Red Nights

Astronomical Observing from the Red Planet

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> "Looking across space with instruments, and intelligences such as we have scarcely dreamed of, they see, at its nearest distance only 35,000,000 of miles sunward of them, a morning star of hope, our own warmer planet, green with vegetation and grey with water, with a cloudy atmosphere eloquent of fertility, with glimpses through its drifting cloud-wisps of broad stretches of populous country and narrow, navy-crowded seas."
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> --H.G. Wells, *War of the Worlds*

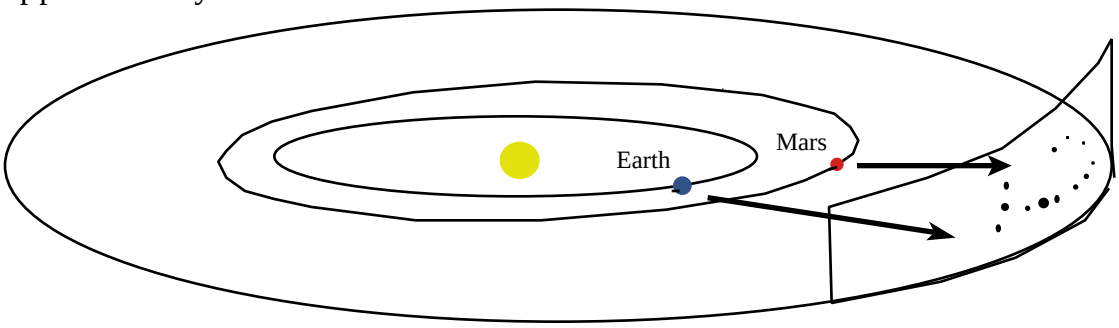
Introduction

The remotely controlled camera on Pathfinder recently became the first astronomical observatory operated from the surface of another planet. Small, fuzzy images of Mars' two moons, Phobos and Diemos, were returned during the initial weeks of the probe's operation. One might wonder: What would it be like to observe the night sky from the surface of Mars? In the future Martian colonists will have the opportunity to observe the night sky in the same way that people living on Earth do today. Will they see anything different than their cousins closer to the sun? Answering this question now may give you different perspective of the appearance of the night sky as seen from Earth.

The Martian sky

Mars is practically in the same location as Earth, at least in interstellar terms. This means that the constellations will appear in the same patterns they do on Earth. Only the most sensitive instruments will be able to detect the slightly larger shift in parallax due to Mars' larger orbit--and take advantage of it to refine distance measurements to the nearer stars.

Another feature of the sky familiar to earthbound amateur observers is the zodiac, which roughly delineates the paths of the sun and planets through the sky-- will so closely match that of the Earth casual observers of planet motions will hardly notice the difference. This is because the zodiac is determined by the motion of the sun and planets in the plane of the solar system. Because all of the planets in the solar system lie roughly in the same plane (with the arguable exception of Pluto), and we are in that plane whether we are on Mars or Earth, the constellations serving as background to the sun and other planets will remain approximately the same.



1. Earth and Mars are nearly coplanar, so they will view the same constellations along their ecliptics.

[The Earth and Mars are approximately on the same orbital plane, so the consellations along the zodiac will appear to be the same on both planets.]

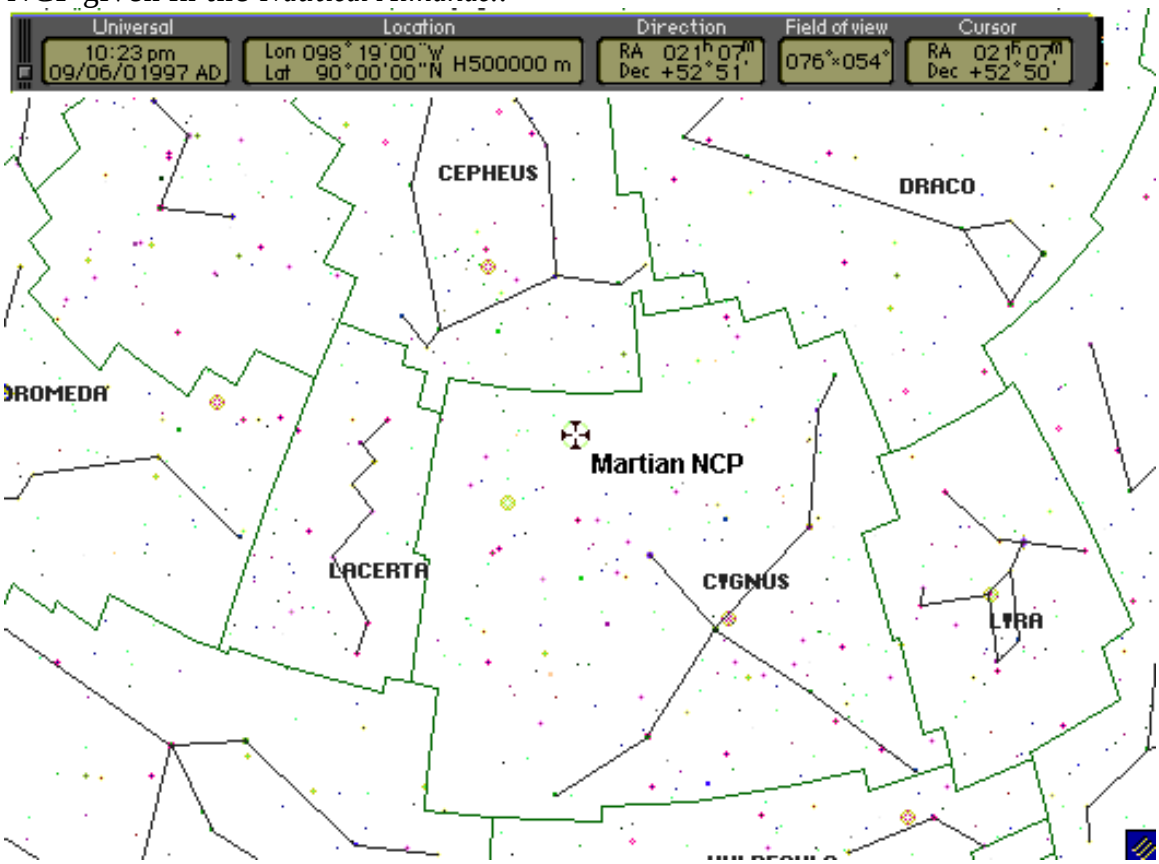
The Martian NCP

The first step for an observer with an equatorial telescope is to align the telescope with the planet's North Celestial Pole (NCP). On Earth, we are lucky in that by circumstance our planet's rotation axis points almost directly at a conveniently isolated, fairly bright star: Polaris. As the Earth's axis wobbles slowly due to precession, other stars could have served as pole stars for our ancestors. The star Thuban(alpha Dra) is an example of pole star from another age.

At other times in history there was no clearly visible pole star (as is presently the case in our own Southern Hemisphere). This is presently the case on Mars, and will probably still be true by the time colonists or explorers have the time and resources to devote to amateur astronomy. Polar alignment would then have to be done to some lower-magnitude star in the general vicinity of the Martian NCP, or computed using reference stars as some of the newer telescope tracking devices do today.

The Martian NCP is located near the constellation Cygnus, at RA 21h 7 m, dec 52 deg, 51 min in Earth-based coordinates. This is fairly close to the star Deneb (alpha Cyg). Modern computer programs are already capable of placing an observer anywhere in the solar system to observe the other planets in a virtual setting. For this article, the location of the NCP of Mars was verified by simulating observing from above the south pole of Mars, looking down on the planet and maneuvering the observing position until the south pole was

centered in the field of view. Turning off the planet display shows the location of the celestial pole. This result corresponded nicely to the location of the Martian NCP given in the *Nautical Almanac*..



[The circumpolar Martian sky. The cursor marks the location of the North Celestial Pole of Mars.]

One exciting consequence of this is that some parts of the Milky Way are circumpolar from everywhere on Mars. Near the Martian equator, the Milky Way will be seen to rise and set like as a great circle going from north to south, sweeping its way from east to west over the course of a night.

The Length of the Martian Day

The Martian day may nearly match the Earth's in length, but it is sufficiently different just enough to be irritating to visitors from Earth. The length of the Martian day is 24 hours, 36 minutes long. Clock drives on equatorial telescopes will have to be recalibrated to run at this slightly slower speed. On a daily basis, colonists or long-term visitors to Mars will probably invent a Martian clock and calendar--an interesting project. Remote operators for the Pathfinder mission have already had to deal with the gradually drifting start and end time of their shift due to the lack of perfect synchronization of the Martian and terran day. Over the course of a little less than three weeks, the Martian day has shifted *twelve hours* out of synch with clocks on Earth.

Effect of the Martian Day on Coordinate Systems

A casual observer on a future Mars expedition could use a classic resource such as *Sky Atlas 2000.0* to identify constellations by sight. However, many deep-sky objects can be more conveniently located using a system of coordinates based on the rotation period and orientation of the observer's planet. The coordinate systems in all earthly sky atlases are derived from the Earth's orientation and motion through space, and must be translated for use on any other planet. (Undoubtedly atlas publishers will correct this oversight in future editions!)

Future Martian atlas makers have the option of dividing the Martian day into 24 Mars hours, and causing confusion when translating earthly intervals of time. On the other hand, they could use time units as defined on earth, causing the Martian day to be divided into about 24 1/2 right ascension zones, making coordinate transformations more complex.

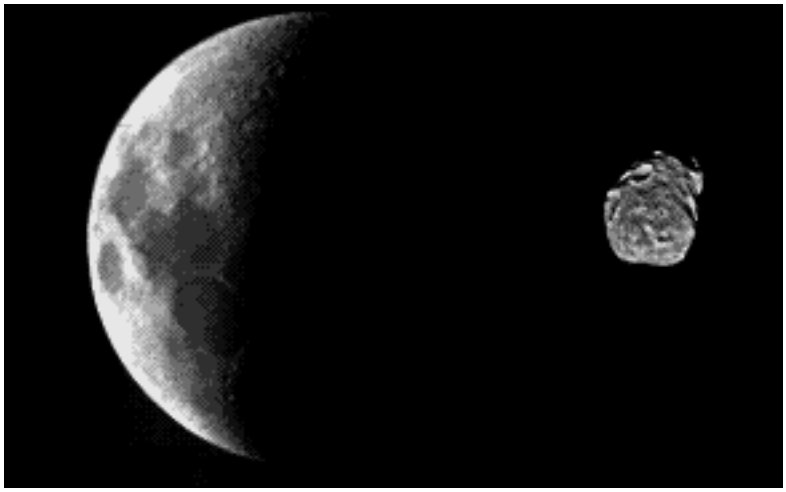
The Martian moons

Mars' two tiny moons Phobos and Diemos cause no solar eclipses as spectacular as the near-perfect match of sun and Luna as seen from Earth. Phobos, the inner moon, travels around the planet faster than the planet rotates, thus appearing to rise in the *west* and set in the *east*. (What the ancient astronomers of Earth--in *any* culture--would have made of a phenomenon like *that* is anyone's guess.) Telescopic views of these moons will require special tracking, due to their great

apparent velocities through the sky, caused by their proximity to Mars and their short orbital periods.

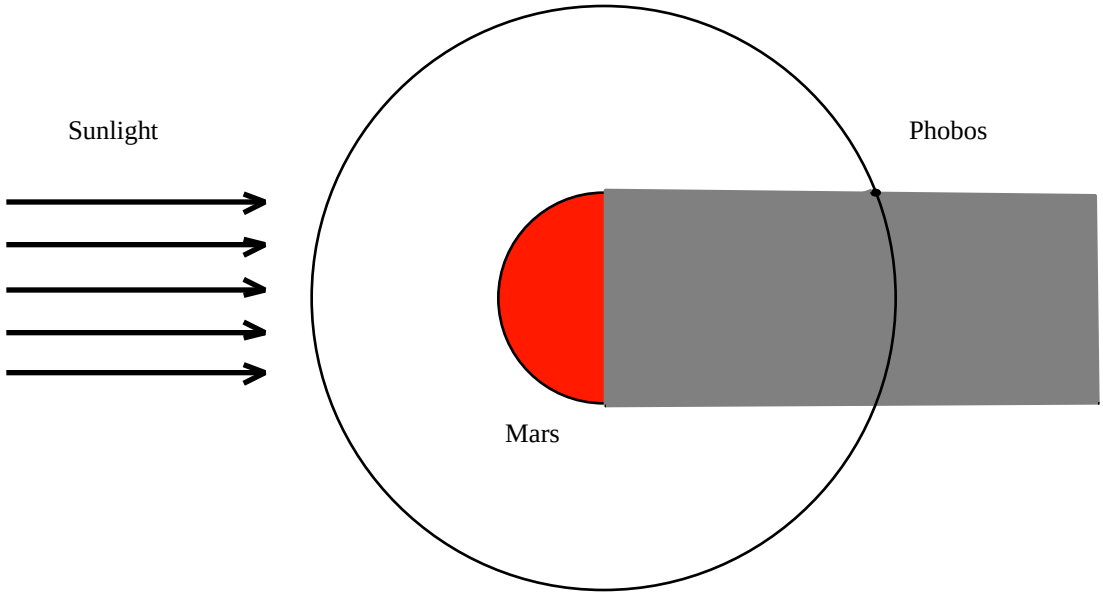
Any astronaut seeking these moons visually from Mars would face a restriction on the latitudes from which they could be seen at all. Like a low orbiting spacecraft, only those observers with a direct line-of-sight could see Phobos, clear views restricted to latitudes less than about 49 degrees north or south of the Martian equator. Observers from all but the most extreme latitudes could observe Diemos during every orbit due to its greater distance from Mars.

From Earth, the moon exhibits visible surface features, phases, and of course a variety of spectacular eclipse scenarios. Mars' moons present a less spectacular but more animated show (including phases). From equatorial Mars, Phobos appears to be no larger than 0.13 degrees along its longest axis. (Phobos is an oblong potato-shaped moon approximately 9.0 x 10.5 x 13.5 km in size). In comparison, from Earth, Luna appears about 4 times as wide as Phobos from the surface of the Mars, typically subtending about half a degree. Thus, visually, at closest approach straight overhead at the Martian equator, Phobos appears about as large as one of the lunar maria does from Earth. Even though Phobos is far smaller than the Earth's moon, it is also much closer to its parent planet. Diemos, being smaller in size and farther from Mars, appears even smaller--so small it is unlikely that it will reveal surface detail without optical aid.



[The visual size of Earth's moon as seen from the Earth, and the appearance of Phobos seen from the Martian equator are compared. Phobos appears about as large as one of the lunar maria. (The image of the moon was taken by the author. The image of Phobos was taken by a Soviet space probe and was copied from the Redshift 2.0 image gallery.)].

Both moons will regularly pass into the shadow of the red planet, causing sudden and dramatic changes in brightness not unlike those observed among Jupiter's moons. Late at night, the Martian moons might be hard to see at all save for the occultation of stars they pass over. During a pass through the center part of the shadow of Mars, Phobos could be completely in shadow--and thus virtually invisible-- for approximately 54 minutes.



3.5. An eclipse of Phobos by Mars lasts approximately 50 minutes.

[Configuration for an eclipse of Phobos by Mars.]

On the other hand, consider the view from Phobos gazing back at the red planet--Mars appears a whopping 42 degrees wide--covering a large portion of the sky! And, consider the same scenario in the Earth-moon system--astronauts exploring the surface of the moon saw an Earth in the sky *four times* as wide as the full moon appears from Earth, because the Earth has a diameter four times the size of Luna's. What a sight either view must be! This brings to mind some of Chesley Bonestell's beautiful paintings of the red planet from the 1950's, depicting the early exploration of Mars. Of course, Bonestell's Mars was based on a planet more earthlike than we now know Mars to be.

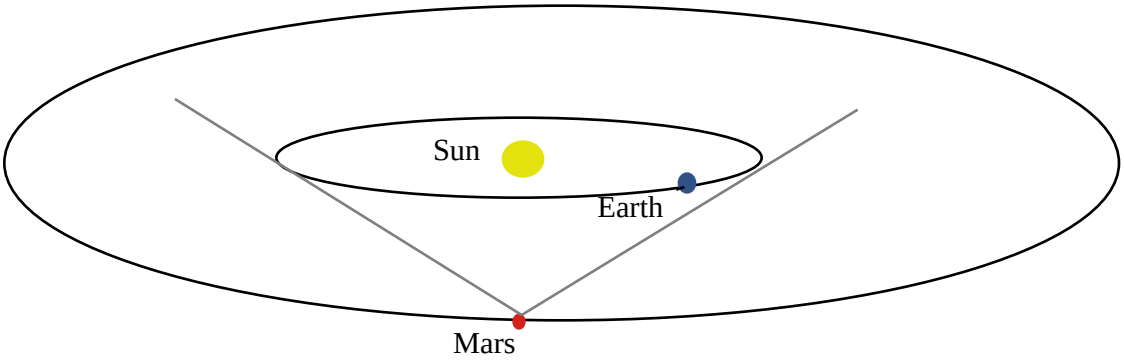
Views of other planets

Views of Jupiter from the Red Planet will be spectacular. The variation in brightness of Jupiter will vary over a wider range than seen from Earth. Jupiter lies closer to Mars than the Earth when they are in conjunction; and they are farther apart than the Earth and Jupiter when they are in opposition. From Mars at an aphelic conjunction with Jupiter (an opposition when Mars is at the farthest distance from the sun), Jupiter will subtend an angle of about 56 arcseconds (compare to 47 arcseconds for a favorable opposition with Earth) and would reveal a disk even in a pair of binoculars. The giant planet will reach a maximum brightness of about magnitude -3, somewhat brighter than its average opposition magnitude of -2.7 on Earth. (The magnitude scale decreases with increasing brightness. By comparison, the brightest star in the sky, Sirius (alpha CMa), has a magnitude of -1.5.)

Similarly, the variation in brightness in Venus will be over a smaller range, because it is more distant generally. Venus will be dimmer than our "morning star" or "evening star". Mercury, at less of an apparent angle from the sun, may be more difficult to observe in this respect, although Mars does not have trees, power lines, houses, dense clouds, and pollution to block low-altitude views.

View of Earth

Ultimately, Martian visitors will cast their eyes and instruments sunward, to see what the home they left behind looks like. What they will see will probably seem both familiar and strange. Earth will appear to be an inferior planet (closer to the sun), and will move through the sky in the same way that Mercury and Venus appear to from Earth, never straying far from the sun.



4. As seen from Mars, Earth is an inferior planet, never straying far from the sun.

[As seen from Mars, Earth is an inferior planet, never straying far from the sun.]

From Earth, careful observers using moderate telescopes can observe the changing size of the Martian polar caps, and large features such as Syrtis Major are easily discernible. From Mars using similar equipment, it is logical to assume that an equivalent amount of detail could be seen. Unfortunately, this configuration would only occur when the sun is in the same general direction, spoiling the view (as the sun does for Venus as viewed from Earth). Arthur C. Clarke's short story "Transit of Earth" describes this scenario for a transit of the sun by the Earth seen by a spacesuited explorer.

When Earth appears as a Martian "morning" star or "evening" star it would be possible to recognize the major continents and oceans of Earth. For example, at a resolution of 1 arc-second--about as good as it ever gets on Earth-- a Martian observer could discern high-contrast details on the earth as small as 950 km in size during maximum elongation, when the Earth will appear at its maximum angle from the sun (about 50 degrees, typically). Features of earth's moon such as maria would also be visible--and, notably, Mars has a much better view of the

"far side" of the moon than does the Earth, which can never see it directly. And, occasionally, the Earth and moon would be visible in the same field of view, giving our home system a truly local appearance.

Observers could challenge each other to recognize detail in the Great Lakes, observe the larger mountain ranges from the shadows they cast, and watch hurricanes work their way across the planets' surface. Unlike the "green with vegetation and grey with water" appearance described by H.G. Wells, observers from Earth are well aware that the earth is essentially blue and white as viewed from space. Regular observers will note the annual pattern of melting and growing ice caps just as earthbound observers see on Mars.

Unlike our conventional view of Earth from low orbit or from the moon, perspective will render the image curiously flat rather than the deep three-dimensional images we are used to. This is a significant point for earthbound observers of other planets to remember when struggling to reconcile what is seen through an eyepiece with what is seen from a space probe. CCD users might be curious enough today to try to adapt their images to a three-dimensional, spherical model, and view the model from much closer to the planet through mathematical manipulation.

Bringing it home

Considering how the Earth would appear to a Martian observer, and what a hypothetical amateur astronomer on Mars would see in the sky, can help the earthbound observer more deeply appreciate the images of other planets

glimpsed through our telescopes. Regular observers who get mired in the technical problems of ever-improving observing techniques should be reminded that when they observe the planets they are gazing at *entire worlds* in their telescopes, and even a tantalizing hint of detail on the surface of another world could correspond to a feature thousands of miles across. A small thought experiment as we have done here should help you appreciate what you are seeing when you look at the Red Planet.

The first full-fledged astronomer on Mars may the be first person who looks up instead of down when stepping onto the red soil and rocks of the frigid Martian desert. At last, the age-old quest of astronomy--to find ourselves among the stars and planets of the sky--will be fulfilled, literally. By far the most popular and interesting object in the Martian sky will certainly be the home planet, Earth.

Acknowledgements:

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