Descriptive Chapters

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WRITTEN BY		July 26, 2024	

REVISION HISTORY			
NUMBER	DATE	DESCRIPTION	NAME

Contents

Chapter 1

Descriptive Chapters

1.1 Description

This database contains a series of descriptional chapters, linked into by other documents. As a result, no table of contents exists for the file.

1.2 The Sun - Fast Facts

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Mass..............................1.9891e30 kg  (332948 times that of Earth)
Equatorial radius....................696000 km  (109.12 times that of Earth)
Surface gravity.........................274 m/s^2 (27.9 times that of Earth)
Apparent semidiameter at 1 AU.........959.64 arcseconds
Average density........................1.41 g/cm^3
Inclination of equator to ecliptic......7.25 degrees
Magnitude, apparent...................-26.8
Magnitude, absolute....................4.77
Average surface temperature............5500 degrees C
Spectral classification................G2-V
Age..........................4,600,000,000 years
Expected life remaining........5,000,000,000 years
Revolution period in Milky Way...200,000,000 years

Rotational periods (*):
  Equatorial............................25.4 days
  Polar...................................36 days
  Internal................................27 days
  Adopted for heliographic longitudes..25.38 days

Motion relative to nearby stars:
  Direction (right ascension)............18 hours
  Direction (declination)................30 degrees
  Velocity............................19400 m/s

Distance from Earth:
  Shortest.....................147,098,447 km (0.9832923836 AU)
  Average......................149,598,023 km (1.0000010178 AU)
  Greatest.....................152,097,599 km (1.0167096520 AU)
```

```
 Composition (by number of atoms):
     Hydrogen...........................92.1%
     Helium..............................7.8%
     Oxygen..............................0.061%
     Carbon..............................0.030%
     Nitrogen............................0.0084%
     Neon................................0.0076%
     Iron................................0.0037%
     Silicon.............................0.0031%
     Magnesium...........................0.0024%
     Sulfur..............................0.0015%
     Others..............................0.0015%
```

* Since the Sun is basically a huge ball of gas, it does not rotate as a solid body. As can be seen from the rotational periods, gas near the equator takes less time to rotate around the Sun than gas at the poles. This differential rotation can also be observed with the gas giant planets Jupiter, Saturn, Uranus, and Neptune.

1.3 The Sun - Structure and Nuclear Processes

Like most bodies in the solar system, the Sun is comprised of several layers, each of which is different from the others in some fundamental respects.

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 The Core
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Occupying the inner third of the Sun, the core reaches a temperature of 15,000,000 degrees C (27,000,000 degrees F), and a pressure 250,000,000,000 times more intense than that of the Earth’s atmosphere at sea level. Since nuclear fusion requires such extreme conditions, the core is the only place in the Sun where it can occur.

Through the process of nuclear fusion, four hydrogen nuclei (four protons) collide together and form an alpha particle, or helium nucleus (consisting of two protons and two neutrons). However, the alpha particle is about 0.7% lighter than the four protons. The missing mass is converted to energy in the form of photons, as specified by Albert Einstein’s famous equation: E=mc^2. These photons then begin their long journey towards the surface of the Sun, and eventually out into space.

In one second, the Sun converts 5 million metric tons of hydrogen into energy. This output of a single second would be sufficient to satisfy the world’s current energy requirements for 1 million years.

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 The Radiative Zone
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The Radiative Zone occupies the region of the Sun encircling the core, reaching out to within 150,000 km of the surface. When energetic photons from within the core strike atomic nuclei in this layer, the photon is absorbed, and another, slightly less energetic photon reemitted. In this way, the decreasing photon energy causes the radiation to shift from gamma rays (as produced in the core), to X-Rays, to extreme ultraviolet, to ultraviolet, to visible light. Though an unimpeded photon, travelling at the speed of light, would only take slightly over 2 seconds to emerge from the Sun, these frequent collisions in random directions result in it taking 50 million years, on average, for energy generated within the core to reach the surface.

As we move out from the center of the Sun through the radiative zone, we would find the temperature, pressure, and density (as well as photon energy) continually decreasing. Eventually, the temperature would be around 2,500,000 degrees C (4,500,000 degrees F) with a density about equal to that of water.

The Convection Zone

Within the Core and Radiative Zone, the temperature is so high that atoms are stripped of their electrons; they basically consist solely of their nuclei. By the time that the Convection zone is reached, the temperature has cooled to the point that the free electrons are starting to recombine with these nuclei, becoming more opaque to radiation. This acts as a blanket and results in a large temperature gradient going towards the surface.

Now, the energy is carried towards the surface by another process in addition to radiation - convection. Heated fluids, because of their lower density, rise while cooled fluids fall. A fluid heated from below will rise in a column until it cools. At that point, it will move aside and fall to be re-heated, continuing the process. Fluid trapped in this cycle is said to be part of a "convection cell".

Convection can occur at any scale. Convection currents may be observed in a warm pot of water (though if boiling, the convection becomes turbulent and more difficult to observe). Towering thunderheads usually evolve their characteristic appearance as warm, moist air rises through the center of the cloud. As the air cools, the moisture condenses to form the cloud, while the air moves aside and falls back down.

Convection cells on the Sun are much larger, however. The top of a column can be 1000 km or more across. These convection cells may be observed in high resolution white light images of the Sun. Since convection patterns appear as ‘granules’, the effect is often referred to as ‘granulation’.

View picture of granulation

The Photosphere

When we look at the Sun, we see the region known as the Photosphere. It is a thin layer, perhaps only 100 km in depth, that produces the radiation transmitted into space, since at its distance from the center of the Sun photons are more likely to escape than be re-absorbed. The Photosphere is considered to be the innermost layer of the Sun’s atmosphere.

The conditions in the photosphere are much less severe than elsewhere in the Sun. The temperature has dropped to a relatively cool 5500 degrees C, the pressure is only one hundredth that of the Earth’s atmosphere at sea level, and the density is about one hundred millionth that of water.

The sun’s limb (edge) appears darker than at its center, due to an effect known as limb darkening. Click here to see an example picture.

Since light travelling through the Photosphere is partially absorbed by material located there, our line of sight can only see so far. When we look at the center of the Sun's disk, we are looking through less of the Photosphere than when we observe near the limb. As a result, we see deeper into the Photosphere near the centre. The limb appears darker because our line of sight ends higher in the atmosphere, where the temperature is cooler.

The Photosphere and other atmospheric layers are the home to a wide variety of features which are visible on the Sun from the Earth. See Solar Activity for more information.

The Chromosphere

This is a level of the solar atmosphere immediately above the Photosphere, extending about 2500 km out. At approximately 500 km above the Photosphere, the temperature is only 3000-3500 degrees C. However for some reason not yet fully understood, the temperature then rapidly increases to 1,000,000 degrees C at its outer reaches. It is felt that the heating is due partially to a dramatic density decrease (the density can be as low as 100 trillion times less dense than water), as well as mechanical energy added to the Chromosphere from the Convection Zone. Granulation can overshoot hundreds of kilometers into the Chromosphere. Due to the decreased density, higher particle velocities are possible, resulting in a higher temperature.

Also present in the Chromosphere are gas streams shooting up from the Photosphere, known as spicules. These can be 800 kilometers thick, up to 15,000 kilometers high, and last for as long as 15 minutes.

The Corona

The outermost atmosphere of the Sun is known as the "Corona". Since it is substantially less bright than the Photosphere, it can only be observed when the surface of the Sun is blocked out during a total solar eclipse.

View picture of Corona

The Corona is dominated by intense magnetic fields, around which the gas accumulates to create its beautiful and delicate structure. The temperature is even higher than that in the Chromosphere, climbing to some 3,000,000 degrees C. However, if an astronaut were to visit the corona and were somehow shielded from the direct rays of the Sun, he or she wouldn't roast to death - in fact, a spacesuit heating system would be required. This is because there simply isn't a lot of gas in the corona. In fact, the atmospheric pressure within the corona rivals laboratory work in creating an almost perfect vacuum.

There is enough energy in the corona to emit X-rays, however. An X-ray picture of the Sun taken from space quite clearly shows the corona.

View X-ray picture of Sun

Coronal holes are the source of great streams of solar matter that flow outward from the Sun. Termed the solar wind, these particles are continuously bombarding the Earth causing a wide variety of geophysical phenomena (such as aurorae or reduced radio reception).

1.4 Solar Activity

Under even casual inspection, the Sun appears as anything but a featureless yellow disk. There are a variety of things to see - some of which can even be observed with the naked eye. However, all solar observations must be done with extreme caution. See Observing the Sun safely for further information.

Sunspots
========
View Picture 1 (close-up view of a sunspot group)
View Picture 2 (full disk of Sun with sunspots)

First detected by Galileo, sunspots are perhaps the most well known solar feature. Where strong magnetic fields intersect with the Photosphere, the temperature of the surrounding gas can be lowered from 5500 degrees C to 4500 degrees C. Because of this, sunspots appear dark when viewed against the background of the much brighter Sun.

A typical sunspot may have a diameter of more than 30,000 km (a few planets the size of the Earth could easily fit within one). Most consist of two parts. The inner region, called the umbra, is the darker of the two, and can reach 13,000 km in diameter. The outer region, known as the penumbra, is somewhat lighter in color. Some sunspots have no clearly defined penumbra because of their smaller size.

The life of a sunspot can range from a few hours to several months. Those sunspots which last longer can often be observed for several solar rotations, and can be used to provide a rough verification of the differential rotation of the Sun with different latitudes.

Granulation
===========
View Picture

As mentioned in The Sun - Structure and Nuclear Processes, granulation may also be observed on the Sun. Due to convective currents in the Convection Zone of the Sun, hot material from within is constantly being interchanged with cooler material at the surface. The resulting appearance of the solar disk is granulation.

Spicules
========
Spicules are structures present in the Chromosphere of the Sun. These streams of gas shoot up from the Photosphere and can be 800 kilometers thick, up to 15,000 kilometers high, and last for up to 15 minutes.

Flares
======
Usually associated with sunspots, flares are huge eruptions taking place on the Sun. They are observed as an increase in brightness on the solar surface, and often give rise to intense bursts of electromagnetic radiation.

The following plot contains a representation of such an event. The data was recorded with the solar radio telescope at the Dominion Radio Astrophysical Observatory in Penticton, BC, Canada on April 1, 1992. The flare can be seen to begin at around 17:30 UT, reach a maximum of about 200 solar flux units above the baseline, quickly decrease from its maximum, then take several hours to return to its original, pre-flare level.

View plot of solar flare radio emissions

Coronal Mass ejections
======================

Periodically, changes in the Sun’s magnetic field trigger the ejection of billions of tons of gas from the corona. About 30% of the gas travels faster than the solar wind, reaching velocities of up to 2000 km/sec. If this gas reaches the Earth, a magnetic storm ensues.

These magnetic storms can affect the ionosphere of the Earth, resulting in a disruption of telecommunications. Sometimes, compass needles are affected and vast power outages occur. In the more northern or southern regions, the storms often create spectacular aurorae. During periods of high solar activity, the Earth intercepts about 70 coronal mass ejections per year.

Magnetic storms on the Earth were previously attributed to solar flares. This mistaken relationship arose since flares are much brighter, and often occur at the same time as coronal mass ejections. However, astronomer Jack Gosling, of the Los Alamos National Laboratory presented evidence to the December, 1993 meeting of the American Geophysical Union indicating the relationship with coronal mass ejections.

Prominences & Filaments
=======================

View Picture 1 - Prominence on solar limb
View Picture 2 - Filaments on solar disk, seen in H-alpha light

Gas suspended above the solar Photosphere by the Sun’s magnetic field is termed a "prominence" if the gas is visible at the limb of the Sun, and a "filament" if the gas is seen against the solar disk as a background. Since filaments are not as bright as the rest of the Sun, they appear as dark, snakelike features.

Viewing prominences or filaments requires a H-alpha filter with a bandwidth of 3 or 4 angstroms. A filter passing a band of less than 1 angstrom is required to see filaments on the solar disk.

1.5 The Solar Wind

In addition to heat and light, the Sun also emits a continuous low density stream of charged particles (mostly electrons and protons). Such a phenomenon was long suspected by scientists, but first confirmed from data returned by the Mariner 2 space probe. These particles are known as the "solar wind", and travel away from the Sun at approximately 450 km/sec (1,620,000 km/hour) in equatorial regions. Recent data from the Ulysses spacecraft seems to indicate that the solar wind originating from the south solar pole flows at nearly double the rate (750 km/sec) while differing somewhat in composition.

The solar wind and higher energy particles released from the Sun during coronal mass ejections combine to have strong effects on the Earth, ranging from aurorae to power line surges to radio interference. Due to the relatively slow speed of the solar wind (as compared to the speed of light at 299,792.458 km/sec), the effects are often felt a few days after an event is observed visually or by radio telescopes.

The following plot contains a representation of such an event. The data was recorded with the solar radio telescope at the Dominion Radio Astrophysical Observatory in Penticton, BC, Canada on April 1, 1992. The flare can be seen to begin at around 17:30 UT, reach a maximum of about 200 solar flux units above the baseline, quickly decrease from its maximum, then take several hours to return to its original, pre-flare level.

View plot of solar flare radio emissions

The solar wind is believed to originate within "coronal holes" - regions of the corona less dense and cooler than surrounding areas. It has been observed by the Voyager and Pioneer spacecraft to exist at least as far as the orbit of Pluto.

1.6 Helioseismology

Since the Sun is basically just a ball of hot gas, its interior transmits sound very well. In studying doppler shifts in the solar spectrum, the discovery of propagating sound waves in the Sun was made as long ago as 1962. It was noticed that certain parts of the Sun appeared to be receding while other parts were approaching. Five minutes or so later, the roles would reverse. This led scientists to the conclusion that the Sun was "pulsating" at a particular set of frequencies.

It is generally believed that convection near the surface of the Sun results in vigorous turbulent flows that produce a broad spectrum of random acoustical noise. Most of this noise is generated at approximately 0.003 Hz - far below the human ear’s limit of 20 Hz. Although sound is generated at a wide range of frequencies, the shape of the Sun forms a spherical resonator. The net result can be likened to a bell ringing at a particular frequency, even when hit by a clapper at random intervals.

The precise frequencies at which the Sun resonates can be used to determine the thermodynamic and compositional state of the material within, in much the same way as geologists use seismic readings to deduce the nature of the Earth’s interior.

Evidence obtained between 1977 and 1989 seem to indicate that the primary frequency of the Sun’s resonation changes with the current point in the solar cycle. When the Sun is less active, the frequency is a bit less than otherwise.

In the March 1995 issue of the "Astronomical Journal", astronomers reported evidence of similar resonations in observations of Eta Boötes.

1.7 The Solar Cycle

The Sun's activity is not entirely constant. Between 1826 and 1843, the German astronomer Heinrich Schwabe produced evidence to indicate that sunspot activity tended to follow an approximate 11 year cycle. From a minimal number of sunspots, it took approximately four years to reach a peak of activity, then about seven years to fall to a new minimum. Later it was discovered that after every cycle of activity, the magnetic polarity of the sunspots was reversed. This suggested the existence of a 22 year cycle. In addition, the data seems to suggest an additional period of around 80 years.

In the last 100 years, the period of rise has ranged between 3.3 to 5.0 years, and the period of fall between 5.7 to 8.3 years, so it is difficult to make predictions about solar activity over any length of time.

At the beginning of each cycle (near minimum activity), sunspots occur in the higher latitudes of the Sun (about 40 degrees from the equator), gradually appearing nearer and nearer to the equator as the cycle progresses.

The number of visible sunspots is not the only indicator of solar activity that seems to follow an 11 year cycle. Radio emissions at a wavelength of 10.7 cm also confirm the pattern. There may also be some evidence that the weather on the Earth may follow a similar cycle. From 1645 to 1717, hardly any sunspots were recorded. This period was known as the "Maunder Minimum". Coinciding with the decrease in sunspots, the average temperature on the Earth fell, and particularly severe winters occurred in Europe.

In addition, studies published by Eigil Friis-Christensen and Knud Lassen of the Danish Meteorological Institute in Copenhagen in the November 1, 1991 issue of "Science" suggest another link between the solar cycle and climate conditions on Earth. They presented data which indicates a surprisingly strong relationship between the length of the solar cycle and the average temperature of the Earth's atmosphere. Warmer temperatures seem to occur during shorter solar cycles.

1.8 Observing the Sun safely

It is likely that everyone has heard time and time again of the dangers of looking directly at the Sun. But such a warning bears repetition: on countless occasions, permanent blindness has been known to occur to individuals who do not use proper methods of solar observation. There are several safe ways to view the Sun which will be described here, but please ensure that you fully understand the technique before you risk your eyesight.

Projection
==========
The safest way to study the Sun is to not look at it directly at all. You can use a telescope or pair of binoculars to project an image of the Sun onto a piece of cardboard. ENSURE THAT YOU NEVER LOOK THROUGH THE TELESCOPE OR BINOCULARS AT THE SUN. EVEN A FRACTION OF A SECOND WILL PERMANENTLY BLIND YOU.

If you are using a pair of binoculars, cover one of the larger lenses first - you will only need to use one side of the binoculars. Likewise, if you are using a telescope with a finder scope, ensure that the finder is capped. Next, aim the telescope or binoculars roughly at the Sun (again, ensure that you do not look through the instrument to find the Sun). You will find it easy to line the instrument up with the Sun by moving it around until its shadows are as small as possible.

If you set up a piece of cardboard behind the telescope (on the same side of the telescope as the eyepiece), and line the telescope up well, you will see the image of the Sun projected onto the cardboard. You may have to adjust the focusing knob to get a clear image. Experiment with moving the cardboard nearer to or further from the eyepiece to get a smaller or larger image until you have the result you want.

The projection method is more than adequate to allow you to view and chart the movement of sunspots across the solar disk. One improvement you may wish to make is to use another piece of cardboard to make a large "collar" around the eyepiece of your instrument. If positioned properly, this collar will create a shadow on the cardboard you are using as a projection screen, making your image appear brighter and with higher contrast.

The projection method has the additional advantage that several people may observe the Sun at the same time. Just ensure you understand that the Sun’s rays are being intensely concentrated by the lenses in the telescope or binoculars to a point just a few millimeters behind the eyepiece. Do not put anything near the eyepiece that you wish to keep (especially your eyes!). It will burst into flame almost immediately.

Filters
=======
Another method of viewing the Sun is with the use of the appropriate filters. Only use filters designed for this particular purpose - dark sunglasses and the like will NOT work and will be dangerous. You should be able to find companies advertising their solar filters for sale in reputable magazines such as "Sky & Telescope" or "Astronomy".

There are two places where filters can be used in a telescope - at the objective (or large lens), and at the eyepiece (the smaller lens). It is strongly recommended that you never use a filter at the eyepiece (and in my opinion, such filters should be banned). Eyepiece filters are dangerous in that they are placed right where the light is being concentrated the most. As a result, they can tend to heat up and crack without warning - blinding you instantly if you happen to be looking through the eyepiece at the time. If you really must use an eyepiece filter, ensure that you never keep the telescope pointed at the Sun for more than a few minutes. As well, if you use a larger telescope, construct a cardboard shield over the front of the instrument to prevent most of the light from entering. This will hopefully keep the filter cool enough to prevent cracking.

A much safer alternative is to use filters that fit over the objective of your telescope. With such a filter, you can observe the Sun all day if you want to - the filter doesn’t warm up any more than the air around it. Of course, ensure that the filter is securely attached to the telescope. You wouldn’t want a sudden gust of wind to pull it off, letting unfiltered light through the telescope.

If you wish to observe filaments or prominences, you will need a special filter called an H-alpha, or Hydrogen-alpha filter. This filter only allows one particular wavelength of hydrogen to pass through, enabling you to see details clearly.

1.9 Solar Eclipses

NOTE: For any attempts at solar eclipse viewing, it is essential that you read the section entitled Observing the Sun safely.

There are several different classifications of solar eclipses:

Total
=====
View Picture

The Sun is about 400 times larger than the Moon, and about 400 times further away. As a result, it appears about the same size in the sky. However, the Earth revolves around the Sun, and the Moon revolves around the Earth in slightly elliptical orbits. The result is that the distances to these objects changes slightly with time. Sometimes the Sun appears slightly larger than the Moon, and sometimes the Moon appears slightly larger than the Sun. It is in the latter case that a total eclipse is possible.

If the Moon passes directly between the Sun and your physical location on the Earth, and appears slightly larger than the Sun, you will see a total solar eclipse. For the few minutes of "totality", the Moon will appear to completely cover the disk of the Sun.

In the hours before the moment of maximum eclipse, the Moon can be observed to slowly obscure the Sun. A few minutes before totality, the total amount of light from the photosphere is reduced to the point that the blinking reflex that normally protects our eyes from the Sun’s light no longer works. This is considered the most dangerous part of an eclipse, since people are tempted to stare at the Sun, even though it is still perfectly capable of damaging their eyesight.

Immediately before totality begins, brilliant points of light can be observed on the edge of the Sun. Known as "Baily’s beads", these are the last bits of sunlight shining through valleys on the edge of the Moon. When the last "Baily’s bead" is visible before totality, the appearance is often called the "diamond ring" effect. 3 to 5 seconds later, it too is obscured by the Moon. For another few seconds, the pink chromosphere is visible, as well as any prominences that may be there. Then totality begins.

During totality, you can see the corona of the Sun. It always surrounds the Sun, but since it shines a million times dimmer than the Sun itself, it is only visible when the Sun is in a dark sky - in other words, only during a total solar eclipse. During this phase of an eclipse (and ONLY during this phase), you can look directly at the Sun, without filters, as the corona is only about as bright as the full Moon.

During totality, the sky is as dark as it is during evening twilight. If you look toward the horizon in any direction, you can see beyond the darkest part of the moon’s shadow. The result is a pinkish glow looking like a sunset extending completely around the horizon.

Though the length of totality varies depending on your location and the particular eclipse being observed, it will never last longer than about 7 minutes. Before it ends, you must stop looking directly at the Sun. The sequence of events following totality mirror those which led up to the event.

```
 Annular
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When the Moon moves directly between the Sun and your physical location on Earth, but appears slightly smaller than the Sun, it will not be able to completely cover the Sun and cause a total eclipse. At the moment of maximum eclipse, an "annulus" or ring of the Sun around the Moon can be observed.

At no point during an annular eclipse is it safe to look at the Sun without protective filters.

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 Partial
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When the Moon only appears to partially cover the Sun from your physical location on Earth, the eclipse is said to be partial. Since the Moon appears as almost the exact same size as the Sun, only a narrow band along the Earth falls within its shadow and can observe a particular solar eclipse as being total. Most of the remainder of the Earth must be content with viewing a partial eclipse.

As with an annular eclipse, it is never safe to observe a partial eclipse of the Sun without protective filters.

See also: Eclipse Details: Solar Eclipse

1.10 The Sun - Exploration

The Sun has been the object of study for several interplanetary spacecraft. A chronological list of some of these probes, sorted by launch date, follows:

```
  Pioneer 6   - Dec. 16/65
  Pioneer 7   - Aug. 17/66
  Pioneer 8   - Dec. 13/67
  Pioneer 9   - Nov.  8/68
  Pioneer E   - Aug. 27/69
  Explorer 49 - Jun. 10/73
  Helios 1    - Dec. 10/74
  Helios 2    - Jan. 15/76
  Ulysses     - Oct.  6/90
```

1.11 The Sun - Pictures

Though links to these pictures occur in various places throughout the document, they are provided here as well for convenience.

```
White light image, showing limb darkening & sunspots
Hydrogen-alpha image, showing filaments
X-ray image, showing activity in the corona
Image of the corona, during a total solar eclipse
Granulation on the surface of the Sun
Close up view of sunspots
Image of a prominence taken in Hydrogen-alpha light
View plot of solar flare radio emissions
```

1.12 Mercury - Fast Facts

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.13 Mercury - Mythology

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.14 Mercury - Discovery

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1.15 Mercury - Exploration

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1.16 Mercury - A Strange Orbit

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1.17 Mercury - The length of its day

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1.18 Mercury - Physical Features

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1.19 Mercury - Observing the Planet

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1.20 Mercury - Pictures

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1.21 Venus - Fast Facts

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1.22 Venus - Mythology

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1.23 Venus - Discovery

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1.24 Venus - Exploration

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1.25 Venus - A Runaway Greenhouse Effect

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1.26 Venus - Length of the Day

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1.27 Venus - Physical Features

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1.28 Venus - Observing the Planet

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1.29 Venus - Pictures

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1.30 Earth - Fast Facts

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1.31 Earth - Structure

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1.32 Earth - Atmosphere

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1.33 Earth - Pictures

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1.34 The Moon - Fast Facts

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1.35 The Moon - Exploration

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1.36 The Moon - Features

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1.37 The Lunar day

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1.38 Phases of the Moon

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1.39 The Moon - Pictures & Audio clips

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1.40 Mars - Fast Facts

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1.41 Mars - Mythology

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"The Digital Universe".  Please consult Ordering The Digital Universe
for more information on how to obtain a registered version.
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1.42 Mars - Discovery

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.43 Mars - Exploration

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.44 Mars - Physical Features

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.45 Is there life on Mars?

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
for more information on how to obtain a registered version.
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1.46 Mars - Observing the Planet

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.47 Mars - Pictures

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.48 Phobos - Fast Facts

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1.49 Phobos - Description

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1.50 Deimos - Fast Facts

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1.51 Deimos - Description

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1.52 Jupiter - Fast Facts

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.53 Jupiter - Mythology

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This information is not provided with the demonstration version of
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for more information on how to obtain a registered version.
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1.54 Jupiter - Discovery

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1.55 Jupiter - Exploration

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1.56 Jupiter - Physical Features

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for more information on how to obtain a registered version.
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1.57 Jupiter’s ring

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1.58 Jupiter - Observing the Planet

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.59 Jupiter - Collision with Comet Shoemaker-Levy 9

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"The Digital Universe".  Please consult Ordering The Digital Universe
for more information on how to obtain a registered version.
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1.60 Jupiter - Pictures

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1.61 Ganymede - Fast Facts

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1.62 Ganymede - Description

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1.63 Callisto - Fast Facts

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1.64 Callisto - Description

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1.65 Io - Fast Facts

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1.66 Io - Description

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1.67 Europa - Fast Facts

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1.68 Europa - Description

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1.69 Amalthea - Fast Facts

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1.70 Amalthea - Description

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1.71 Himalia - Fast Facts

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1.72 Himalia - Description

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1.73 Thebe - Fast Facts

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1.74 Thebe - Description

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1.75 Elara - Fast Facts

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1.76 Elara - Description

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1.77 Pasiphae - Fast Facts

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1.78 Pasiphae - Description

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1.79 Metis - Fast Facts

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1.80 Metis - Description

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1.81 Carme - Fast Facts

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1.82 Carme - Description

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1.83 Lysithea - Fast Facts

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1.84 Lysithea - Description

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1.85 Sinope - Fast Facts

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1.86 Sinope - Description

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1.87 Ananke - Fast Facts

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1.88 Ananke - Description

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1.89 Adrastea - Fast Facts

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1.90 Adrastea - Description

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1.91 Leda - Fast Facts

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1.92 Leda - Description

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1.93 Saturn - Fast Facts

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1.94 Saturn - Mythology

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1.95 Saturn - Discovery

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1.96 Saturn - Exploration

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1.97 Saturn - Physical Features

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1.98 Saturn's rings

This information is not provided with the demonstration version of "The Digital Universe". Please consult Ordering The Digital Universe for more information on how to obtain a registered version.

1.99 Saturn - Observing the Planet

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1.100 Saturn - Pictures

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1.101 Titan - Fast Facts

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1.102 Titan - Description

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1.103 Mimas - Fast Facts

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1.104 Mimas - Description

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1.105 Enceladus - Fast Facts

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1.106 Enceladus - Description

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1.107 Tethys - Fast Facts

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1.108 Tethys - Description

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1.109 Dione - Fast Facts

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1.110 Dione - Description

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1.111 Rhea - Fast Facts

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1.112 Rhea - Description

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1.113 Hyperion - Fast Facts

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1.114 Hyperion - Description

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1.115 Iapetus - Fast Facts

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1.116 Iapetus - Description

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1.117 Phoebe - Fast Facts

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1.118 Phoebe - Description

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1.119 Telesto - Fast Facts

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1.120 Telesto - Description

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1.121 Calypso - Fast Facts

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1.122 Calypso - Description

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1.123 Helene - Fast Facts

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1.124 Helene - Description

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1.125 Pan - Fast Facts

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1.126 Pan - Description

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1.127 Atlas - Fast Facts

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1.128 Atlas - Description

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1.129 Prometheus - Fast Facts

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1.130 Prometheus - Description

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1.131 Pandora - Fast Facts

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1.132 Pandora - Description

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1.133 Epimetheus - Fast Facts

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1.134 Epimetheus - Description

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1.135 Janus - Fast Facts

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1.136 Janus - Description

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1.137 Uranus - Fast Facts

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1.138 Uranus - Mythology

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1.139 Uranus - Discovery

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1.140 Uranus - Exploration

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1.141 Uranus - Physical Features

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
for more information on how to obtain a registered version.
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1.142 Uranus' rings

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.143 Uranus - Observing the Planet

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1.144 Uranus - Pictures

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1.145 Miranda - Fast Facts

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1.146 Miranda - Description

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1.147 Ariel - Fast Facts

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1.148 Ariel - Description

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1.149 Umbriel - Fast Facts

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1.150 Umbriel - Description

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1.151 Titania - Fast Facts

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1.152 Titania - Description

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1.153 Oberon - Fast Facts

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1.154 Oberon - Description

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1.155 Cordelia - Fast Facts

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1.156 Cordelia - Description

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1.157 Ophelia - Fast Facts

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1.158 Ophelia - Description

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1.159 Bianca - Fast Facts

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1.160 Bianca - Description

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1.161 Cressida - Fast Facts

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1.162 Cressida - Description

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1.163 Desdemona - Fast Facts

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1.164 Desdemona - Description

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1.165 Juliet - Fast Facts

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1.166 Juliet - Description

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1.167 Portia - Fast Facts

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1.168 Portia - Description

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1.169 Rosalind - Fast Facts

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1.170 Rosalind - Description

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1.171 Belinda - Fast Facts

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1.172 Belinda - Description

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1.173 Puck - Fast Facts

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1.174 Puck - Description

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1.175 Neptune - Fast Facts

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1.176 Neptune - Mythology

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1.177 Neptune - Discovery

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1.178 Neptune - Exploration

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1.179 Neptune - Physical Features

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1.180 Neptune's rings

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This information is not provided with the demonstration version of
"The Digital Universe".  Please consult Ordering The Digital Universe
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1.181 What is the furthest planet from the Sun?

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"The Digital Universe".  Please consult Ordering The Digital Universe
for more information on how to obtain a registered version.
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1.182 Neptune - Observing the Planet

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1.183 Neptune - Pictures

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1.184 Triton - Fast Facts

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1.185 Triton - Description

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1.186 Nereid - Fast Facts

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1.187 Nereid - Description

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1.188 Naiad - Fast Facts

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1.189 Naiad - Description

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1.190 Thalassa - Fast Facts

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1.191 Thalassa - Description

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1.192 Despina - Fast Facts

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1.193 Despina - Description

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1.194 Galatea - Fast Facts

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1.195 Galatea - Description

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1.196 Larissa - Fast Facts

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1.197 Larissa - Description

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1.198 Proteus - Fast Facts

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1.199 Proteus - Description

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1.200 Pluto - Fast Facts

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1.201 Pluto - Mythology

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1.202 Pluto - Discovery

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1.203 Pluto - Exploration

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1.204 Pluto - Physical Features

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1.205 Pluto - its strange orbit

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1.206 Pluto - Observing the Planet

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1.207 Pluto - Pictures

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1.208 Charon - Fast Facts

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1.209 Charon - Description

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