DUST IN SPACE
By
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The regions between the stars in space are not empty. They contain a tenuous gas (mostly hydrogen) and grains of dust. In places the gas and dust congregate together to form interstellar clouds. If the clouds become dense enough they can give birth to new stars. Most interstellar space dust originates from old dying stars. Dust is also formed in our solar system when fragments are shed by collisions between asteroids, and when debris is shed by comets.

My interest in cosmic dust was sparked recently when I read that creationists (who do not believe in evolution) claimed that the small amount of cosmic dust that has accumulated on the moon proves that our solar system is much younger than is claimed by science. Neil Armstrong, they say, would have sunk into hundreds of feet of dust on a moon that was billions of years old, instead of leaving the neat foot prints, that we all admired in awe, in dust a few inches deep. Of course, the depth of dust deposited is determined by multiplying the rate of deposition by the time of deposition. Astronomers explain that the creationists greatly exaggerate the rate of deposition.

Outside of interstellar clouds, gas and dust are spread very thinly in space. A volume of interstellar space the size of a small packet of cigarettes would contain about 6 atoms of hydrogen gas, and one would have to search a volume the size of a large cathedral to find one dust grain. Individual grains are less than one millionth of metre (a micrometre) in diameter. But, despite their tiny size and sparse distribution, interstellar distances are so great that light from faraway stars has to pass a vast number of dust grains in order to reach Earth.

Distance in space is measured in light-years - the distance light travels in one year (9.46 million million kilometres). Light reaching Earth from a star 3,000 light-years away is dimmed by half by space dust between the star and Earth. Earth is about 30,000 light-years from the centre of the Milky Way galaxy, but because of the dimming by half of light every 3,000 light years, we can see little or nothing of the centre of the galaxy.

The dense concentration of dust in interstellar clouds essentially blocks out all light from stars beyond and the cloud appears as a dark silhouette in the heavens. A string of dark clouds can be seen in the northern hemisphere in the constellation Cygnus. These clouds extend over several thousand light-years and contain as much matter as one million Suns.

Light from the stars travels as a wave motion and there are many different wavelengths in the light. Matter can absorb light and different chemicals in matter absorb light preferentially at specific wavelengths. The light absorption characteristics of a piece of matter can therefore identify the chemical composition of the matter. Cosmic dust absorbs radiation at a wavelength of 9.7 micrometres, indicating that the majority of grains consist partly of silicates (compounds of silicon and oxygen with various metals), i.e. tiny chips of rock.

There is also evidence that cosmic grains contain other common elements, carbon, nitrogen and hydrogen. Along with oxygen these elements can form two kinds of molecule - ices and organic molecules. The ices consist of frozen water (H_2O), ammonia (NH_3), methane (CH_4), carbon monoxide (CO) and carbon dioxide (CO_2). Organic molecules tend to be large, with a backbone of carbon atoms to which are attached atoms of hydrogen, oxygen and nitrogen. Ultraviolet radiation starts reactions between the ice molecules to form a complicated mixture of organic molecules.

In addition to rocky grains, covered in sticky organic material and ice, cosmic dust also contains much smaller (0.01 micrometre) carbon grains. These make up only a few per cent of the total amount of space dust. The carbon occurs in two forms - amorphous (specks of soot) and hydrogenated (specks of soot with hydrogen atoms attached).

The largest and densest interstellar clouds are called molecular clouds because the gas atoms can join up to form simple molecules such as molecular hydrogen (H_2), formaldehyde (H_2CO) and ethanol (C_2H_5OH). The gas and dust can become so dense that individual blobs can condense under their own gravity to form new stars each surrounded by a disc of dust and gas that may form a system of planets. Our solar system was formed in this way about 5.0 billion years ago. The system was originally very dusty but most of the original grains have been incorporated into the planets. The rest were blown out of the solar system when the young sun exhaled a high velocity 'wind' of gases. Nevertheless, a dilute sprinkling of dust orbits the sun between the planets. Also, in 1983, Japanese researchers found a denser ring of dust particles orbiting the sun closer than the planet Mercury, and belts of dust were also found in the asteroid belt between Mars and Jupiter.

Interplanetary dust in our solar system is formed from two sources - the asteroid belt and comets. Asteroids are very small planets (total mass of all asteroids is less than our moon) that orbit the sun between the orbits of Mars and Jupiter. The asteroids would probably have coalesced to form a major planet but for the gravitational influence of the giant Jupiter. Collisions between asteroids produce cosmic dust.

Many astronomers believe that icy dust grains in the outer part of the early Solar system, unaffected by the heat of the infant sun, coalesced into icy bodies a few tens of kilometres across - cometary nuclei. A storage cloud of cometary material exists far beyond the orbit of Pluto - the Oort Cloud. Occasionally the gravitational effect of passing stars may send a comet hurtling inwards towards the sun. The heat of the Sun evaporates the comet’s ices and jets of steam and gas spurt out to form the coma (head) and tail of the comet. These jets dislodge grains from the cometary nucleus.

In 1986 European and Soviet spacecraft flew past Halley's Comet and viewed it in close-up. The comet was ejecting 12 tonnes of dust per second. Three kinds of dust grains were found. Some grains were rocky silicates, the majority were a mixture of silicates and organic molecules, and the third type consisted entirely of organic molecules.

A small dust grain entering Earth's atmosphere burns up with frictional energy and is seen as a meteor or shooting star. On the other hand, meteorites are much larger and much of the mass can survive passage through the atmosphere to hit the ground. Meteorites are not really cosmic dust. They are larger splinters of rock or iron, broken off in a collision between two asteroids.

Interstellar dust is made by old dying stars. Nuclear reactions inside a star convert hydrogen and helium into heavier elements - oxygen, silicon, carbon, etc. When a star gets old it expands into a red giant and the temperature at the surface drops so low that some of the gases condense into solids. Depending on its history a star may be rich in either carbon or oxygen. A carbon star emits a pall of soot - carbon grains. If the star contains more oxygen than carbon, the oxygen reacts with silicon and other metals to form silicates thereby producing the major components of interstellar dust - the larger silicate grains.

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