons and neutrons. Hydrogen, the lightest element, has only one electron and one proton. The heaviest natural element uranium has 92 electrons, 92 protons and between 141 and 146 neutrons. You can build protons and neutrons from their component quarks in the *Building the Universe* game available on Store.SteamPowered.com at https://store.steampowered.com/app/1237700/Building_the_Universe_The_Beginning_of_Time/