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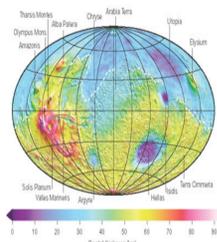


1) Background: Mars' magnetic field

Unlike the Earth, Mars has no inner dynamo to create a major global magnetic field. This, however, does not mean that Mars does not have a magnetosphere; simply that it is less extensive than that of the Earth and probably that because Mars is small than Earth so lost its internal heat energy to sustain convection to drive the dynamo.

A strong magnetic fields coming from rocks in the crust

- First detected in 1997 (MGS)
- 10-20 times more magnetic than Earth rocks



Mars had a dynamo long ago

- The crustal magnetic fields are so strong that's the only explanation for how they got that way
- Dynamo shut off, leaving magnetized crust. Heating events (impact, volcanism) erased magnetization in many regions

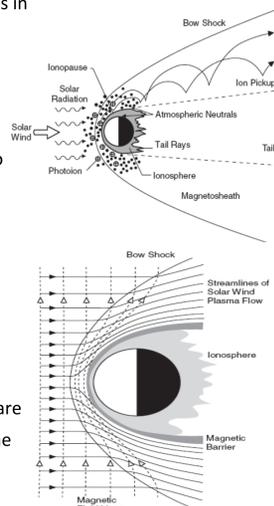
Induced Magnetosphere Formation

1. Sunlight ionizes neutral particles in the upper atmosphere

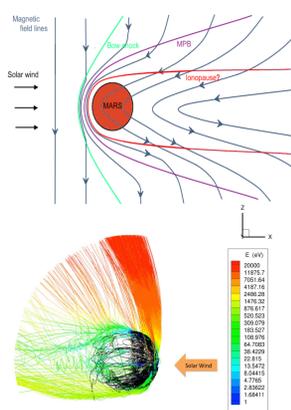
2. The solar wind magnetic field moving toward the ionosphere causes the ionospheric particles to move (Faraday's Law: changing magnetic field creates a current)

3. Ionospheric currents create a magnetic field (Ampere's Law: currents create magnetic fields)

4. Solar wind particle trajectories are bent by the magnetic field from the ionosphere (Lorentz Force)



The magnetic field lines carried by the solar wind drapes around the planet



- As magnetic field lines cannot pass through electrically conductive objects (such as Mars), they drape themselves around the planet.
- The draping direction of the magnetic field can tell us about the direction in which planetary charged particles move or escape.

2) The project ?

Compute the draping direction of the magnetic field at Mars, and use it as an indication to tell us about the direction of the interplanetary magnetic field (IMF).

3) Approach

Once per orbit, look at the horizontal field and find out which way it points (Azimuth Angle).

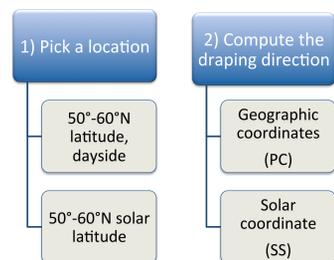
- Data from the magnetometer and electron reflectometer instruments (MAG/ER) on the Mars Global Surveyor spacecraft (MGS)

- For the horizontal field component, spherical coordinates computed B_N, B_E, B_R

$$B_H = \sqrt{B_E^2 + B_N^2}$$

- Azimuth angle $\theta = \tan^{-1}\left(\frac{B_N}{B_E}\right)$

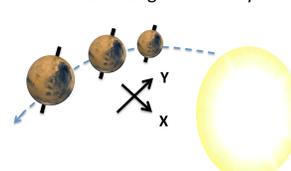
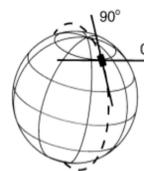
4) Flow of Analysis



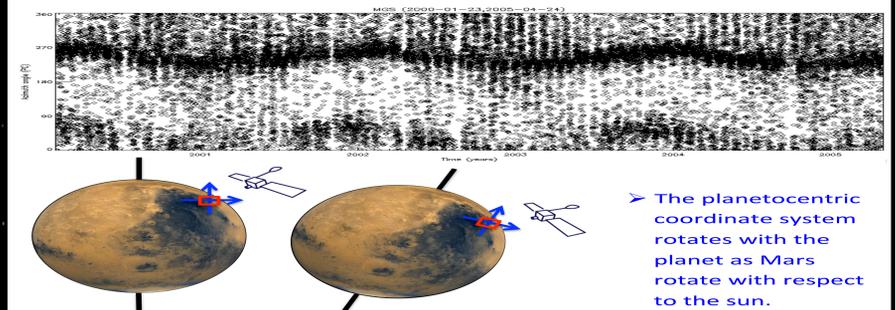
- (1) Geographic latitude, PC coordinate system.
- (2) Geographic latitude, SS coordinate system.
- (3) Solar latitude, PC coordinate system.
- (4) Solar latitude, SS coordinate system.

PC coordinate system Vs. SS coordinate system

- Planetocentric (PC)
- Tied to the planet
- X axis is 0° & points to East
- Y axis is 90° & points to north
- Sun-State (SS) (same as MSO Mars-Sun-Orbit)
- Tied to the Sun
- X-axis positive toward the sun
- Y-axis points opposite to Mars' orbital angular velocity

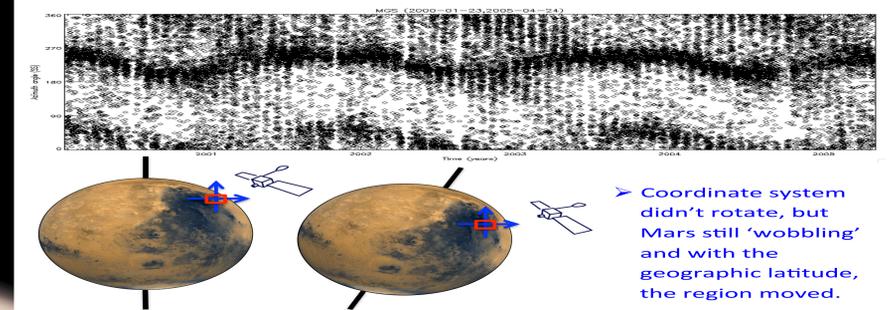


Geographic latitude, PC coordinate system



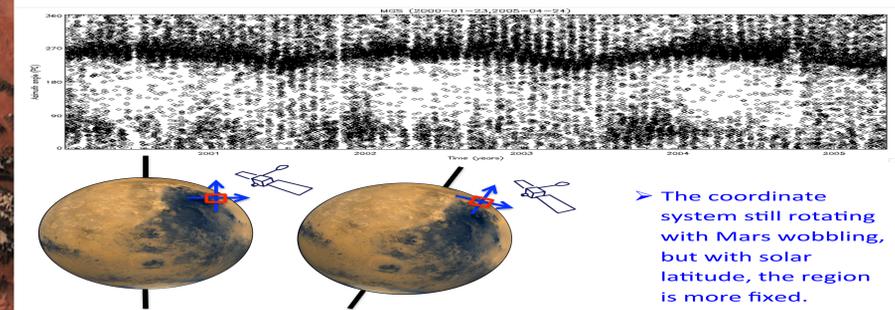
➤ The planetocentric coordinate system rotates with the planet as Mars rotate with respect to the sun.

Geographic latitude, SS coordinate system



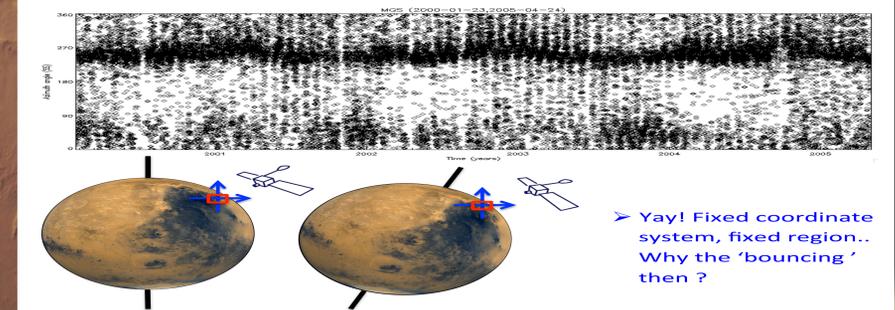
➤ Coordinate system didn't rotate, but Mars still 'wobbling' and with the geographic latitude, the region moved.

Solar latitude, PC coordinate system



➤ The coordinate system still rotating with Mars wobbling, but with solar latitude, the region is more fixed.

Solar latitude, SS coordinate system



➤ Yay! Fixed coordinate system, fixed region.. Why the 'bouncing' then ?

5) Conclusion

- Using a coordinate system tied to the Sun gives the best indication about the IMF direction.
- The error bars in draping direction for each orbit show which orbits provide reliable estimates.
- The draping direction changes with different altitude and different local time.