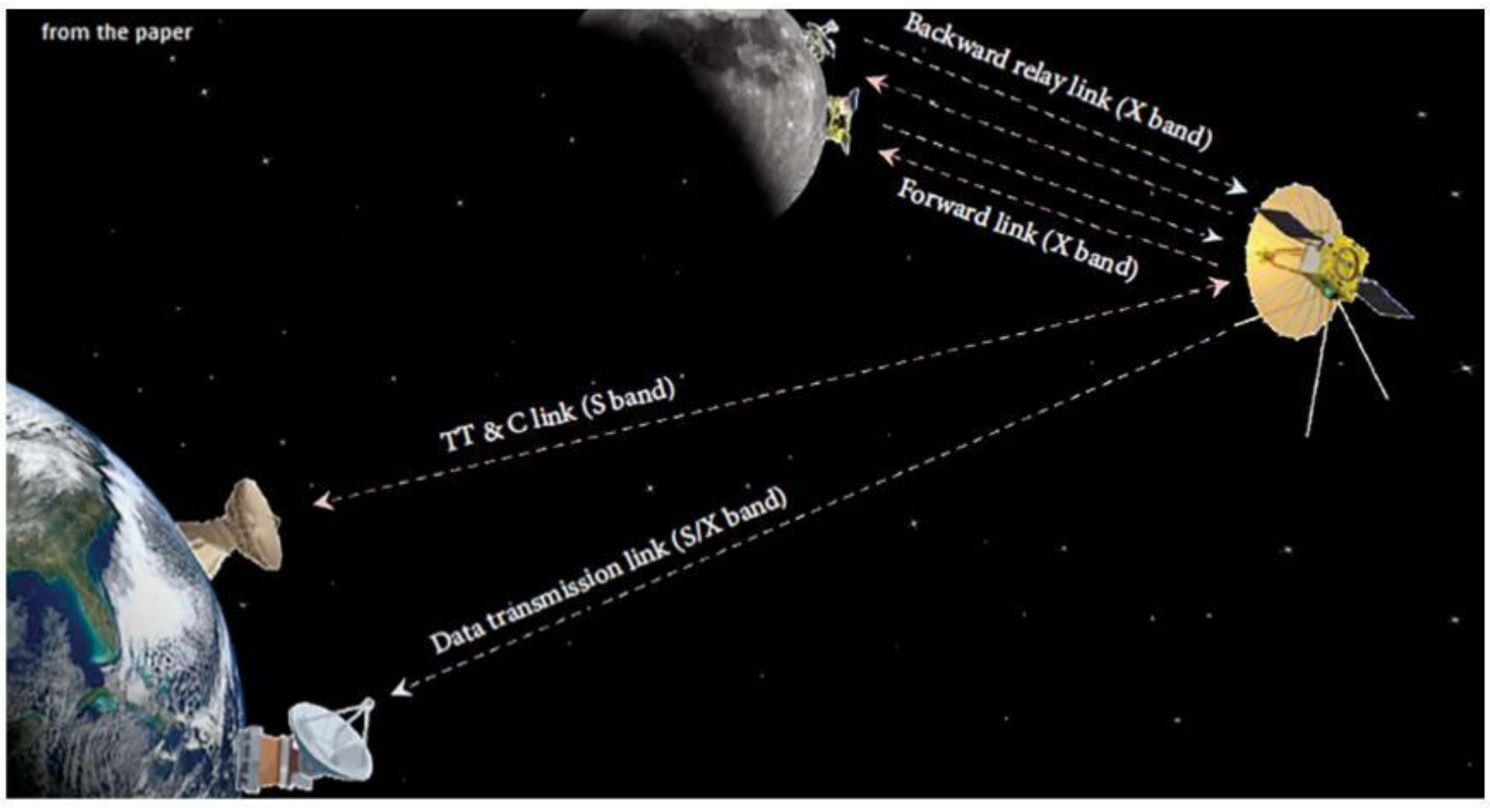
Speaking with the far side

The unseen part of the Moon is not in radio contact

S ANANTHANARAYANAN



From Earth, we can see only one face of the Moon. That is because the Moon, unlike Earth, turns around on its axis only once every 28 days, the same time as it takes to go around the Earth. The result is that although all parts of the Moon get to point towards the Sun over the "lunar day", the face that is pointed towards Earth is always the same.

The face of the Moon that we see has hence been extensively studied by telescope. And several probes, including manned missions, have landed on this face of the Moon. A reason for that is we can make good use of a probe or manned mission to the parts that we are able to see. Another reason is that radio communication with the Moon needs to be through "line of sight". As that is not possible on the far side, missions to that side were not attempted.

There is interest, of course, in the far side of the Moon, which has been mapped, so far, with the help of satellites that were placed in orbit around the Moon. And a special interest has been that a mission to the far side could remedy a current deficiency. The deficiency is that we have studied only the surface of the Moon, and hardly have an idea about its internals. As bore holes are typically good for a few metres, we could do better if we start the bore hole at the bottom of a natural depression, say one caused by an asteroid strike. And this is where the far side can help – the deepest depression on the surface of the Moon is located on the far side.

The Chinese Lunar Exploration Programme took the first step by landing Chang'e 4, a robotic spacecraft, on the far side of the Moon in January 2019. The lander carried Yutu-2, a robotic, lunar rover, which could identify the mineral content of the bottom of the crater, to look for traces of what may lie deeper there.

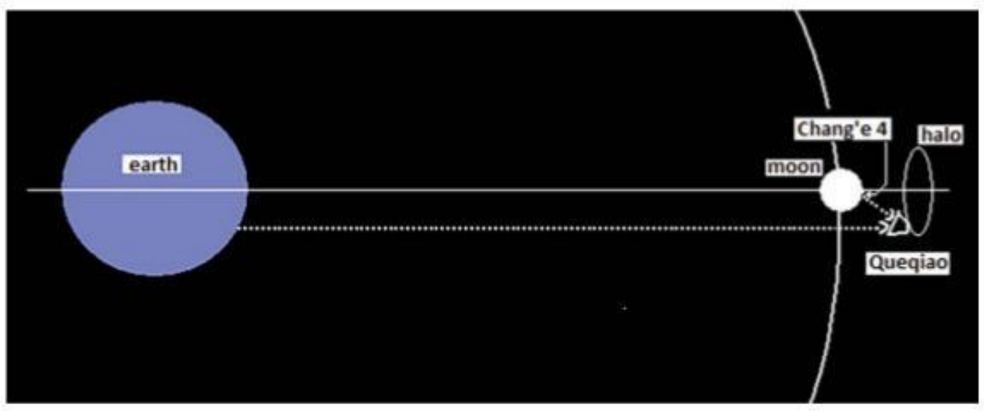
But how could the landing of Chang'e 4 be managed, Yutu-2 controlled, and data brought back to Earth, without a radio link? Lihua Zhang, from the DFH Satellite Company Limited in Beijing, describes in the American Association for the Advancement of Science journal, *Space: Science and Technology*, the arrangement for "relay communication" that was put in place before Chang'e 4 was launched. DFHSat is a professional company, a part of the policy of including private participation in aerospace innovation. The company, which is under the Chinese Academy of Space Research, provides space communications services worldwide and has arranged the launch of scores of satellites.

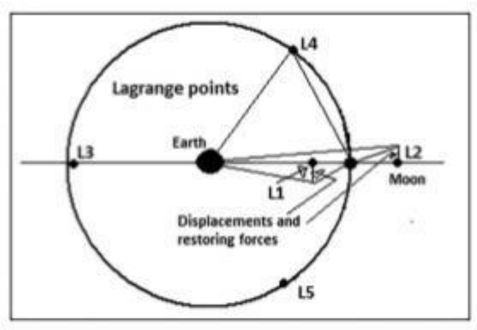
The solution provided to Chang'e 4 was to place Queqiao, a radio repeater satellite, in the proximity of the Moon, so that it was constantly in "line of sight", both with Earth and the far side of the Moon, as shown in the picture. And how did the device stay in this position, with respect to the Moon, while it moved in its orbit around Earth? Well, because of the interplay of combined gravitational forces of the Earth and Moon, which provided special places where the satellite was stationary, with respect to the Earth-Moon positioning.

In effect, the device is also in orbit around Earth. But as it is farther away from Earth than the Moon, it should follow a slower orbit and fall behind. This is corrected, however, by the gravitational pull of the Moon, which speeds up the orbit to be as fast as its own orbit. And the device is in orbit around the Moon too but moving around it at the same speed as its rotation, so that it always faces that same side of the Moon's surface. And to maintain its position, it is helped by the gravitation of the Earth, in addition to that of the Moon.

In cases of pairs of objects, like the Earth and Moon, there are a handful of special points where the gravity of one object just compensates the gravity of the other. One such point, shown as L1 in the diagram, would lie directly between the two objects, and we can see that it would be nearer the smaller of the two objects. Another point, shown as L2, would be beyond the smaller object. At L2, the tendency of the device to fly away from Earth as its pull is weaker, is compensated by the pull of the Moon, which adds to the Earth's pull. L3 is the third point, which is on the opposite side of the Earth. And then there are L4 and L5, which are on either side, kept at their distance from Earth or the Moon because of their relative motion.

The relative motion of a pair of objects, one object in orbit around the other, is the classical problem of the Earth and Moon, which was solved by Isaac Newton. If we introduce a third object, with all three objects interacting, however, the problem becomes impossible to solve. Except that if the third object is so small that its effect on the other two can be ignored, then, a solution is possible. This is what is done when considering the





radio repeater device, which is miniscule compared to the Moon or Earth. This case had first been worked out by the mathematician Joseph-Louis Lagrange, and the five points where the third object can be relatively stationary are known as Lagrange points.

The points L4 and L5, are stable, but the others are partially stable, which is to say they move, and stray from the Lagrange point. The DFHSat team placed Queqiao at L2, which is a partially stable point. The satellite hence moves in an unstable orbit, over an area called a "halo". And hence needs to periodically correct its position. The movement away from L2, however, makes it possible for Queqiao to be in "line of sight" of Earth as well as the surface of the far side of the Moon for most of the time.

The paper by the DFHSat scientist explains that Queqiao uses a pair of antennae and separate channels of communication – one for control of the lander and rover on the surface of the Moon, and another for transmission of the data collected. Thanks to Queqiao, a great deal of data has been collected over the two years that Chang'e 4 has been in position. There are plans for more exploration and a role for radio links like this, particularly in a plan to study the terrain at the south pole of the Moon.

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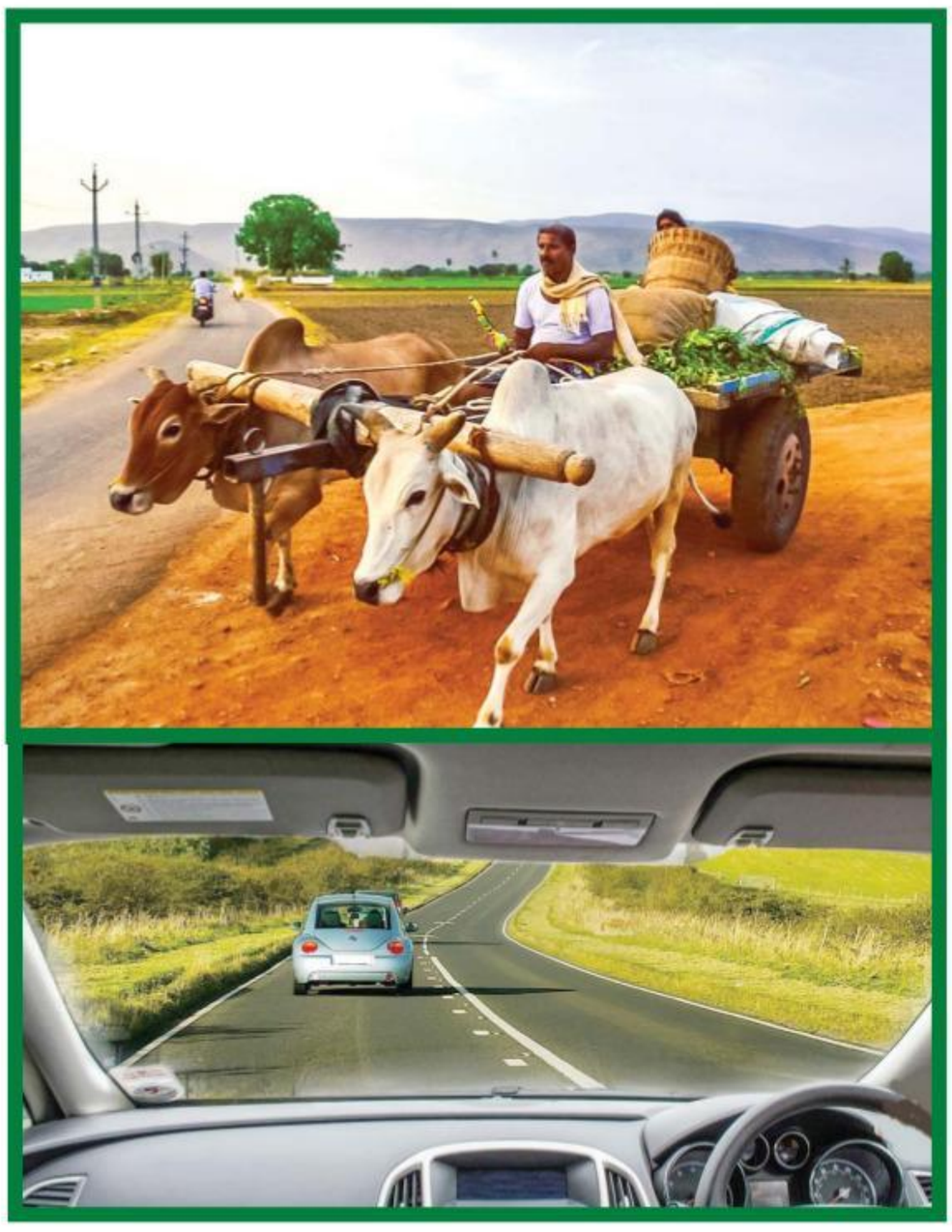
LOOKING AHEAD WITH PURPOSE

Boasting about the scientific heritage of times past will dampen advancement today

BIJU DHARMAPALAN



Every civilisation in the world boasts of great scientific heritages. They make tall claims about great discoveries made by their forefathers and such claims are often validated through certain stories or archaeological evidence. People today get so carried away by those claims that they think their predecessors were great scientists, only based on certain assumptions.

As someone born in the late 1970s, I have seen the vast changes brought about by science and technology in every segment of society. During my childhood, cattle were used to plough fields but for a child born in 2021, that would seem like a fictional tale, much like what we hear in "heritage stories". Similar is the case of bullock carts, which were abundant on our roads as a transport system till the late 70s. There were workshops to service those carts and owning one was a status symbol.

One should only look at how technology has transformed entertainment. From soundless motion pictures we now have interactive movies in 7D technology. When we were children, we used to have movie shows in schools with huge projectors and large rolls of film. But today we can project a movie with a hand-held device.

In medical diagnostics, the changes have been unimaginable. Time was when it took a couple of days to get the analysis of a routine blood work. These days, everything is automated and even a full body scan can be conducted within minutes. Even the role of doctors has been redefined from that of a diagnostic professional to an interpreter.

During our school days, teachers used to tell imaginative stories of sending letters between relatives living on different planets. But today that has almost become reality as scientists are striving hard to establish space colonies within this decade. Amazon co-founder Jeff Bezos and his brother Mark will board the first crewed space flight from his rocket company Blue Origin on 20 July this year marking a new era in space travel.

The global pandemic that struck us last year has sped up change in human civilisation with a new culture of social distancing and virtual communication emerging. Gone are the days when children could not see their beloved friends during holidays – today's children have friends across the world thanks to social media.

Human civilisation is at the crossroads. At one end we have a generation who are surrounded by technological innovations and on the other, we have a fluid society of middle-aged people desperately looking for space in the changing world.

Now, let's undertake a little scientific speculation. Imagine what would happen in the year 3030 when all the advancements we have seen in our lifetimes become part of history. Like what we study in history books about various civilisations today, people of 3030 will boast of the great scientific heritage their forefathers had – they discovered tractors, mobile technology, movies and robots. Some may even proudly declare that their forefather was behind the discovery of a vaccine for Covid-19 that saved humanity from extinction.

In 3030, roads may be flooded with driverless cars. In that generation, can anyone digest the transport system prevailing in 2021? Space travel may become as normal and affordable as air travel today. There may not be any school or college campuses, everything will be virtual, and more Artificial Intelligence-based gadgets will be ruling the education field.

In every civilisation or every generation, we see technological advancements to solve issues prevailing during that time. As cattle ploughing has become extinct, many technologies used by the present generation will become extinct due to varied factors. If somebody makes a comment in 3030 that a community destroyed the unique technology of cattle ploughing by purposefully introducing tractors at the behest of some external force during the 1900s, how would that sound?

Similarly, the knowledge kept within families or sects will vanish in future. Many traditional industries like handicrafts and handlooms have suffered badly due to mechanisation. It's nobody's fault as humans always prefer to lead an easier life, free of hardship.

Science is always moving ahead with a progressive mindset. If we keep focusing on heritage, we are in a way hindering the development of our youth. If they keep concentrating on a problem that existed thousands of years ago, science will not progress. Of course, one can get insights from historical facts and find ways to come up with better solutions. But they cannot be the same solutions our forefathers came up with for their society and their time.

We must be smart enough to overcome the threat of a world where machines are going to overpower humans through AI technology in every sphere of life, from education to the job market. For that to happen, creative minds need to be cultivated in our younger scientific community. We must look forward and proceed, not look back and loiter.

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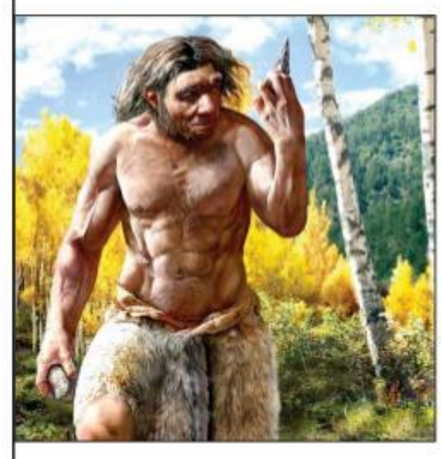
PLUS POINTS

Dragon Man



A new species of ancient humans may replace Neanderthals as our closest relative and potentially rewrite major elements of human evolution, according to scientists.

Dubbed *Homo longi* or "Dragon Man", the species was identified in China from a skull fossil, known as the Harbin cranium, reportedly found in Harbin, the capital city of Heilongjiang province, in 1933. The Harbin cranium is thought to be more than 146,000 years old and came from a male individual, aged about 50.

Researchers say the skull is big enough to hold a brain similar in size to that of a modern human. But the Dragon Man would have had comparatively larger eye sockets, thick brow ridges, a wide mouth, and oversized teeth.

In their findings, published as three separate papers in the journal *The Innovation*, the experts said the fossil suggests *Homo longi* was closer to modern humans (*Homo sapiens*) than the Neanderthals and points to a new sister lineage.

Xijun Ni, a professor of primatology and paleoanthropology at the Chinese Academy of Sciences and Hebei GEO University, and author on two of the papers, said, "It is widely believed that the Neanderthal belongs to an extinct lineage that is the closest relative of our own species. Our discovery, however, suggests that the new lineage we identified that includes *Homo longi* is the actual sister group of *Homo sapiens*."

The researchers believe the Dragon Man lived in a forested, floodplain environment as part of a small community. They said he, and the ancient Harbin people, would probably have been "very large in size" and capable of adapting to harsh environments. Ni said, "Like *Homo sapiens*, they hunted mammals and birds, and gathered fruits and vegetables, and perhaps even caught fish." They hypothesise that the Dragon Man's community would have encountered modern humans during his time, which was "a dynamic era of human species migration".

Professor Chris Stringer, research leader at the Natural History Museum in London, and an author on two of the papers, said, "We see multiple evolutionary lineages of *Homo* species and populations co-existing in Asia, Africa, and Europe during that time. So, if *Homo sapiens* indeed got to East Asia that early, they could have (had) a chance to interact with *Homo longi*, and, since we don't know when the Harbin group disappeared, there could have been later encounters as well."

Stringer said that, apart from being huge, the Harbin cranium "also shows other features resembling our species", including "flat and low cheekbones with a shallow canine fossa" and a face that looks "reduced and tucked under the braincase".

The researchers said their findings had the potential to rewrite major elements of human evolution and push the common ancestor that modern humans share with Neanderthals even further back in time – roughly 400,000 years earlier than previously thought. Ni said, "The divergence time between *Homo sapiens* and the Neanderthals may be even deeper in evolutionary history than generally believed – over one million years.

"Altogether, the Harbin cranium provides more evidence for us to understand *Homo* diversity and evolutionary relationships among these diverse *Homo* species and populations."

But, although the Harbin cranium has been described by the team as a new species, Stringer said he was in full agreement with his colleagues and thinks the skull bears resemblance to another fossil belonging to *Homo daliensis* – another type of ancient human. He said, "But regardless of that, the morphology of the fossil is very informative about later human evolution."

Stringer said the Harbin cranium may even be a representative of the enigmatic Denisovans – an extinct subspecies of ancient humans – but added it was "something for the next stages of research".

– The independent/agencies