Agnirva Space Internship Project Report

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Introduction:

Agnirva is an 8 week long space internship conducted by Agnirva.com inaugurated by ISRO. The first and second weeks of Agnirva's 8 week long space internship focus on the foundations of space exploration and history of space respectively. In Week 3: 'Beyond Earth's Boundaries', the exploration deepens as we get to unravel the intricacies of the Current Space Sector, examining major players in the public and private domains, alongside insights into the upstream, midstream, and downstream segments. In week 4, the participants are introduced to the *'Artemis Accords'* and the complexities involved in space diplomacy and international collaboration. The first 4 weeks of the program introduces the participant to the current scenario in the fascinating world of Space Exploration.

In Week 5: 'Future Frontiers', the curriculum explores diverse topics such as the interplay between agriculture, climate, and space, the convergence of the internet and space, emerging technologies in space exploration, next-gen navigation systems, and a profound exploration of sustainable development challenges and future outlooks. In the final stretch, Week 6 : 'Beyond Earth's Horizon' and Week 7 & 8, the participants are introduced to insightful discussions on the fascinating realms of space tourism and defence, the quest for extraterrestrial life, and the Goldilocks zone. The week culminates with a deep dive into civilizations and the Kardashev Scale, providing a comprehensive understanding of humanity's place in the cosmic world.

Summary of Learning:

Throughout human history, we've looked up at the night sky with awe and wonder. The Egyptians used constellations to track the seasons and predict floods, while the Mayans built elaborate astronomical observatories to study the movements of the planets. These early astronomers laid the groundwork for our modern understanding of the universe, paving the way for future generations of explorers.

On October 4th, 1957, the Soviet Union, amidst the tensions of the Cold War, launched Sputnik 1, the first artificial satellite to successfully orbit Earth. While seemingly insignificant in size, Sputnik represented a monumental achievement, marking the beginning of the Space Age and igniting a fierce competition for technological supremacy between the USSR and the USA.

Coming to the present day, major private and public players in the space sector are looking forward to space exploration and colonization. Some of the major public players are NASA, ISRO, ROSCOSMOS, JAXA, and ESA. The private players are SpaceX, Blue Origin, Virgin Galactic, and Boeing. The shift from public to private space exploration has made the space industry more dynamic than ever. SpaceX operates mainly as a spacecraft manufacturer, launch service provider, defense contractor, and satellite communications company with a mission to reduce space transportation costs and make space travel feasible and ultimately colonize Mars. Meanwhile, Blue Origin is developing 4 rocket engines. Boeing is also a popular private player in the space exploration field, mostly focusing on aeronautics. Similarly, Virgin Galactic also focuses on developing commercial space flights for suborbital missions.

Stars are formed through a process called “stellar formation”, which occurs within colossal reservoirs of gas and dust called “Molecular Clouds”. A good example of one close to home is the Orion Nebula. These clouds, composed predominantly of hydrogen and other molecules, serve as the cosmic cradles where stars are born. Turbulence deep within the molecular clouds due to external factors such as shockwaves due to a neighboring supernova, causes “knots” (localized gas and dust mix regions within the molecular clouds of sufficient mass) and these knots develop into protostars (a primitive ancestor of a star) The growth of the protostar due to nuclear fusion gives rise to a star. A star is a luminous ball of gas (mostly Hydrogen and Helium) held together by its own gravity. Based on mass, a star can be a low-mass star (less than 0.4 solar masses), intermediate star, or a high-mass star (more than 8 solar masses). The pressure from the fusion reactions happening inside the star balances the enormous gravity due to its mass, thus preventing the star from collapsing into itself. However, in case of high-mass stars, this delicate balance can be maintained only until the fusion reaction reaches Iron. Iron fusion is energetically unfavorable as it doesn’t produce any energy to “push” outward the immense gravitational pressure, thus leading to a violent implosion and collapse of a star due to its own gravity turning it into either a neutron star - a celestial object that is made of densely packed neutrons, or a black hole - an extremely dense region of space from which even light cannot escape.

As for low and intermediate mass stars, their deaths, though inevitable, are quite different from that of high mass stars. As low mass stars approach the end of their main sequence phase, the gradual exhaustion of hydrogen in their cores initiates a transformation into red giants. During this phase, the outer layers of the star expand, and the star sheds its atmosphere into space, forming a planetary nebula and what remains is a dense core composed mainly of carbon and oxygen – a “white dwarf”. Over astronomical timescales, white dwarfs cool and dim, thus fading into cosmic insignificance. Intermediate stars also face a similar process after a “cosmic burp”.

Planets are astronomical bodies formed through “Nebular Hypothesis”. Nebular Hypothesis asserts that solar systems are formed out of collection of gas and dust. Planets can be of two types: terrestrial planets, and gas giants (also called “jovian” planets). The latter are normally considerably larger in size than their terrestrial counterparts and lie in the outer edges of their

solar system. Dwarf planets are celestial bodies in the solar system that are round enough to be similar to other planets but lacking the dominance over their orbits as other planets. Pluto is a dwarf planet in our solar system. Despite the name suggesting that they're a group of planets, the IAU considers them as sub-planetary celestial objects and not as planets. An exoplanet, or extrasolar planet, is a planet located outside our Solar System. Discovery of exoplanets has led to an increased interest in the existence of extraterrestrial life.

The death of the universe could happen in 3 possible ways: The Big Rip, or The Big Crunch, or the Big Bounce. The Big Rip Theory believes that the universe could keep on expanding until everything gets ripped apart. Whereas the Big Crunch Theory believes in contraction after initial expansion. None of the theories are proven yet. Hubble's law, also known as the Hubble–Lemaître law, is the observation in physical cosmology that galaxies are moving away from Earth at speeds proportional to their distance. In other words, the farther they are, the faster they are moving away from Earth. The Hubble Constant is the proportionality constant. In simpler words, it tells how fast galaxies are moving with respect to the distance between them.

Star systems are large collections of stars orbiting each other. Galaxies are massive gravitationally bound star systems consisting of stars, stellar remnants, interstellar gas, dust, and dark matter all bound by gravity. Nebulae are the interstellar clouds of gas and dust in a galaxy. Though invisible, Dark Matter is believed to take up significant mass of the galaxy. At the center of our Milky Way galaxy, lies Sagittarius-A, a supermassive blackhole which is 4.15 ± 0.16 Million times more massive than our Sun!

The Universe is the entirety of space-time, matter and dark matter, and energy. CMB (Cosmic Microwave Background) is the leftover radiation from the early universe and can help us understand more of the initial stages of our universe.

Artemis Accords a non-binding multinational agreement involving the United States govt., and global govts., engaged in the artemis program, with an intention to prevent conflict and competition in space exploration. However, the Artemis Accords are subject to criticisms, among them being biased towards the USA, and being vague with a lack of info and possibly leading to misunderstandings.
Though space exploration has been a subject of interest for decades, there are numerous challenges that come with it and need to be addressed. Firstly, inefficiency of chemical based propulsions call for an advanced propulsion system such as either nuclear propulsion or ion propulsion. Secondly, the risk of human life during space exploration calls for robots to be used. 3D Printing (Additive Manufacturing) methods are being considered an alternative to traditional manufacturing methods. Quantum communication is also being considered.

An innovative concept is the idea of solar sail principle which uses the momentum of photons from the sun to derive energy for space exploration. The knowledge of fields like Artificial Intelligence, Machine Learning, Cybersecurity, Robotics, and others are being used

extensively in the space navigation industry. For example, AIML uses in space navigation are data driven approach, route optimization, feature extraction, collision avoidance, adaptive navigation systems, and feedback loops. Cybersecurity principles can be used in implementing anti-jamming technologies.

The Asteroid Belt lies in between Mars and Jupiter. It is a vast region of space that contains comparatively few asteroids, which means that it's not dense at all. The distance between asteroids is about 1 million km (600,000 miles), posing little to no danger to space flight. The Kuiper Belt is a Trans-Neptunian region containing mostly icy bodies. Other Trans-Neptunian objects include Pluto, Eris, and Makemake.

The upstream segment, mi-stream and downstream segments play an important role in the space industry. Atmospheric pressure decreases as altitude increases, due to lesser volume of air above us. Earth has an atmosphere, hydrosphere, cryosphere, geosphere, and biosphere. CFCs break down the O_3 molecules in the Ozone layer leading to Ozone layer depletion. This can lead to passing of UV - A, B, and C Rays leading to various problems.

Acid rain is when the pH level of rain is acidic, and can make plant leaves become yellow and fall off. A “Heat Wave” is when there’s continuous heat lasting from days to several weeks. This can lead to fatal heat strokes and dehydration. Even plants and animals can suffer heat stroke. It is best to stay inside and hydrate oneself during heat waves to prevent heat strokes and dehydration. IPCC i.e. Intergovernmental portal for Climate Change is a worldwide group of scientists who collect data from weather stations and form climate reports.

Climate Variability can be due to both Natural causes (ex: volcanic eruptions) and man-made reasons (ex: burning fossil fuels). Climate adaptation can be achieved by planting more trees to reduce Carbon Dioxide, or building higher walls to prevent floods. Green Economy refers to usage of “Green Resources”, that is processes that do not pollute the environment and can be reused and recycled. Sustainable Aviation Fuel is an example of this. Satellites are extensively used in climate studies and meteorology due to their exceptional imaging capabilities. They are equipped with radars, sensors, and cameras and can even detect the amount of snow on an icy land or the greenness of a farmland. They send and receive lasers, allowing them to discover even ancient underground cities!

Space based solar power is an interesting concept that plans to take solar energy from the sun and send it to Earth in the form of microwaves and lasers where it can be harnessed as electrical energy to supply electricity or run machinery. Satellites can even measure moisture in the air, ocean temperature, etc.

Climate Sensitivity refers to how the temperature changes with respect to greenhouse concentration in the atmosphere. Climate Resilience refers to making structures withstand extreme weather conditions. Biofuels are fuels obtained from plants and animals as opposed to fossil fuels found beneath the earth’s surface.

Sun sends out CMEs (Coronal Mass Ejections) Solar winds from the sun are normally stopped by earth's magnetic field. However, strong solar winds could pass through, leading to disruption in some of the modern satellite communication and navigation systems and technologies. Biochar is formed by pyrolysis of organic materials and can trap Carbon in it like a sponge trapping liquid in its pores. Crop Yield Forecasting can make farming more efficient.

The Drake equation is a probabilistic argument used to estimate the number of active, communicative extraterrestrial civilizations in the Milky Way Galaxy. The Kardashev scale tells us the technological advancement of a civilization based on its energy harnessing capabilities. A Type-1 civilization would be able to harness the entire energy of its planet (for reference, we aren't type-1 yet), Type-2 would harness its host star's energy using a dyson sphere (a proposed megastructure built around a star that can extract the star's energy) or similar structures that are variations of the dyson sphere (dyson rings, dyson swarms, etc.), whereas a Type-3 civilization would be doing this on a galaxy-wide scale. The Kardashev Scale's relevance extends beyond its initial astrophysical context, shaping conversations about the potential trajectories of technological evolution and the search for extraterrestrial intelligence. Its speculative nature invites us to contemplate the vast possibilities of advanced civilizations. and the challenges they may face as they progress along the scale.

Conclusion:

The space industry not only has significance in space exploration, but also in our daily lives ranging from satellite communication, to healthcare, and even climate monitoring activities. Our universe has a fascinating history, and numerous theories are being proposed to predict what would happen in the future. This has led to an even more interest in the space exploration industry which has been instrumental in shaping our knowledge about space ever since the dawn of the space age during the cold war. International collaborations between public and private players in the space exploration industry and the upstream, midstream, and downstream segments would help in navigating the depths of space not yet known to mankind.