Reflections

Martian Discoveries

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Every two years plus two or three months, the planet Mars passes through opposition, the point at which it is opposite the Sun in the sky along the ecliptic. Near this time it also has a closest approach to our planet and Earthlings have a better-than-average view of the Red Planet. (One is tempted to say the same thing in reverse about Martians, but read on.) Several discoveries have been made during oppositions of Mars, and the carmine brilliance of the planet at the nearest approaches has inspired wonder and fear.

First some basic facts: it is a peculiarity of orbital motion that we least often encounter the planets closest to us, that is, Venus and Mars. The formula for the synodic period T_s of two planets is:

$$\frac{1}{T_s} = \frac{1}{T_1} - \frac{1}{T_2}$$

where T_1 is the shorter period and T_2 is the longer. Strictly speaking, this formula is only exact for two planets in uniform circular motion in the same plane, but it is a reasonably accurate estimate for planets in elliptical orbits with low inclination, in most cases. For the languid outer planets Jupiter, Saturn, Uranus, Neptune, and Pluto, the synodic periods relative to Earth are just over a year, the longest being a year plus 34 days in the case of Jupiter. For fleet-footed Mercury, who speeds around the Sun in 88 days, the mean time between inferior conjunctions is 116 days.

Venus is the major planet that comes closest to us, the mean approach distance being 0.277 Astronomical Units (AU). However, her sidereal period of nearly 8/13 year means that Venus only laps Earth every 584 days, almost exactly 1 3/5 years. However, Venus is shrouded in clouds, so there is very little to see at any time. Even if there were no clouds, Venus shuns Earth at inferior conjunctions by turning her back (or unlit side) to us each time.

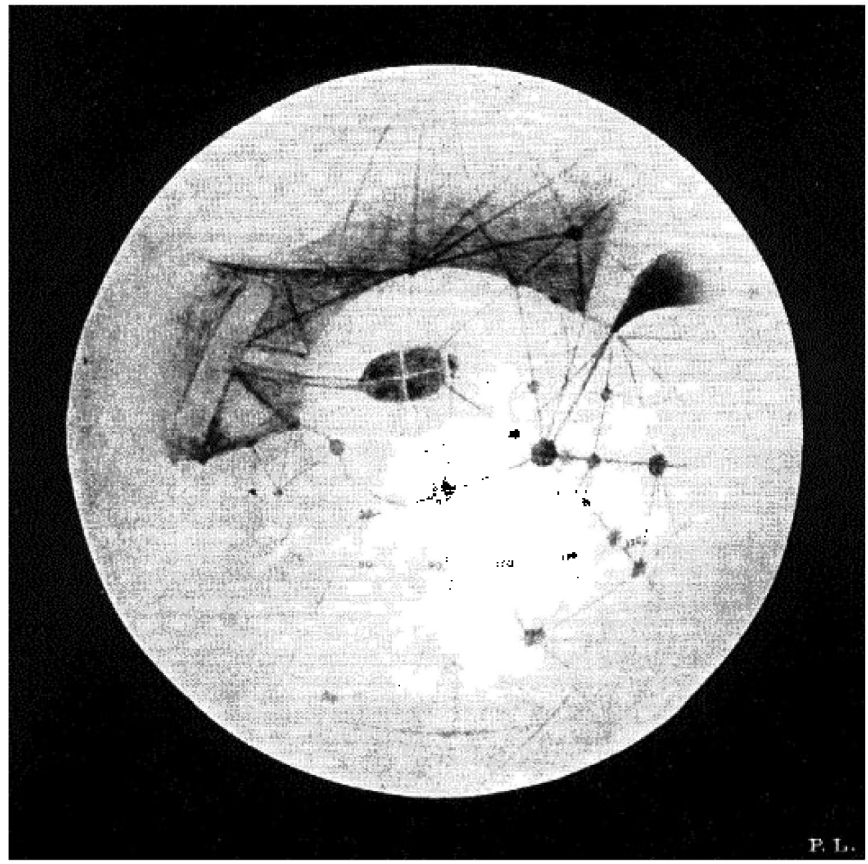

Figure 1. — One of Percival Lowell's fanciful sketches of Mars, showing "canals" with vast lakes at their intersections.

Things brings us to Mars, the next closest planet. In his case, he is in the outer lane with sidereal period 687 days, so Earth catches up with Mars only every 780 days, that is, 2 years and 50 days. The eccentric nature of the orbit of Mars has two consequences. Firstly, the time between oppositions is highly variable, being as much as one month off the mean period of 780 days. Secondly, as pointed out by Bruce McCurdy in his April 2003 *JRASC* "Orbital Oddities" column, the distance of closest approach is also variable, ranging from "far" closest approaches of about 0.68 AU to "near" closest approaches of about 0.37 AU. These nearest approaches have been dubbed "perihelic oppositions." The "distant" closest approaches occur in late winter (typically February) while the "near" closest approaches take place in late summer (typically August). This year's perihelic opposition on August

27, 2003 is the closest approach in recorded history.

The variability of Martian oppositions is remarkable: almost a factor of two in diameter and a factor of four in brightness, which translates into 1.5 stellar magnitudes. Late this summer, Mars is more than a magnitude brighter than Jupiter, yet a magnitude dimmer than Venus; unfortunately, both of these fellow travellers will not be seen in a dark sky. This summer, Mars will be the most prominent celestial object after the Sun and the Moon.

Almost all of the important observations of Mars have been made around the time of opposition, and some significant ones took place during perihelic oppositions. The Danish astronomer Tycho Brahe (1546–1601) recorded the positions of the stars and visible planets with great precision, but he was particularly interested in Mars because of its anomalous orbit, which defied his theoretical analysis. He observed and recorded positions of Mars at ten oppositions during 1576-1596, including two perihelic oppositions.

Brahe himself was never able to solve the puzzle, but Johannes Kepler (1571–1630) was able to put these observations to very good use. Using the positions of Mars at multiple oppositions, Kepler deduced that the orbit of Mars was an ellipse with the Sun at one focus, and that Mars moved along the ellipse nonuniformly. (Kepler expressed this by saying the line joining the Sun and Mars sweeps out equal areas in equal time. Today we recognize this as conservation of angular momentum.) These two laws of planetary motion (and a later third law) proved to be universal, although Kepler never understood the fundamentals of dynamics and gravitation that governed them.

Up to that time, the planets were simply wandering points of light to Earthbound observers, but the telescope changed that. During the months preceding and following the opposition of 1610, Galileo (1564–1642) observed gibbous phases of Mars, much like those of the Moon before and after Full Moon. At the opposition of 1659, Christiaan Huygens (1629–1695) observed a persistent mark on the surface of Mars (the V-shaped plateau Syrtis Major). By observing its comings and goings, he estimated the rotation period of Mars to be about the same as Earth: 24 hours. During the opposition of 1666, Giovanni Cassini (1625–1712), presumably using a better telescope, estimated the rotation period to be 24 h 30 m, and conclusively observed the polar caps.

During the perihelic opposition of 1719, a new chapter in the history of Mars began. Mars was so bright and red, people mistook it for a sinister red comet destined for Earth, and widespread fear and panic ensued. Since that time, the history of Mars has been a mixture of fact and fiction, observation tainted by wishful thinking, and scientific study mixed up with hysteria and quackery. The public — and some astronomers — did not know what to think! Some of these attitudes persist in modern times.

There has been much speculation about life on Mars, and in the early 19th century, Karl Gauss (1777–1855) and others proposed signaling to the inhabitants of Mars during opposition by lighting fires in uninhabited places such as the Sahara desert. (Remember, for the Martians, Earth would be at inferior conjunction, with our dark side facing Mars.) In 1877 Giovanni Schiaparelli (1835–1910) convinced himself he saw "canals" on Mars. Schiaparelli interpreted these markings as natural, not artificial. The possibility of intelligent life on Mars captured the imagination of the public and several astronomers. Percivall Lowell (1855–1916), a wealthy and educated young man from Boston, became so enthralled with this idea that he built a major observatory at Flagstaff, Arizona to observe Mars. He observed at several oppositions between 1896 and 1916, including the perihelic opposition of 1909. He wrote extensively about his ideas, and there is no doubt that he is the patron saint of the intelligent-life-on-Mars followers. These "observations" of canals were eventually proven to be illusions, but it took considerable time to dispel the myth, which was only laid to rest with the Mariner space probes of the 1960s. On a positive note, Lowell Observatory became a leading centre of planetary observation and research.

Meanwhile, serious astronomy was being done at perihelic oppositions. Wilhelm Beer (1797–1855), another independently wealthy astronomer, and his co-worker Johann Madler (1794–1874) produced the first good charts of Martian features in September 1830. (They reported no canals.) In September 1877 (when Schiaparelli was focusing on canals) Asaph Hall (1829–1907), observing with the new 26-inch refractor at the U.S. Naval Observatory, discovered Phobos and Deimos, the elusive satellites of Mars. In August 1892, William H. Pickering (1858–1938) observed features within the bright areas on Mars, putting an end to the "Martian seas" hypothesis. Also in 1892, Edward E. Barnard (1857–1923) observed craters on Mars, but did not have the confidence to publish his results. (The existence of craters was finally confirmed in 1965 by the Mars probe Mariner 4.)

Returning to the question of life on Mars, the idea was given a considerable boost when French astronomer M. Javelle announced he had seen bright flashes on Mars in 1894. This, combined with the claims of Schiaparelli and Lowell, may have inspired H.G. Wells to write *The War of the Worlds* in 1898. This account of the arrival of unfriendly Martians and their surprising demise became a classic of science fiction and set the tone for much of 20th century pop culture concerning Martians. (Well, Mars is the God of war!) U.S. actor Orson Welles turned the novel into a "reality radio" broadcast on October 30, 1938, with the setting moved from Britain to America. Welles' mock radio documentary actually convinced listeners that a Martian invasion was underway and thereby caused widespread panic. A Hollywood film was made in 1953; it received an Academy Award for Special Effects. I hear that a remake is nearly ready for release . . .

I hope I have convinced you that oppositions of Mars are worthy of note. The exceptional perihelic oppositions take place only every 15-17 years, so the typical Earthling only has 5-6 opportunities to get a really good look at Mars. Don't waste this one!

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