Multiple cameras probe solar secrets

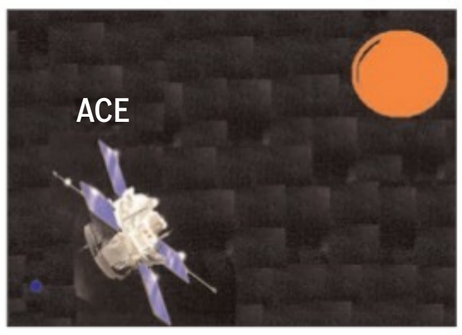
IMAGING THE SUN FROM A PAIR OF VANTAGE POINTS HAS UNCOVERED NEW TRUTHS ABOUT OUR MOTHER STAR, WRITES **S ANANTHANARAYANAN**

The sun sustains the seasons and all life on earth with its bounty. Sunshine is the light emitted by searing hot gases just near the sun's surface, by virtue of being hot. But the heat comes from feverish activity that leads to emissions other than light, like *alpha particles*, which are helium atoms whose electrons have been stripped, or *protons* that are bare hydrogen atoms and also light of very high energy, like X-Rays or gamma rays.

The reason for this variety of emissions is that the mass of the sun has compressed its core to very high pressures, setting off high energy nuclear reactions. This vaporises all matter so that the sun is actually a ball of hot gas — gas so hot that collisions of atoms have separated the negatively charged electrons and the positive nuclei of atoms, and the hot gas is a maelstrom of charged particles. Add to this that the sun also rotates, like the earth, and there are currents and tides and waves in the seething mass of moving charged particles. The sun is also difficult to observe, as the glare of the visible light blocks the possibility of any detail. It is only by indirect observation of images of the sun that many features, like *sunspots*, which are regions that cooler than the surroundings for a short time and, hence, appear dark, or *solar flares* that are flashes of light as a result of eruptions of hot gases, can be detected. Solar flares are eruptions accompanied by massive emission of matter, a part of which has speeds enough to escape the sun's gravity, leading to sprays of charged particles striking the earth, which causes disruption of radio communication or power supply, for example.

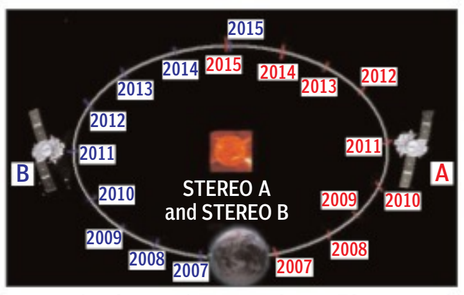
And even apart from matter emitted in flares, there is a continuous stream, a form of "evaporation" that emerges from the sun, the so-called *solar wind*.

The features of the sun, and the sources of the emissions, known as *Coronal Mass Emissions* or *Solar Energetic Particle* events, are of great interest as they could reveal the activity in the interior of the sun, which is one of the billions of stars where similar processes are



going on. The distance of the earth from the sun and the fact that the sun is rotating complicate the interpretation of what is observed. The sun goes round once in about 25 days and considering its diameter is more than 100 times that of the earth, this is a very fast speed. The matter that is emitted thus describes an arc in its approach to the earth, like the jet of water from a lawn sprinkler. Making sense out of what is seen could hence be easier if the observer were not on earth but somewhere well removed, and in communication with our planet. The origin of a stream of matter striking the earth is not where it appears to come from, but towards the right edge of the sun. With the help of satellites *Stereo* and *Ace*, an arrangement that enables observation both directly as well as from the side, two teams of researchers — one led by Nariaki Nitta from the Lockheed Martin Advanced Rechnology Center in the USA in June this year and the other headed by Radoslav Bucik from the Max Planck Institute for Solar System Research in Germany this month — have independently reported in the *Astrophysical Journal* a possible mechanism behind one kind of emission from the sun.

The emission that was studied is of atoms of helium-3, a form whose nucleus has only one neutron, along with two protons, in place of the usual two neutrons. Helium-3 (denoted as ^{3}H) is produced in high-energy nuclear reactions and the emission from the sun was found to occur at the same time as massive waves, named *blast*

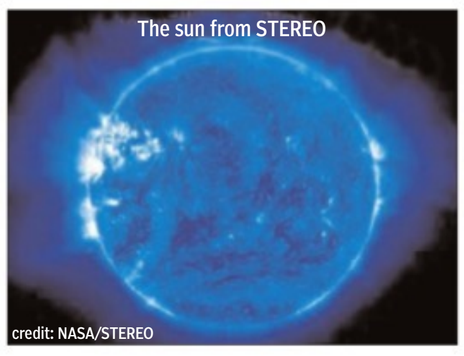


waves, in the sun's atmosphere. Blast waves occur in fluids when large energy is pushed into a small volume, not unlike what causes the *Tsunami*. The waves, which were found to extend over half a million kilometres and moved at 300 km a second, were detected by observing the sun's atmosphere in extreme ultraviolet light. It is considered that the energy of the huge waves was able to accelerate the ^{3}H particles towards the earth.

Stereo and *Ace*

Unlike observation stations placed in orbit around the earth, mainly to escape distortion by our planet's atmosphere, *Stereo* and *Ace* have been placed in orbit around the sun so that they can detect what it looks like from well outside the atmosphere and from a different angle than the view from earth. *Stereo* — an acronym for Solar TErrestrial RElations Observatory — and *Ace* are placed one ahead of the earth and the other trailing. Observation from separated points helps scientists in the same way as the fact that we have a pair of eyes in place of only one is useful for us. Thanks to our pair of eyes, separated by a few inches, each sees a slightly different image with the help of which the brain is able to make out a *sense of depth*, or the real distance of an object from the observer. In the same way, observations from *Stereo A* and *Stereo B*, because one is Ahead and the other Behind, are able to create views of the sun that reveal much more that can be made out by observation from only one place.

Ace is the acronym for Advanced Composition Explorer, another Nasa satellite in orbit around the sun in a region along the line from the earth and the sun, where the gravity of one balances the gravity due to the other. One of the services that *Ace* provides is that it gives radio operators on earth advance warning of solar storms that may cause disturbance to communications.



In early 2010, *Stereo A* was positioned so that it was looking at the right limb of the sun, while *Ace* was observing the stream of matter emitted towards the earth. While *Ace* detected the particle stream coming towards the earth, *Stereo A* was able to observe the place where the stream came from, and thus the blast waves. Helium-3 ejection from the sun has been observed before and the trace of helium-3 on earth is believed to have arisen from the sun in this way. But the conjunction of ^{3}H emission with the blast wave had not been well observed before.

It was only in early 2010 that the position of *Stereo A* was just right. This position, which enables observing both the blast wave and the helium-3 burst, would not happen again till 2025, says a news release from the Solar Research Team in Germany. At present, *Stereo B* is out of radio communication and it is only *Stereo A* that is in action, it says.

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ABNORMAL MUTATIONS

TAPAN KUMAR MAITRA EXPLAINS THE MECHANISMS BY WHICH DNA REPAIR IS INHIBITED THEREBY LEADING TO THE FORMATION OF CANCER CELLS

The normal mutation rate for any given gene is about one in a million per cell division, so it seems unlikely that a cell would ever acquire the stepwise series of mutations needed to cause cancer. But the reason cancers occur so frequently is because mutation rates in such cells are almost a thousand times higher than normal. This state, called genetic instability, comes about in several ways.

One mechanism involves disruptions in DNA repair. As an example, inherited defects in genes are responsible for hereditary non-polyposis colon cancer, a syndrome that elevates a person's risk by allowing mutations to accumulate rather than being corrected by mismatch repair. Another hereditary disease, xeroderma pigmentosum, is caused by inherited defects in genes needed for excision repair. Children who inherit this condition develop an extremely high skin cancer risk because they are unable to repair DNA damage triggered by exposure to sunlight. Faulty DNA repair has also been implicated in hereditary forms of breast cancer, which account for roughly 10 per cent of all such cases. Hereditary breast cancers (and to a lesser extent, ovarian cancers) arise in women who inherit mutant forms of genes called BRCA1 or BRCA2, which code for proteins involved in repairing DNA damage, especially double-strand breaks.

Genetic instability is not restricted to cancers triggered by inherited defects in DNA repair. Most cancers are not hereditary but in some cases, the instability can be traced to mutations in DNA repair genes caused by environmental mutagens. Another explanation is that the p53 pathway is defective in most cancer cells, which removes a protective mechanism that would otherwise destroy or prevent the reproduction of cells containing damaged DNA.

Genetic instability can also be caused by defects in mitosis that cause chromosomes to separate improperly during cell division, resulting in broken chromosomes and aneuploidy (an abnormal number of chromosomes). Although the mechanisms underlying these mitotic defects are not well understood, some cancer cells possess extra centrosomes, which are the structures that organise microtubule assembly during spindle formation. Extra centrosomes can cause the formation of abnormal spindles that possess more than two poles and therefore cannot separate chromosomes properly. Defects in proteins involved in attaching chromosomes to the spindle or in monitoring the spindle checkpoint have also been detected in cancer cells. If such mechanisms do not function properly, there is no guarantee that each daughter cell produced during cell division will receive a proper set of chromosomes.

Genes coding for proteins involved in DNA repair and chromosome sorting fit the basic definition of tumour suppressor genes because their loss or inactivation can contribute to the development of cancer. However, such genes are not in the same category as the RB, p53, and APC, which produce proteins that restrain cell proliferation and whose loss can directly lead to cancer. To distinguish the two classes of tumour suppressors, genes like RB, p53, and APC are called gatekeepers because their loss directly opens the gates to excessive cell proliferation and tumour formation. In contrast, genes involved in DNA repair and chromosome sorting are referred to as caretakers because they maintain genetic stability but are not directly involved in controlling cell proliferation. Defects in caretaker genes simply facilitate the accumulation of mutations in other genes, including gatekeepers.

This specimen of cancer tissue viewed by light microscopy shows a cell with an abnormal mitotic spindle containing three spindle poles. Such spindles, which cannot separate chromosomes properly, are created by the presence of three centrosomes rather than the normal two.

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Alien 'megastructures'

A STAR IDENTIFIED BY THE KEPLER SPACE TELESCOPE MAY HARBOUR STRUCTURES THAT COULD POINT TO AN ADVANCED TECHNOLOGICAL CIVILISATION, WRITES **LEE WILLIAMS**

A large cluster of objects in space looks like something you would "expect an alien civilisation to build", astronomers have said and Jason Wright, one of them from Penn State University, is set to publish a report on the "bizarre" star system, suggesting the objects could be a "swarm of megastructures", according to a new report.

"I was fascinated by how crazy it looked," he told *The Atlantic*. "Aliens should always be the very last hypothesis you consider, but this looked like

something you would expect an alien civilisation to build."

The snappily named KIC 8462852 star lies just above the Milky Way between the constellations Cygnus and Lyra. It first attracted the attention of astronomers in 2009 when the Kepler Space Telescope identified it as a candidate for having orbiting earth-like planets. But KIC 8462852 was emitting a stranger light pattern than any of the other stars in Kepler's search for habitable planets.

Tabetha Boyajian, a postdoc at Yale, told *The Atlantic*, "We'd never seen anything like this star. It was really weird. We thought it might be bad data or movement on the spacecraft, but everything checked out."

In 2011, the star was flagged up again by several members of Kepler's "Planet Hunters" team — a group of "citizen scientists" tasked with analysing the data from the 150,000 stars Kepler was watching. The analysts tagged the star as "interesting" and "bizarre" because it was surrounded by a mass of matter in tight formation.

This was consistent with the mass of debris that surrounds a young star just as it did with our sun before the planets formed. However, this star wasn't young and the debris must have been deposited around it fairly recently or it would have been clumped together by gravity — or swallowed by the star itself.

Boyajian, who oversees the Planet Hunters project, recently published a paper looking at all the possible natural explanations for the objects and found all of them wanting except one — that another star had pulled a string of comets close to KIC 8462852. But even this would involve an incredibly improbable coincidence.

That's when Wright and his colleague, Andrew Siemion, director of Search for Extra-Terrestrial Intelligence, got involved. Now the possibility that the objects were created by intelligent creatures is being taken very seriously by the team. The three astronomers want to point a radio dish at the star to look for wavelengths associated with technological civilisations. And the first observations could be ready to take place as early as January, with follow-up observations potentially coming even quicker.

"If things go really well, the follow-up could happen sooner," Wright told *The Atlantic*. "If we saw something exciting… we'd be asking to go on right away."

PLUS POINTS

Carbon footprint

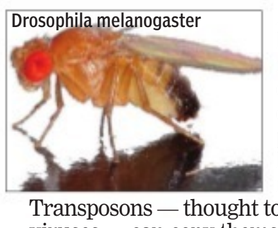
Whatever happened to your old Windows 2000 desktop computer? Are you still hanging on to mobile phone handsets of the past? And what about the monolithic printer you chucked out in a zen-inspired fury? Well, you might soon be wearing them on your wrist if a new tracker concept made entirely from recycled electronics finds enough interest to get off the ground.

London designer Benjamin Hubert's device, which was recently unveiled at this year's London Design Festival, is not just a guilt-easing accessory. Although still at a conceptual stage, his WorldBeing wristband plans to track a wearer's carbon usage by connecting a variety of data sources to create individual maps of consumption, based on items purchased and food eaten, to modes of transport taken and energy used in the wearer's home.

Checking into the app each morning will provide you with instant visual feedback on your daily carbon footprint using cloud-shaped graphics that change colour and size to indicate good and bad consumption. The downside? Just one: insufferable carbon footprint bragging – inevitably coming soon to a social media platform near you. Big Brother, it seems, is watching.

LIZ CONNOR/THE INDEPENDENT

Tethering transporons



Most genomes harbour unruly, mobile DNA elements that can cause potentially harmful mutations. Transposons — thought to be related to viruses — can copy themselves and insert randomly around the genome. A paper published on 15 October 15 in *Science* provides a greater understanding of how cells shut down these rogue jumping genes. Greg Hannon of the Cancer Research UK Cambridge Institute and his colleagues have identified a protein in fruit flies that appears to halt transposons before they begin to leap.

"This is a mountain of impressive work, a huge amount of data, (the result of which) is that we now understand something about how piRNAs are transcriptionally silencing their targets," said molecular geneticist Keith Slotkin of Ohio State University, who was not involved in the work. "We knew that this was happening, but the mechanism was all question marks and hand-waving."

RUTH WILLIAMS/THE SCIENTIST

Rewriting migration

Dozens of human teeth recovered from a cave in China's Hunan Province just might upend the thoroughly entrenched paleoanthropological hypothesis that humans migrated from Africa to East Asia about 50,000 years ago — if the dating of the fossils are confirmed. A team of researchers from China and elsewhere analysed minerals and animal fossils found near the teeth and determined that the materials were 80,000 and 120,000 years old, respectively. The researchers published their findings on 14 October in *Nature*. If confirmed, these teeth would be the oldest *Homo sapiens* fossils yet found in Asia.

"This changes everything. It's the best evidence we have for modern humans in East Asia this early," University of Oxford archaeologist Michael Petraglia, who was not involved with the work, told *Science*. Researchers have proposed earlier dispersals of humans out of Africa in the past, but the Chinese teeth, if their age and provenance is confirmed, could lend evidence to these hypotheses. "We really have to understand the fate of this migration. We need to find out whether it failed and they went extinct or they really did contribute to later people," María Martinón-Torres, a coauthor on the paper from University College London, told *BBC News*. "Maybe we really are descendents of the dispersal 60,000 years ago — but we need to rethink our models. Maybe there was more than one Out of Africa migration."

H. sapiens fossils don't turn up in Europe until much later — the earliest known specimens are about 40,000 to 50,000 years old. In their paper, the authors suggested this lag may have been due to the colder climate of Europe at the time or the presence of competitive Neanderthals keeping our species at bay.

BOB GRANT/THE SCIENTIST