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MANNED MARS MISSION ASTRONOMY OPTIONS

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ABSTRACT

Astronomical observations during the transit phase, in orbit about Mars, and from the surface present important scientific objectives. Primary astronomical objectives are being summarized by J. Burns (Univ. of New Mexico). Additional or alternative options will be introduced here, together with their strengths, weaknesses, viability, and value. It is important to note at the outset that not all possible options are necessarily important or viable[1].

Options

Potential experiments are limited only by imagination. Several options are listed in Table 1 and discussed individually below. Ultimately, in addition to weight, power, and volume limitations, the selection of experiments will be based on research interest and the value of anticipated scientific return.

Radio Astronomy

Prime radio astronomy experiments and observations that can be made from the manned Mars mission are those that require the radio quiet conditions found far from the neighborhood of the Earth. Some frequencies of interest here are quite low so that dipole arrays, in addition to parabolic dish antennas, would be used.

In addition, there are several active and passive radio measurements that can be made of the Martian in situ plasma wave detector. Many of these would make use of the same equipment used for the radio astronomy experiments. The plasma wave detector would be on the free-flying spacecraft in low Martian orbit.

Finally, the radio telescopes may be used for further monitoring of solar activity from the surface of Mars.

Solar Astronomy

Solar optical observations show the photospheric structure of the Sun and, with simple filters, map the large scale magnetic field structure, sunspots, filaments, and flares. During a large part of the transit

TABLE 1

OPTIONS

Experiment	Transit/In Orbit/Surface (X:yes, -:no)
Radio telescope	-/-/X
Met wave dipole array radio telescope	-/-/X
Solar astronomy	X/X/-
Optical observations of cataclysmic variables	X/-/-
UV all-sky mapping	X/-/-
Lyman-alpha all-sky mapping	X/-/-
Cosmic ray detectors/telescope	X/X/X
Gamma ray telescope	X/X/X

TABLE 2

SOLAR INSTRUMENTATION

Hydrogen-alpha telescope

25- 40-cm optics
Birefringent filter
1000 x 1000 CCD detector
Digitally stored images
Digital display

Weight	50 kg including multi-use display terminal
Power	< 1 kw

Whole-disk x-ray monitor

0.5- 8 Angstrom sensitivity
1 second time resolution

Weight	< 10 kg
Power	< 0.1 kw

and while at Mars, the side of the Sun exposed to the spacecraft will be invisible from the Earth. Observations of the Sun in the Hydrogen-alpha spectral line will therefore be necessary for solar flare/erupting filament prediction and warning. These observations would have to be made during all three phases of the mission, but would be done from orbit during the surface excursions. More information on this is given in the white paper on Solar Physics: Solar Activity Monitoring and Prediction. A minimum instrument package is outlined in Table 2.

Additional solar observations are possible with more complex instruments - including magnetic field and velocity measurements. However, it is probable that these observations would be more efficiently and accurately made from Earth orbiting spacecraft.

The solar telescope will be used for other observations[2] with supporting equipment such as special filters. Planets will be observed to determine their albedo in the UV and visible ranges, and the same UV filters will be used for an all-sky UV survey. Opportunities will occur for the observation of stellar occultation by the outer planets, and the ephemerides should be developed for these observations. Other opportunities may occur for the observation of cataclysmic variables[2].

Planetary Astronomy

Optical observations of the planets and asteroids are possible during all three phases of the mission. The main advantage of doing these from the manned Mars mission is that during the transit phase the spacecraft will approach significantly closer to the main asteroid belt than is ever done by the Earth and will have uninterrupted viewing during the transit phases. However, it is likely that Space Telescope observations would supersede any information that would be gained from the size and quality of a telescope that could be carried to Mars, except for those types of observations noted above in the solar astronomy section. Therefore, it is suggested that the solar telescope will be sufficient for planetary astronomy in visible, ultraviolet, and infrared wavelengths.

These low spatial and spectral resolution, uninterrupted measurements will supplement the extremely high spatial and spectral resolution observations that will be made in the near future from Earth orbit.

One opportunity is that stereo observations of the planets or asteroids would be possible using Earth and mission based telescopes. However, there has been no stated need for such experiments.

Backscattered Solar Lyman-alpha

An opportunity exists to make high spatial resolution observations of Lyman-alpha solar emission that is backscattered from interstellar neutral gas that is entering the solar system. Low resolution observations have been made from unmanned spacecraft and have provided important information of solar spectral emission variability and the properties of the local interstellar medium. These observations are best made far from the Earth because of contamination by the Earth's hydrogen geocorona.

Optical, Infrared, Ultraviolet, and X-ray

Extra-Solar System Astronomy

Observations of stars, the Milky Way, nebulae, pulsars, extra-galactic objects, etc. will be receiving particular emphasis with Earth-orbiting spacecraft. The Space Telescope and AXAF are only the first of a variety of missions planned by NASA and ESA. It is extremely unlikely that a large variety of useful information would be gained from manned Mars mission observations. However, there are a few narrowly selected specific observations that suggest potential benefits from being made on the manned Mars mission.

Galactic and Solar Cosmic Rays

Cosmic ray detectors and telescopes will be used for monitoring solar energetic particles. In addition, the data from these instruments will show galactic cosmic ray intensities and their variation with solar activity and the solar cycle. The modulation mechanism of cosmic rays in the solar system is not understood and data on variations at Mars, with correlative data from solar observations, will help solve this problem. The observations can be made from the surface of Mars, as well as from orbit and during transit phases.

Gamma Rays

Gamma rays are emitted impulsively during very short astronomical events. The location of these events is determined through timing of the detection of the gamma ray pulse at widely spaced spacecraft. Placing a gamma ray event detector on Mars would help with these calculations by making it easier to do the timing calculations.

Summary

All types of astronomical observations are technically possible from the manned Mars mission, and it is desirable to go into space for many of these observations. However, the advantages of going into space are equalled or even exceeded by placing many of the instruments in low Earth orbit (LEO), rather than sending them to Mars. The reason for this is that the main purpose for going to space is usually to avoid atmospheric interference and the day/night cycle. These goals are best achieved from LEO or, to avoid the day/night cycle, from a polar orbit or near-Earth stable position.

A more distant observing position is required by four types of observations. The first is any measurement which might be obstructed by the Earth's hydrogen geocorona - which extends out to many Earth radii. The second is any radio observation of low magnitude objects which might be obstructed by artificial radio sources on and near the Earth. This second source of pollution also extends to several Earth radii at some wavelengths and has led to suggestions for observatories on the opposite side of the Moon[1]. The third is a cosmic ray observatory/detector on the Mars orbiter and on the surface, to monitor solar cosmic rays and provide a more global view of how solar disturbances and evolution modulate galactic cosmic rays. The fourth is a gamma ray detector to give a long baseline for gamma ray event timing and triangulation. A minimal instrument package to meet these goals is outlined in Table 3.

Also, it will be essential to conduct solar observations from the manned Mars mission for the purpose of activity monitoring and prediction, complimented by solar whole-disk x-ray detectors and energetic particle monitors.

TABLE 3

OTHER INSTRUMENTATION

Backscatter Solar Lyman Alpha

Utilizes solar telescope

Special filter

Weight	< 5 kg
Power	No additional

UV All Sky Map

Utilizes solar telescope

Special filter

Weight	< 5 kg
Power	No additional

Radio Astronomy

Dish antenna			
	Weight	< 100 kg	
	Power	< 1 kw	receiving
		< 10 kw	transmitting
Dipole array			
	Weight	< 100 kg	
	Power	< 1 kw	receiving
Ionosonde			
	Weight	<100 kg	
	Power	< 1 kw	receiving
		< 10 kw	transmitting

Cosmic Ray Detectors/Telescope

Weight	< 10 kg
Power	< 1 kw

Gamma Ray Detector

Weight	< 20 kg
Power	< 1 kw

REFERENCES

1. Astronomy and Astrophysics for the 1980's, Volume 1: Report of the Astronomy Survey Committee, Astronomy Survey Committee, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20418, 1982.
2. Scientific Experiments for a Manned Mars Mission, NASA TM X-2127, March 1971, by H. Dudley, J. Harrison, J. Ballance, M. Page, J. Dabbs, J. Power, K Hudson, and M. Powell, Marshall Space Flight Center.