Date: _____ Day: web of Science

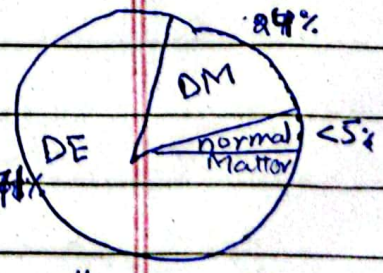
Q. What is Universe? Its size, structure, Origin and Possible Shapes?

Ans. **Universe:**

1. Universe is everything. It includes all of the space, the matter and the energy that space contains. It also includes all the time as well. (NASA).

2. For practical convenience, clumps of matter is categorised base on their attributes into galaxies, stars, planets etc. (study)

3. Universe also contains a bunch of matter and energy that can't be seen or observed directly. All the tangible matter is less than 5% of the total universe's composition. About 27 pc of the remainder universe is dark matter and 68 pc is dark energy. (NASA).
   - Normal matter
   - Dark matter



4. A galaxy is the building block of universe. It is believed that 10^{11} to 10^{12} galaxies are there in the universe.

Origin of Universe:

"The problem of the origin of the Universe is a bit like the old question. Which came first, the chicken, or the egg. In other words, what agency created the universe? And what created that agency? Or perhaps, the Universe, or the agency that created it, existed forever, and didn't need to be created."

renowned Cosmologist (Stephen Hawking)

Intro

① The best supported theory about how the universe began is big bang ~~theory~~. It was first put forward by Belgian priest named Georges Lemaitre in the 1920s. when he theorized that the Universe began from a single primordial atom.

② This theory tells how the universe hailed from a single point, then inflated over the next 13.7 billion years to the cosmos that is acknowledge -d today.

Theory

① Astronomers believe the universe began in a bigbang about 13.7B years ago. At that time, the entire universe was inside a bubble that was thousand times smaller than the pinhead. It was named ~~Sing~~ Singularity. It was hotter and denser. than any thing imagined.

② Then the singularity exploded. Time, space and matter was born. Along with these

Date: Day:

four fundamental forces ~~were forged~~ - gravity, electromagnetism, and the strong and weak nuclear forces - were forged together.

(less than 1 second)

③ In less than a fraction of second, all the matter and energy expanded outward on quantum ~~scale~~ Scale. This model of breakneck expansion is called Inflation, which explains the distribution of temperature and matter.

formation steps

ⓐ Radiation era ⓑ Matter era.

④ Universe, Immediately, After the formation entered into the Radiation era. In that era no ~~particle~~ matter was formed but the radiations were prevailing the whole universe. And that period is divided in small stages epochs.

⑤ In final epoch of Radiation era, particles started to form. Mather and anti-matter came into being on futher cooling off. But these opposite particles ~~annihilate~~ annihilated one another and somehow, the excess matter survived.

(1 second old)

⑥ When the Universe was 1 second old, subatomic particles - protons, electrons and neutrons - came to life.

(3minutes old) Nucleosynthesis.

⑦ 3-minutes after bigbang, the temperature dropped ~~to~~ 1 below 1-billion degrees celcius, the hydrogen and helium nuclei started to form.

⑧ Then, began the matter era which consitutes threes epochs namely: Atomic, galactic and Stellar.

Date: _____ Day: _____

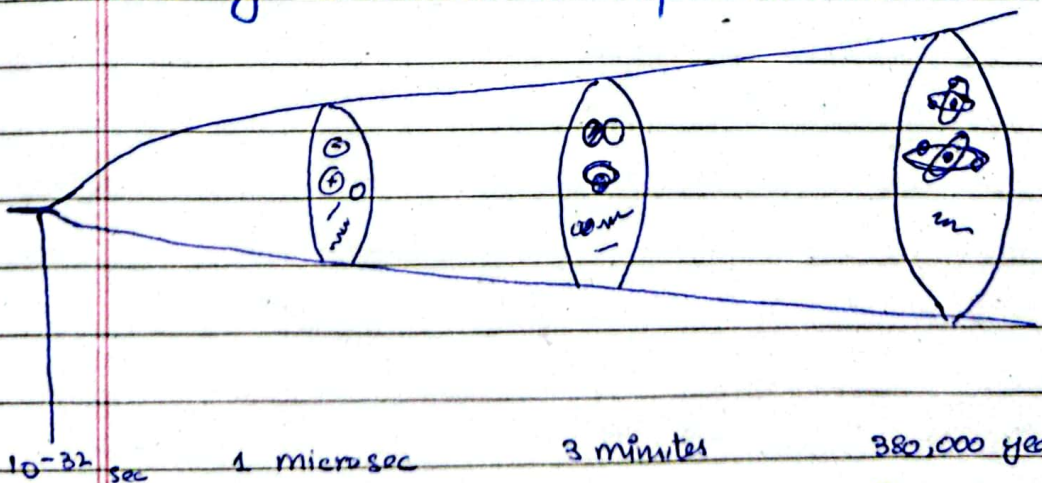
⑨ Recombination: Around 380,000 years after the big bang the universe had cooled enough that the nuclei could capture electrons to form neutral atoms. So the universe filled up with clouds of Hydrogen and helium gas and dust, from which no light could escape.

⑩ Dark ages: For next 200 million years the universe remained dark as there were no stars to shine

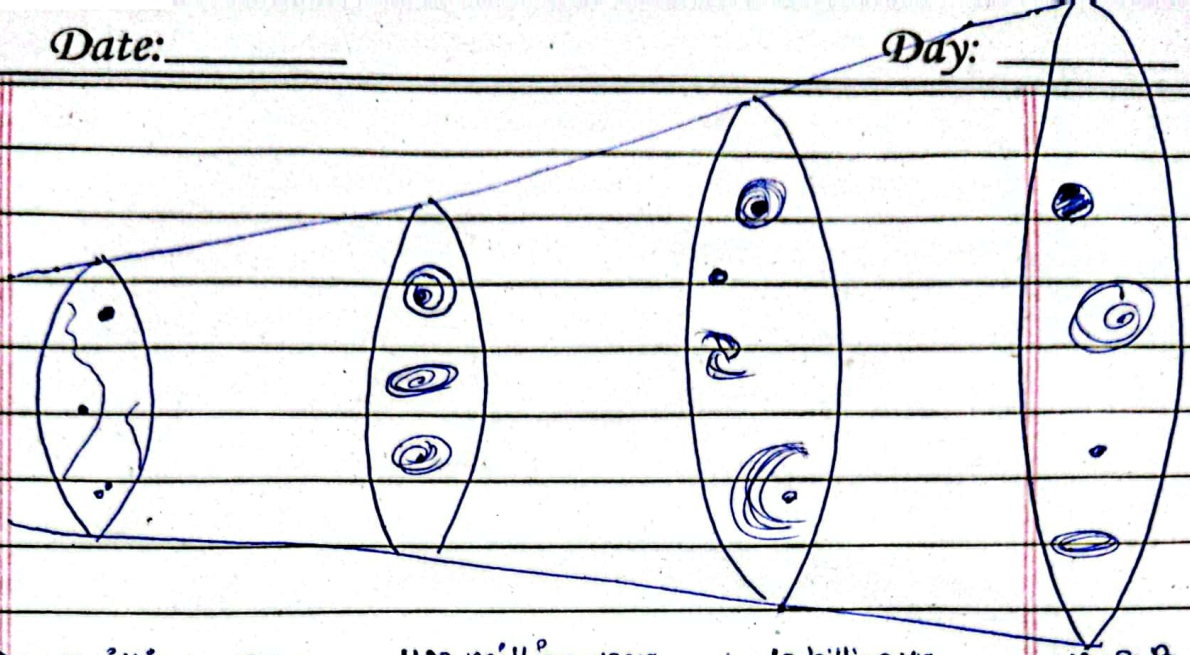
⑪ First stars: (But, As ↓ The clumps of matter grew more massive and denser, they became hot and eventually nuclear fusion reaction occured. And it marked the birth of the first stars. Over several hundred million years, the first stars collected into the first galaxies

- In February 2018, an australian team announced that they have detected signs of the "cosmic dawn" just 400 million years after the big bang. → which could be from the first galaxies.

History timeline of Universe:



Date: _____ Day: _____



* Nasa credit figure.

Evidence for the Big Bang theory :

Two major scientific discoveries provide strong support for the big bang theory :

(1) Hubble's law of expansion

(2) Cosmic microwave background radiation.

(Report of the University of western Australia)

Hubble's Law:

① In 1924 American astronomer edwin hubble used a technique to measure the distances to remote objects in the sky. He used spectroscope.

② By analysing the light (spectrum) from stars and galaxies, astronomers discovered that celestial bodies were moving away from one another. And this discovery was made possible by the red shift effect.

③ Red shift is when an object is moving away.

its light shifts to longer, redder wavelength.

④ ~~So the galaxies farther away~~

④ So the light from distant galaxies is red shifted, which tells us that they are moving away from earth.

⑤ This ~~theory~~ law clearly supports the posulates of big bang. As big bang signifies the expansion - movement of the celestial bodies - from the point of inception called the Singularity. The same is proved by ~~by~~ the Red Shift spectrum effect of bodies moving away.

⑥ Discuss blue-shift effect as well in paper. Both in the same canvas. (Not necessary)

(2) Cosmic Microwave background Radiation: (CMBR)

① According to big bang, after the explosion, the universe was very hot but with time it cooled off. So the radiation that had started emitting from the big bang ~~ba~~ was cooled down due to expansion. On the basis of the above poswates ~~cosmologists~~ ~~eventually~~ Arno penzias and Robert wilson ~~as~~ accidently discovered CMBR - leftover heat from big bang - in 1964 while studying radio signals.

② As, today, CMBR is very cold due to

Date: Day:

expansion and cooling of the universe. So the CMBR detected was only 2.725 K (-270°C)

③ The CMBR discovery supports the big bang. As the radiations emitted from singularity ~~and cooled down and~~ travelled and eventually detected by astronomers proved the posulate of the theory, as the radiations were around absolute zero temperature. which was already calculated before even the discovery

④ The detected radiations were from the period when atoms were formed.

Size Of the Universe:

① ~~Bang~~ Size and age of the universe depends on a number of things including its shape and expansion. Before the dawn of modern physics, Universe was considered ~~static and~~ to only have Milkyway in it. ~~(Article Mt wilson~~ (Article: Milky way ten-times bigger than thought by Mount Wilson observatory astronomer Harlow shapley - 1919) So its size was determined to be 300,000 light years across and age infinite.

② But with time modern instruments, ~~and~~ giant telescopes and above all ~~Edwin hubble's~~ the discovery of CMBR made it easier for Scientists to estimate the size and

Age of the Universe.

③ In 2013, the ESA's planck space mission released the most accurate map ever of the universe's oldest light. And it revealed that the Universe's ~~age~~ is 13.8 billion years old. Planck calculated age by studying CMBR.

"The cosmic microwave background light is a traveler from far away and long ago"

(NASA's propulsion scientist Charles Lawrence)

"When it arrives, it tells us about the whole history ~~of~~ of our universe."

④ So the connection between distance and speed of light, implies that scientists can look at a region in space that lies 13.8 billion light-years away. ~~This~~ It means that earth is inside an observable sphere of radius 13.8 billion light-years. The diameter becomes 28 billion light-years. And keeping in mind the universal expansion the same spot which is visible to scientists from 13.8 billion-light year will be 46 B-light-years away today - according to Ethan Siegel, writing for Forbes. making the diameter of the observable universe as 92 Billion.

Shape of the Universe:

"If you want to find the secrets of the Universe, think in terms of energy, vibration and density"

(Nikola Tesla)

① The ~~fate~~ shape of the Universe is determined by the physical properties of energy in the Universe, its average density and rate of expansion.

② There is a growing consensus among cosmologists and physicists that the Universe is flat and will continue to expand. Several lines of evidence point to this flat Universe. Different Scientists have proved - some ~~geometrically~~ mathematically and some scientifically - their argument of flat Universe by researching in a single domain. Just as stated by Tesla in the above quotation.

③ So, it shows that the shape of the Universe could be determined by the physical attributes of energy in the Universe, its average density and rate of expension.

⇒ David spergel's study of total energy:

④ A professor of astrophysics at princeton University, In 2003 published a study in 'Astrophysical journal' showing that the amount of

Date: Day:

in the Universe

positive and negative energy is ~~also~~ almost same, and therefore they cancel ~~each~~ each other out. ~~Making~~ So, this study of Cosmic microwave background radiation varified the flat Universe hypothesis. Because ~~if~~ if the Universe had a curvature, one energy would be higher than the other. And it was later observed and testified by European space agency's planck spacecraft. that the Universe is flat and expanding. on the same grounds. ~~In 2013, Scientists~~

④ Another reason Spergel is positive, the Universe is flat is its rapid expansion, which is measured by hubble constant. Hubble constant, when calculated, showed how quickly the Universe was expanding

Critical density study

⑤ According to Einstein's theory of general Relativity, space itself can be curved by mass. As a result, the density of the Universe — how much mass it has spread over its volume — determines its shape, as well as its future.

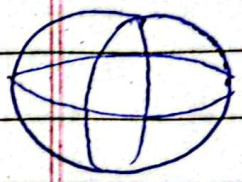
⑤ Scientists calculated the critical density of the Universe - directly proportional to Hubble Constant - and compared it with the actual density to help understand the cosmos. It ~~showed if the Actual density is less than the critical density~~ on studying the data

Date: _____ Day: _____

⑥ Scientists released three Universe models:

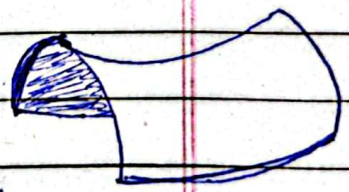
(a) Spherical shape: If the actual density of the Universe is greater than the critical density, then it will contain enough mass to stop expansion. ~~and~~ In this case the Universe will be closed and spherical in shape.
Once the Universe stops ~~expansionding~~ expanding, it will begin to contract and start moving closer and closer together. Eventually, the Universe will undergo opposite of the Big Bang often called the Big Crunch.
(Swinburne University of Technology Australia)

$\Omega_0 > 1$



(b) Saddle Shape : open Universe
If the actual density is less than the critical density, then there will be not enough matter to stop expansion, so ~~it~~ Universe will take up the shape of horse saddle. This is also known as ~~an~~ the Open Universe model. $\Omega_0 < 1$

* also called Big chill or Big Freeze



(c) Flat Shape: steady state model
If the actual density is equal to the critical density, then there will be a steady state expansion, ~~and~~ so the universe will be open and flat in shape.

$\Omega_0 = 1$

according to NASA:
On probing these models, In 2013 NASA's Wilkinson Microwave Anistropy probe (WMAP) measured the distance between the brightest

microwave background fluctuations and confirmed that the Universe is flat with only a 0.4% margin of error.

The Ultimate Fate of the Universe:

"Some say the world will end in Fire, Others say in Ice." Robert Frost.

(L) Just as the Robert Frost imagined two possible fates for the earth, Cosmologists envision two possible fates for the Universe:

(a) Endless expansion (b) Big Crunch

(a) Endless expansion: The future of Universe is dependent upon the struggle between momentum of expansion and the gravity. While the strength of gravity is dependent on density. If the density of the Universe So is the density is directly proportional to Hubble's Constant of expansion. Then the fate of the Universe is governed by density.

* Infuse critical density study except spherical.

(b) Big crunch:

Shperical model (Previous page). Add: Then the gravity will eventually win and Universe will collapse back on itself.

"The Stars may dissolve, and the fountain of light. May 2second live sink in a never ending chaos and night." poet shelly 1809.

Multiverse

Date: _____ Universe Day: _____

② Recent Reasearch:

~~Latest observations of NASA~~

According to a report - published by NASA on their website - Latest observations of distant Supernova have suggested that the expansion of the Universe is actually accelerating. which implies the existence of a strong negative pressure. This strange pressure is refered to as "dark energy".

Unlike gravity ~~dark~~ which works to slow the expansion down, dark energy helps to speed ~~up~~ the expansion up. As the dark energy is 71% of the total Universe, it clearly signifies that the Universe is expanding and will expand indefinitely.

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