3 SUN and GALAXY

SYNOPSIS

SUN - Powerhouse of the Solar System
The Sun is a star - a nuclear reactor at the hub of the Solar System. Each second, the Sun loses four million tonnes of mass – energy that gives us heat, light and life. Yet the Sun, overall, is no denser than yoghurt, a cauldron of incandescent gas spewing flares and prominences. Electrically-charged particles stream from the Sun – the solar wind. Twists in the magnetic field trigger gigantic ejections that turn the wind into a storm.

GALAXY - Our Milky Way
The Sun is one of more than 200-billion stars in our Galaxy, the Milky Way. The Galaxy is a spiral disc 100-thousand light years wide and 20-thousand thick. Our closest stellar neighbour is Alpha Centauri, 4.25 light years away. The Sun is two-thirds of the way from the galactic centre. In five billion years, when it is ten billion years old, the Sun will bloat into a red giant and die as a white dwarf. More massive stars have shorter lives and end in supernovae. The most massive collapse to become black holes.

BACKGROUND

Constituting 99.8 per cent of the Solar System, our local star powers our planet. Without the Sun, 150 million kilometres distant, Earth would be lifeless. The Sun sustains almost every form of life. It grows our crops and drives our weather systems. Our fossil fuels are stored sunlight.

The Sun was born of a cloud of gas and dust. Five billion years ago that cloud was disrupted by a supernova, the shockwave of an exploding superstar. The cloud centre collapsed under its own gravity and heated so much it fired up as a nuclear furnace – the infant Sun. From the surrounding, slowly-spinning disc, the planets formed.

Earth and the entire Solar System orbit the Sun. All are captive to its gravitational pull – the planets, their moons, asteroids, comets and the swarm of icy particles called the Oort Cloud that stretches a third of the way to the next star.

On average, the Sun is no denser than yoghurt. But at the white hot core it is ten times denser than lead. The core is a nuclear reactor converting hydrogen into helium. As nuclei of hydrogen fuse to produce nuclei of helium, there is a tiny loss of mass. Each second, the Sun loses four million tonnes of that mass – energy that will keep the Sun blazing for another five billion years.

The Sun is a ball of incandescent gas - 70 per cent hydrogen, 28 per cent helium and two per cent heavier elements such as iron. Sunlight is emitted by the yellow photosphere, a soup of bubbling granules, each the size of Texas. Gas rises through the granules, cools, and descends through the lanes that separate them.

Sunspots dot the photosphere. They are cooler than their surroundings and come and go over several days. One could swallow Earth. Through an 11-year transition, a spotless Sun (at minimum solar activity) can become very spotty (at "solar max"). The cycle is closely linked with the vast magnetic field that tangles through the Sun. Every 11 years or so, the field reverses as the magnetic poles flip.

Above the photosphere is the red chromosphere. This inner solar atmosphere erupts with searing gas. Prominences lick into space - fuelled by magnetic surges beneath. But solar flares are more violent. They can trigger coronal mass ejections with the energy of a billion megatonnes of TNT.

Between the convulsions, the Sun emits a steady stream of tenuous gas and electrically charged particles – the solar wind. It becomes a storm at the time of flares and mass ejections. The likely cause is twists in the magnetic field.

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From Earth, the Sun is the greatest object in the heavens. But from a wider perspective, the Sun is just one star among 200-billion or more that populate our Galaxy, the Milky Way. More sobering - the Milky Way is just one among the 50-billion or so galaxies believed to comprise the Universe.

Our closest stellar neighbour is Alpha Centauri, 4.25 light years away. A light-year is the distance light travels in a year. So light from the next closest, Barnard's Star, takes just under six years to reach us – even travelling at 300-thousand kilometres a second. Farther out lie Sirius (8.6 light years), Arcturus (37), Capella (52), Mizar and Alcor (59), Algol (95) and Beta Lyrae at 300 light years distant.

Such distances are insignificant on a galactic scale. The Milky Way is a spiral disc 20-thousand light years thick and 100-thousand light years wide. The Sun is in a spiral arm two-thirds of the way from the galactic centre where lurks – most probably – a massive black hole.

Pink patches in the spiral arms are stellar nurseries. Clouds of hydrogen collapse under their own weight. Pressure and temperature soar. Just as our Sun was born, so new stars fire up. Powerful telescopes have captured breathtaking pictures of such starbirth – incubators like the wondrous Pillars of Creation in the Eagle Nebula.

The Sun is an average star with a lifespan of ten-billion years. In five-billion years time, when hydrogen at its core runs out, the Sun will start to die. The balance of radiation pushing out and gravity pushing in will be gone. The Sun will swell. Mercury and Venus will be consumed. Deep within, helium will desperately fuse to carbon. Shells of gas will convulse into space. The Sun will be a red giant.

Earth will probably survive as a cinder. Finally, as it blows off its outer layer, the Sun's collapsed core will be exposed – a dying ember, a white dwarf. But the Sun is long-lived compared to more massive stars. A giant, with perhaps three times the mass of the Sun, comes to a faster and more furious demise – but also as a white dwarf.

Supergiants have a different end. A star with 15 times the mass of the Sun will fuse an array of elements in its death throes. When it reaches iron, the supergiant explodes as a supernova - bright as a galaxy. The remnant is a neutron star, a pulsar spinning many times a second. Compacted to less than 20 kilometres, a grain of a pulsar weighs one million tonnes.

Eta Carinae is one of the largest known stars, maybe 100 times more massive than the Sun. When it goes supernova, the colossal explosion will compress the core to beyond a neutron star – to a black hole. Supernovae are the lifeblood of our Galaxy. Their debris and shockwaves help create stars like the Sun. Their chemical elements are in every planet and every one of us.

Weblinks for SUN - Powerhouse of the Solar System

http://www.nasa.gov/vision/universe/solarsystem/sun for kids main.html - NASA's "Sun for Kids" page with lots of useful information about the Sun, plus links to other Sun-related websites and the top ten Sun facts.

http://www.teachersdomain.org/K-2/sci/ess/eiu/lp_superstar/index.html - From the Teachers' Domain, multimedia resources for the classroom and professional development, a useful overview of the Sun with lesson tips, links and resources.

http://en.wikipedia.org/wiki/Sun - From Wikipedia, the free encyclopedia, detailed information about all aspects of our nearest star.

http://www.windows.ucar.edu/tour/link=/sun/sun.html - From the University Corporation for Atmospheric Research's "Windows on the Universe" programme, information about the Sun, at beginner, intermediate and advanced levels.

http://solarscience.msfc.nasa.gov/ - From the Solar Physics Group at NASA's Marshall Space Flight Center, an overview of solar activity, with links to sites covering sunspots and the sunspot cycle.

http://sohowww.nascom.nasa.gov/ - The Solar and Heliospheric Observatory (SOHO) web pages provide general information about the Sun and solar activity with links to the very best and latest SOHO images.

http://solar-center.stanford.edu/observe/ - Essential advice for teachers on observing the Sun safely from the Stanford Solar Center at Stanford University.

http://www.astrosociety.org/education/publications/tnl/05/stars2.html - More advice on safe solar observing from the popular "Universe in the Classroom" series.

http://teachingtreasures.com.au/solar-energy/solar-power.htm - From Teaching Treasures, a useful site about the Sun's energy, with helpful facts and practical examples to encourage more effective use of solar energy.

http://www.atoptics.co.uk/phen800.htm - A fascinating site about atmospheric optics, explaining how light playing on water drops, dust or ice crystals in the atmosphere produces a host of visual spectacles - rainbows, halos, glories, coronas and many more.

Weblinks for GALAXY - Our Milky Way

http://curious.astro.cornell.edu/milkyway.php - Answers to some of the most common questions young people ask about the Milky Way, written by an astronomer.

http://imagine.gsfc.nasa.gov/docs/features/objects/milkyway1.html - From NASA's Goddard Space Flight Center, some useful background information on our Galaxy, the Milky Way.

http://en.wikipedia.org/wiki/Milky_Way - From Wikipedia, the free encyclopedia, a most useful overview of the Milky Way, its age, structure, the Sun's place within it, and our galactic neighbourhood.

http://cassfos02.ucsd.edu/public/tutorial/MW.html - An illustrated astronomy tutorial on the shape and structure of our Milky Way galaxy.

http://www.le.ac.uk/ph/faulkes/web/stars/y_st_intro.html - A Faulkes Telescope Educational Guide about the birth, life and death of stars, at beginner, intermediate and advanced levels.

http://janus.astro.umd.edu/astro/stars/SunsLife.html - An interesting graphic animation showing the life of the Sun from its birth, through its subsequent expansion, the red giant phase, and its final contraction into a white dwarf.

http://imagine.gsfc.nasa.gov/docs/teachers/lessons/xray_spectra/background-lifecycles.html - From NASA's Goddard Space Flight Center, a very good summary of the life cycles of stars and how supernovae are formed, with links to teachers' corner and lesson plans.

http://www.public.iastate.edu/~astro.505/IbenTutST/iben1.html - A useful summary of the birth, life and death of stars, written at a popular level by two distinguished astronomers.

http://www.universetoday.com/am/publish/building_life_from_star-stuff.html - Originally from NASA's Astrobiology Magazine, an article exploring the idea – generally attributed to the late Carl Sagan – that all life is made of star-stuff.