4.3. Martian UV Clouds Observed by Hubble Space Telescope in Polarized Light in 2003

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The Hubble Space Telescope (HST) carried out extensive observations of Mars that, for the first time, included polarimetric observations during the close approach to the Earth in August and September 2003. Our Institute was responsible for data processing and analyzing of polarimetric images.

The observations took advantage of the closest Earth-Mars encounter in nearly 60,000 years as Mars passed within 0.372 AU of Earth. The angular diameter of the apparent Martian disk was 25.1 arc seconds. Five series of images of Mars at phase angles about 6, 8, 10, 13, and 16° were taken with polarization filters. Each series consisting of 4 sets of images taken with different wide spectral bands centered at 250, 330, 435, and 814 nm. Each set contains 3 images taken with 3 linear polarization filters, each offset by 60°, allowing complete information of the linear polarization. The observation moments were chosen so that the same hemisphere of Mars, containing Valles Marineris and contrasting albedo details of Terra Meridiani and surroundings, faced Earth (the disk center is approximately 19°S, 30°E). The High-Resolution Channel of the Advanced Camera for Surveys took the images, having a resolution of 7 km/pixel near the sub-Earth point. This is the highest spatial resolution observations of Mars ever made from the Earth. The Martian atmosphere was relatively free of both dust and water ice clouds during this perihelion observation period. Southern Mars summer occurred at this time.

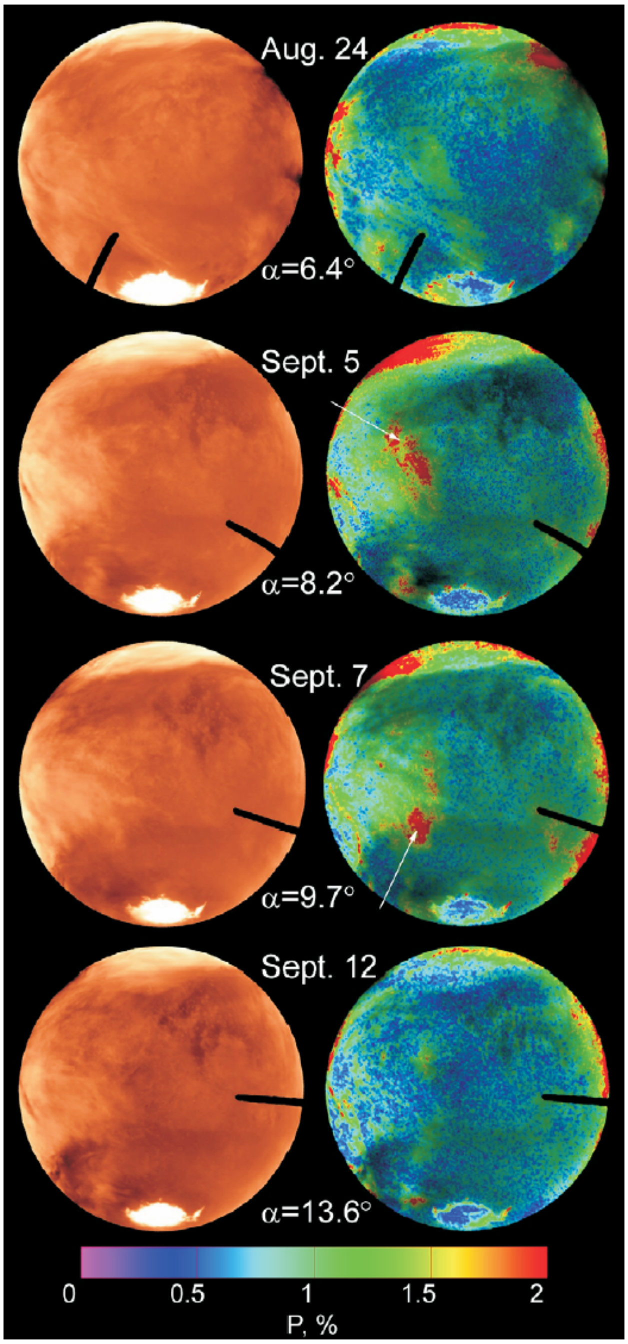

Figure 20. Intensity (left) and polarization degree (right) for Mars on four observation dates of HST (filter F330W). The black coronographic finger and spot are shadowed areas of the detector. The arrows show the polarimetric transient effect.

Linear polarization of scattered light can be described by two parameters, for example, the polarization degree P and the polarization plane position angle ϕ, or normalized Stokes parameters $Q/I = P \cos 2\phi$ and $U/I = P \sin 2\phi$. Figure 20 presents initial images (left side) and corresponding distributions of polarization degree P (right side) acquired at wavelength 330 nm and the phase angles near 6, 8, 10, and 13°. Coronographic (dark) spots in the field of view obscured a small portion of the disk. All brightness images reveal small surface contrasts and the high-contrast polar areas.

The Martian surface and atmosphere both contribute to the polarization of scattered solar radiation. The surface scatterers are soil particles of different sizes and shapes. The atmospheric scatterers include molecules and sub-micron dust haze particles of the clean atmosphere, faint high altitude mists made of very small aerosols, clouds consisting of dry-ice crystals, and clouds composed of comparatively large dust particles associated with local dust storms.

The South-polar region (bottom) is clearly visible showing gradual decreasing in size with the phase-angle increase during almost a month. The North-polar region is hidden with clouds. Globally, polarization degree of Mars in our observations is ~1% (on average the polarization is negative). Minimal values of P are observed for the south-polar cap and some clouds (< 0.1%). In particularly, the clouds over the North-polar regions have relatively low polarization. The dust storm feature that is observed in the left portion of the disk has polarization lower than that of the surface. This is seen especially at phase angles 13°.

We revealed a new phenomenon, clouds that are only visible in the UV with polarized light. This new type of clouds with P as high as 2% are located in the left part of the disk in the images acquired at 8 and 10° (see arrows). The clouds are located at the edge of a dust storm. They also are seen in other UV filters, but the contrast of the clouds is highest at λ = 330 nm. We suggest that this could be a zone of ice condensation on small dust grains. Being almost invisible at the moment corresponding to α = 6°, the cloud appeared in a few days and shifted to the south limb during a week and then disappeared. The most interesting feature of such clouds is that they are almost transparent. The surface albedo pattern remains visible through them with almost no attenuation even in the UV spectral band. Thus, they are recorded by their polarization only.

Thus, the HST observations that were designed to obtain maps of surface scattering properties have led to the discovery of a new type of clouds, the UV polarimetric clouds that are transparent and can be revealed only with polarimetric measurements.

Further analyses of these results promise a new insight into microphysics of aerosols with possible wide implications to global climate models of Mars.