THE NOW FRONTIER

MAN LINKS EARTH AND PLANETS

PIONEER TO JUPITER

ISSUE NUMBER ONE

JUPITER . . . GIANT OF THE SOLAR SYSTEM

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RELATIONSHIP OF JUPITER TO THE OTHER PLANETS

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Jupiter is the target of two Pioneer spacecraft, the first of which, Pioneer 10, is due to arrive and fly close by the planet early in December, 1973.

In Roman and Greek mythology, Jupiter was the name of the most powerful and capricious ruler of the heavens. Small wonder that ancient astronomers gave the same name to the planet that is the brilliant ruler of the night sky year after year. Today, astronomers acknowledge Jupiter as perhaps the most important planet of the Solar System, certainly the largest and most massive. Indeed, the Solar System has been referred to as the Sun and Jupiter plus a lot of debris because after the Sun, Jupiter contains two-thirds of all the matter in the Solar System.

Planets of the Solar System consist of two distinct types: small, dense inner planets with solid surfaces—Mercury, Venus, Earth and its Moon, and Mars—and large, predominantly gaseous outer planets—Jupiter, Saturn, Uranus and Neptune. Pluto, the outermost known planet, cannot be observed well enough to be accurately classified though it is believed to be similar to the inner planets. Also, between the orbits of Mars and Jupiter is a zone of minor planets called asteroids, the largest of which, Ceres, is only 500 miles in diameter while most are much smaller.

In distance outwards from the Sun, the asteroids represent the end of the inner planets while Jupiter is the first of the outer planets.

DOMINANT POSITION

Jupiter is an unusual planet by earthly standards. Only slightly denser than water, the planet would almost float. Yet Jupiter is 318 times more massive than Earth. Because of its great mass Jupiter dominates the Solar System, secondary only to the Sun itself. Its gravity affects the orbits of the other planets and may have prevented the asteroids from falling together to become a planet. The orbits of many comets, too, are affected by Jupiter. Some have been captured and are now under control of the big planet.

Jupiter is close to being a second Sun; it is just slightly too small for its own weight to raise its central temperature high enough for nuclear fire to be ignited in its core. Had Jupiter been slightly larger the Solar System could have been a binary star system and nighttime would have occurred rarely on Earth. As it is, Jupiter emits more energy into space than it receives from the Sun.

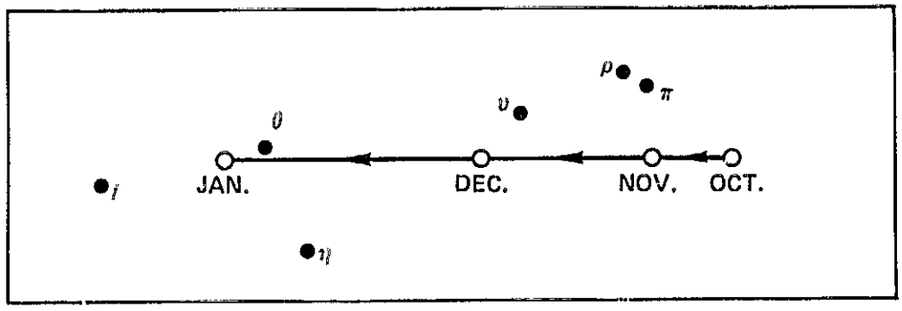

Figure 1. Movement of Jupiter Against Stars of Capricornus

FAMILY OF SATELLITES

Galileo discovered four satellites of Jupiter in 1610 when he first looked at the planet with the newly invented telescope. Two of these satellites, Callisto and Ganymede, are about the size of the planet Mercury, while Io and Europa rival Earth's Moon. You can easily see these big satellites through a pair of field glasses. They range in an almost straight line on either side of Jupiter as star-like objects. Watched night after night they change their positions as they follow orbits around Jupiter. Romer measured the finite speed of light (186,000 miles, or seven times around the Earth, per second) over astronomical distances by observing the motions of these satellites.

Today, Jupiter is known to have at least twelve satellites—the other eight are much smaller bodies. The Jovian system thus resembles a miniature Solar System, except that some satellites of Jupiter orbit oppositely to others, whereas all the planets go around the Sun in one direction.

SOLAR ORBIT AND APPEARANCE OF JUPITER IN THE SKY (APPARITIONS)

It is instructive to look at Jupiter from the standpoint of the early astronomers. Earth bound, they watched the motions of the planets against the background of stars and deduced that the planets including the Earth move around the Sun in almost circular orbits. Because Jupiter orbits the Sun outside the orbit of the Earth, Jupiter is called a superior planet. As seen from Earth, superior planets appear to move close to the ecliptic (the apparent yearly path of the Sun relative to the stars, which is the plane of the Earth's orbit projected against the stars), and to move eastward all the way around the sky as they travel on their solar orbit. Jupiter takes 11.8 Earth years to travel completely around the Sun; thus, it also takes almost 12 years to move around the star sphere. Jupiter moves along the ecliptic year by year progressively entering each of the Zodiacal constellations. This year (1973) Jupiter is in the western part of Capricornus (The Goat). Next year it will have moved eastward into Pisces (The Fishes).

When a superior planet is directly opposite to the Sun in the sky, astronomers call this opposition of the planet. At this time the Earth is between the Sun and the planet and the planet shines its brightest in the southern sky at midnight. It is closest to Earth, too. Inferior planets, Mercury and Venus, cannot reach opposition.

Conjunction occurs when a planet is on the part of its orbit directly behind the Sun as seen from Earth and thus is not visible in the night sky. The planet is then most distant from Earth.

Quadrature is when the planet appears 90 degrees away from the Sun in the sky.

SIGHTINGS AND MOTIONS OF JUPITER, 1973

Because the orbit of a superior planet is outside the orbit of the Earth, and because the Earth moves fastest, there is a period each year around the date of opposition when a superior planet appears to move backward—towards the west—among the stars, in what is termed retrograde motion. During 1973 Jupiter started to retrograde in June and continued moving westward until October when it halted and then went back to its normal eastward motion. (See drawing, Figure 1.)

Jupiter is easy to identify in the early evening sky. The bright star Vega is close to the Northern Cross (Cygnus) as shown in the star map of Figure 2. South of Vega are three close stars, the bright central one being Altair. An imaginary line from Vega through Altair leads towards the southwest horizon and to a bright star-like object—the brightest in that part of the sky. Shining more steadily than the stars, this is the planet Jupiter. Look at it through field glasses or a telescope and you will see that it is more than a star-like point. Also the several faint stars lined up nearby are the large satellites.

In October, 1973, about one hour after sunset when the sky has just become dark, Jupiter is almost due south. The planet appears a little more to the west each month until it is southwest in January as shown in Figure 2. Venus is in the same region of the sky and is brighter than Jupiter, but each month it is lower in the sky and closer to the horizon where the sun sets.

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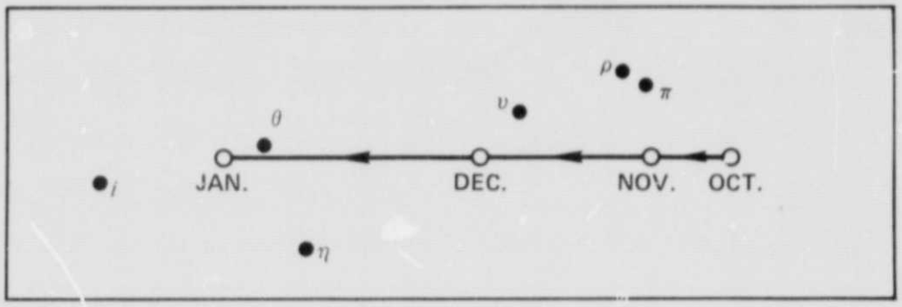

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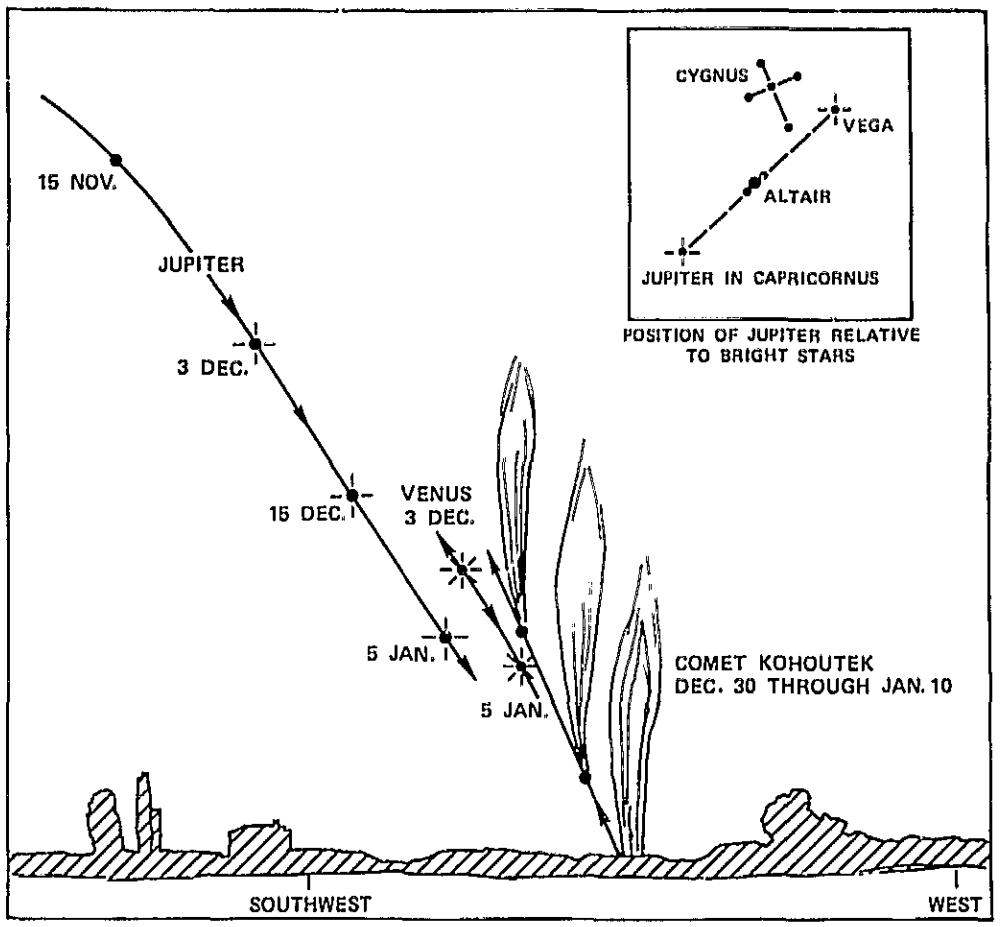

Figure 2. Positions of Jupiter, Venus, and Comet Kohoutek in Weeks Following Pioneer 10's Flyby of Jupiter (S.W. Sky About 1 Hour After Sunset)

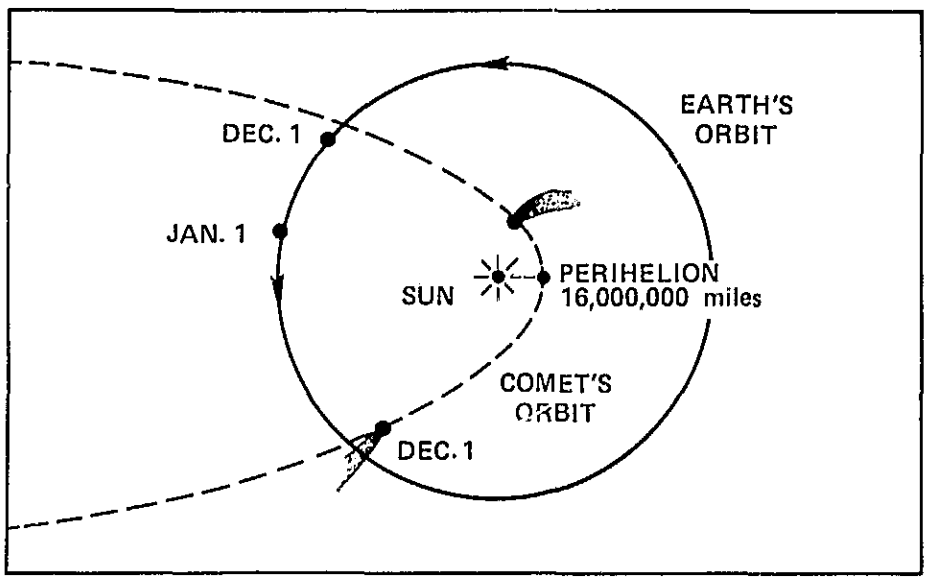

Figure 3. Relative Paths of Earth and Comet Kohoutek

Early in January, 1974, too, the tail of the bright comet Kohoutek is expected to appear above where the sun sets. And by mid-January the comet should move past Venus and Jupiter to form a spectacular trio in the early evening sky.

STUDY PROJECTS

ONE

Early in October look at the evening sky when it becomes dark about an hour after sunset. The Sun sets in the west. Look left from the sunset point and thus to the southwest and make a sketch of the sky similar to that shown in Figure 2. Indicate the stars and name them from a star map. Find the planets Venus and Jupiter and place them on the sketch in correct position relative to the stars. In November, December and January do likewise. Note how the two planets move relative to the stars while the stars themselves all appear to be slipping, month by month, toward the sunset glow. Look out for the comet coming into view early in January and plot its path, too.

TWO

Refer to an astronomical textbook and draw a plan map of the Solar System showing the orbits of Earth, Venus (inside Earth's orbit) and Jupiter (outside Earth's orbit). Try to draw them to scale. Then try to work out where Earth and the two planets must be on their orbits to appear in the western sky as they do a few hours after sunset. Remember, as seen from above (North) the Earth rotates on its axis and all the planets revolve around the Sun in a counterclockwise direction. Jupiter was in opposition in 1973 at the end of July. You will have two possible positions for Venus, but since Venus is at its greatest brilliance in the middle of December, you can decide which is the more likely position for Venus (it is brighter when closer to Earth).

The orbit of comet Kohoutek is an elongated ellipse (see Figure 3). Try to place this ellipse on your map of the Solar System. The Figure shows the positions of the comet and Earth on December 1 and January 1 to help you. At its closest, the comet will be only 13 million miles from the Sun compared with the distances of Earth, 93 million; Venus, 60 million; and Jupiter, 485 million miles.

READING LIST

Abell, Exploration of the Universe, pp. 23-26. 30 (Orbits).

Driscoll, Science News, July 14, 1973, pp. 24-25 (Comet Kohoutek).

NASA SP-268, The Pioneer Mission to Jupiter, pp. 1-3.