As you are reading this right now, sitting on earth, a space rover called Curiosity, onboard a rocket called the Atlas V, is speeding away towards Mars. Curiosity, also called the Mars Science Laboratory or MSL in short, is going to explore if Mars is habitable. Meanwhile, another spacecraft is winding its way to Jupiter and will enter its orbit in another five years. The Dawn spacecraft that reached Vesta in July 2011 is due to start off on its journey towards Ceres in June 2012.

The year 2012 looks to be an exciting year for space exploration. Let’s take a look at the various missions which may be headed towards new discoveries, starting off with our neighbour planet Mars.

Humans on Mars?
The Mars Science Laboratory, christened Curiosity, was launched on the 26th of November 2011 from Cape Canaveral in Florida. It will land in the Gale crater on Mars in August 2012 if everything goes according to plan.

The rover weighs almost two thousand tons, more than the last three Mars rovers put together, and so landing it on Mars will be a challenge. Two-thirds of previous missions sent to Mars have either crashed or lost contact with Earth. Methods like airbags to cushion a freefall will not work, given the weight of Curiosity. To solve this problem NASA has designed an ingenious rocket-powered ‘sky-crane’ that will hover above the surface and lower the rover gently down to the Martian surface.

The year 2012 seems to be an exciting year for space travel with various space agencies around the world lining up innovative and penetrating missions to space and beyond.

SHOILI PAL
So why is Curiosity so heavy? The reason is, it is carrying a large collection of instruments to Mars. These instruments are among the most sophisticated technology ever sent to space. In fact, the instruments are so numerous and so varied in function that NASA has likened the rover to a living creature. The ‘body’ of the creature is a warm box that protects the circuits and controls the temperature inside. The ‘brain’ of the box is the computer onboard. The rover has a robotic arm that will work much like a human geologist’s arm would, scraping and collecting samples.

The rover has ten cameras that can be likened to its eyes. Some of these cameras are simply for navigation. Some are for scientific purposes. The MastCam will capture colour pictures and video of the Martian terrain. There are some spectrometers on board. These will try to identify the chemical substances on Mars like minerals, water and carbon-based compounds. An instrument called the ChemCam will use a laser beam to vaporise thin layers of a target, take pictures of the illuminated areas and identify the excited atoms with a spectrometer.

There are two radiation detectors onboard the Curiosity called RAD and DAN. ‘RAD’ stands for Radiation Assessment Detector and will measure all the high intensity radiation near the surface. ‘DAN’ stands for Dynamic Albedo of Neutrons and will measure neutrons escaping the surface, thus helping the search for water on Mars.

The Spanish government is also contributing a weather monitoring station to the rover’s scientific payload. It will measure atmospheric pressure, winds, temperature and humidity.
The whole thing is powered by radioactive plutonium.

So what is the unified aim of all these instruments? They will try to collect data to help us ascertain if Mars can or ever could support life. But how will we reach the conclusions?

The Gale crater was chosen for the Curiosity landing for a particular reason. In fact, it was chosen after a series of workshops where many sites were considered. The rover will land near the foot of a mountain. It will explore a mound of materials that are stratified, i.e. formed in layers, and may contain evidence of major climatic changes. On the basis of data collected about the minerals found, scientists can look for biosignatures. A biosignature is a phenomenon produced by life. For example, the presence of a photosynthetic pigment would be a sign that life may have existed at a place.

In short, Curiosity will revolutionise our understanding of Mars. The data about the atmosphere and weather collected will take us closer to being able to send a manned mission to Mars. The European Space Agency plans to perform this by the year 2030.

Exploring the Outer Planets

Another exciting mission is presently on its way to Jupiter. The mission is named Juno because in Greek mythology it was Jupiter’s wife, the goddess Juno, who could look through the clouds surrounding him, to his true mischievous self.

Launched in August 2011, the spacecraft took just a day to cross the earth’s moon but it will take another five years to reach its destination. The mission is a part of NASA’s New Frontiers program which aims to send spacecraft to conduct highly focused scientific investigations to help us better understand the solar system.

Jupiter, the largest planet, is a gas giant. It is made of mostly helium and hydrogen. It was probably formed in the early stages of the solar system, out of the materials left over from the formation of our sun. Thus, studying Jupiter may improve our knowledge of the origins of the solar system and also enhance our understanding of other planetary systems being discovered around other stars.

Juno will orbit Jupiter thirty-three times in one year, each orbit lasting for eleven days. The orbit will be around the poles and the spacecraft will be spinning to simplify the scientific operations.

Juno will observe Jupiter’s gravitational and magnetic fields. It will also measure the water and ammonia in Jupiter’s atmosphere to better understand the belts of colourful clouds that cover Jupiter.

The New Horizon spacecraft is also presently on its way to Pluto and its moon Charon. It is the first mission to an icy heavenly body.

Destination Asteroid Belt

Another mission that is currently journeying through space is the Dawn mission. It is the ninth mission in NASA’s Discovery Program. This mission has been sent by NASA, in collaboration with the Jet Propulsion Laboratory. Humans are also aiming to visit asteroids. US President Obama has set sight on achieving this aim by 2025. Asteroids being much smaller than the planets, their gravity is much less and astronauts could float away into space.
Laboratory, California, to the asteroid belt between Mars and Jupiter, with the aim of gaining an insight into the early stages of the solar system. Dawn will orbit two of the largest asteroids, Vesta and Ceres. This makes Dawn the first spacecraft to orbit two separate bodies.

The Dawn spacecraft took off from earth in 2007. It then flew towards Mars. When passing Mars in 2009, it received a boost to its velocity from Mars’ gravitational field. It reached Vesta in July 2011. It is due to take off from Vesta in June 2012 and start its journey towards Ceres.

The day is not far away when humans set foot on and maybe even have settlements on other planets. And maybe someday we will ‘reach for the stars’, literally.
The Discovery program of NASA aims to enhance our understanding of the solar system by studying the planets, their moons and comets and asteroids. Vesta and Ceres were chosen for this mission because they are two very unique asteroids. They are two of the oldest bodies formed in the solar system. They are the two most massive asteroids and would have probably become planets if it wasn’t for Jupiter’s enormous gravitational influence.

The characteristics of Vesta and Ceres are quite different from each other. Ceres has the potential to have water-ice on it. It has a clay-like surface, water bearing minerals and may have a weak atmosphere. Vesta, on the other hand, is a dry body. It was probably shaped by volcanic activity and has a layer of basaltic dust. Many meteorites from Vesta have come to earth and so we know a little about Vesta’s composition.

Vesta’s characteristics are more like the inner planets while Ceres resembles the outer planets. Scientists hope that by studying the two they can understand more about the change from inner rocky planets to outer icy planets.

Like the MSL, Dawn will carry cameras to take pictures and spectrometers to identify elements present in the outer layers of the bodies. It will also measure the gravitational fields of the asteroids to help better understand the internal compositions. It is powered by two large solar panels. The energy collected is used to ionize the fuel, xenon, that it is carrying, powering the mission.

Dawn will orbit Vesta several times, allowing it to study most of its surface. After

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New Earth-like Planet Found

THE Kepler Space Telescope, which is the tenth mission in the Discovery program, has recently discovered a planet that has high chances of supporting life. The planet, named Kepler-22b, is in the habitable zone around a star very similar to the sun. Habitable zone refers to the narrow band around a star where water can exist as a liquid. Kepler 22-b also has a temperature which is conducive to life as we know it.

While the Kepler Telescope can identify planets that may support life, it is not capable of searching for life.

SETI, the Search for Extra Terrestrial Intelligence, which had shut down due to a lack of funds is now back in operation again. The Allen Telescope Array (ATA) will be searching the planets found by the Kepler Telescope for signs of life.
Chandrayaan 2

Chandrayaan 2 is the second lunar mission planned by ISRO. It will have an orbiter, a lander and a rover. The Russian Federal Space Agency (RSA) will provide the lander, the rest will be developed indigenously. The orbiter will orbit the moon at an altitude of around 200 km. The rover will roam the surface, collect samples of soil or rocks, analyze them with a spectrometer and send the data to the orbiter to be relayed back to Earth. The orbiter itself will also carry some scientific instruments that will map the elements present in the moon’s surface and look for water.

leaving from Vesta in 2012, Dawn is supposed to reach Ceres in 2015.

If the mission is a success then we will have gained a lot of insight into the shape, size and composition of both these protoplanets. We will also be able to verify if the Howardite, eucrite and diogenite meteorites have come to earth from Vesta and understand their geological history. We will also know more about the role of water in the evolution of asteroids.

Other Missions

The seventh mission in the Discovery program, the Messenger spacecraft is also currently orbiting Mercury. Messenger stands for MErcury Surface, Space Environment, Geocaching and Ranging.

The biggest challenge when sending a mission to mercury is the intense heat. A sunshade has therefore been added to protect the probe from the intense rays of the sun. Messenger will also photograph Mercury and collect data about its composition.

China has planned to put a man in space again this year. Two missions, the Shenzhou 9 and 10, are scheduled to be launched this year. Both of them may be manned and at least one of them will be. Shenzhou 10 will probably be manned, and in fact China’s first woman astronaut or ‘yuhanvyuan’ may be aboard it. But the identities of the astronauts have been kept under wraps so far. Both these missions will perform dockings at the space station Tiangong 1.

ISRO, the Indian Space Research Organisation, is planning to launch a spacecraft named ‘Aditya’ sometime this year or the next, a period of high solar activity. It will orbit the earth at an altitude of around 600 kilometres. Its aim is to study coronal mass ejections, the phenomenon of the solar corona emitting plasma, which results in disturbances in the coronal magnetic field.

ISRO is also working on the Chandrayaan 2, another moon mission, which will probably be launched in 2014 (see box).

Space Tours?

Apart from these spaceflights of academic interest, Virgin Galactic will probably start its space tourism programme sometime in 2012. They have already started taking bookings. NASA, on the other hand, has had to cut down on its commercial spaceflight idea because of a budget cut.

Hotel entrepreneur Robert Bigelow even predicts that hotels will come up in space within this decade! These will give people the unique experience of living in zero gravity and maybe they will provide exciting new types of adventure sports. Not to forget that the view would be incomparable to any on earth.

Has the Future Arrived?

The year 2011 marked the end of NASA’s space shuttle programme. After 30 years of shuttling to and from space stations, the shuttles have been retired and put on display at national museums in the USA (see Science Reporter, September 2011 for more details). It truly is the end of an era.

Now what does the future portend for space travel? The future of space travel will aim to find life in the solar system, send human missions to various destinations in the solar system and to eventually make human settlements wherever possible.

The moon is the body nearest to earth in the solar system and if humans go there and stay for a while then they would need to pitch a camp to live in. A company called Bigelow Aerospace, founded by Robert Bigelow, is already working on this idea. They have made an expandable module which can house six people and can be joined together to make a bigger living complex.

Another seemingly impossible idea that engineers are working on is the lunar elevator. A cable, thousands of kilometres long, suspended from the moon would be connected to a spacecraft and things could be ferried to and fro between them.

Humans are also aiming to visit asteroids. US President Obama has set sight on achieving this aim by 2025. Asteroids being much smaller than the planets, their gravity is much less and astronauts could float away into space. To keep them tethered down to the surface, scientists are thinking of a net bolted to the asteroid’s surface, holding on to which the astronauts can walk around.

A factor that could limit human space exploration is the space suit astronauts have to wear. Previous suits like the ones we have seen were heavy and stiff and limited movement. A new, lighter suit has been developed by NASA team member Pablo de Leon from Argentina. The suit shall be ready for use by the time a manned Mars mission sets off. It is being tested in various environments like the Australian outback and the Antarctic to see if it can endure all the extreme conditions of Mars.
SCIENCE REPORTER, FEBRUARY 2012

Cover Story

Critical Solar Angle

SOLAR beta angle is the smaller angle between the orbit plane of the body (e.g. a satellite or space shuttle) and the vector drawn from the sun to the earth. It can vary between -90° to +90° and its sign is determined from the direction of the revolution of the satellite around the body or in this case earth. If the satellite is revolving in a counter clockwise direction around the earth with respect to the sun, the beta angle is defined as positive and vice-versa. This angle keeps changing as the earth moves around the sun and the orbital plane of the satellite changes due to the equatorial bulge of the earth.

The satellite heats up when it is facing the sun or is in the sunlight and excess sunlight can overheat the satellite and cause damage. The amount of sunlight received by the satellite depends on the solar beta angle. When the solar beta angle is less than 60°, the satellite spends tolerable amount of time in sunlight and cools down during nighttime. But when the beta angle is more than 60°, the satellite might get overheated and various thermal problems may arise that might disrupt the functioning of the equipments. Therefore, when the beta angle is greater than 60°, the satellite is said to be in the solar beta angle cutout period.

To overcome the overheating problem, satellites generally do a slow barrel rolling motion to keep the sun from overheating one side. This is also known as barbeque mode as it results in more even heating of the body. This technique has been used in previous lunar missions to cool down the propellant tanks of the space shuttle.

When the shuttle is docked to the ISS, it cannot do barrel roll ups so the whole station needs to be in the beta angle of less than 60°. The shuttle visits normally extend up to two weeks, which means there should be at least a two-week window of continuous solar beta angle of less than 60° at the ISS. When the ISS is itself in the solar angle cutout range, several measures are taken to counter the thermal effects that are not possible when the shuttle is docked to the station.

The station orbit is inclined at 51.6° from the equator, which needs to be taken care of while calculating the beta angle for the shuttle. Normally the ISS is located in Local Vertical, Local Horizon (LVLH) attitude like an airplane. As the beta angle increases, the solar rays fail to produce adequate power. In that case, the ISS changes its orientation with its x-axis perpendicular to the orbital plane thus augmenting the power generation. Since the high beta angle increases the thermal concerns to the installed equipment, the ISS is oriented in such a way that it receives sufficient sunlight for the power generation and can keep rolling at the same time to avoid excessive heating up on one side.

Generally large beta cutout periods occur only during few times a year, especially near summer and winter solstice, i.e., when the earth’s axis of rotation is tilted nearest or farthest from the sun. Great precaution needs to be taken while calculating the launch dates and times. The solar beta angle also depends heavily on the time of the day the shuttle is launched. It might see a beta angle close to 0° if launched at noon and a beta angle close to 90° if launched near sunrise or sunset. The lighting conditions also change the experience of the astronauts. Sometimes the satellite is always at the terminator line which is a fictitious line dividing the illuminated day side and dark night side on the surface of the earth. This twilight region may last for several days for the satellite.

ISS service orbiter called Endavour was grounded until 11 July 2009 because of the solar beta angle cutout from 3 July to 13 July 2009. It takes three days for the space shuttle to reach the ISS so it was finally launched on July 11 to avoid the high beta angle regime. Most recently, the STS-133 launch was delayed until February 2011 due to the month long solar beta angle cutout from 1 January to 1 February 2011.

Although, mainly technical difficulties, for example, the hydrogen leak on the pad of NASA’s STS-127 mission, or the busy schedules of ISS traffic contribute to the delay of shuttle launches, solar beta angle cutout remains a major factor in determining the possible launch date and times of the space-crafts.

Contributed by Ms Swati Saxena, c/o Dr. Ashok Saxena, 204, Narain Towers, Sanjay Place, Agra-282002

A professor at MIT, Dava Newman, has also designed a bio-suit that is less bulky and she thinks it could be suitable for Mars exploration. The suit’s tight stretchy material maintains pressure without constricting movement. A big bonus of this suit is that if you tear it, pressure decreases only around the tear. In the normal old suits a tear would mean a gas leak that would be a major emergency for the astronaut.

Apart from Mars, humans have identified Jupiter’s moon Europa as being the most likely place in the solar system where life might be found. Europa has oceans under its surface. Given the discovery of giant worms that live under the ocean in thermal vents and microbes that live in lakes under the Antarctic ice on earth, scientists hope similar life forms can be found there. Stone Aerospace in Texas, USA is developing a robot that will navigate the Antarctic seas and they hope that a version of it can be sent to Europa someday.

With all these exciting developments, the day when humans set foot on and maybe even have settlements on other planets, may not be far. And maybe someday we will ‘reach for the stars’, literally.

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