Understanding the martian upper atmosphere with the MGS Accelerometer

The structure and dynamics of the martian upper atmosphere are not well understood. Analyis of recent MGS data will improve our understanding of them. This improved understanding can then be applied to other atmospheres. It is also critical for the success of future missions using aerobraking.

MGS aerobraking data, collected primarily for operational reasons, will soon be available for general scientific use via the PDS. Data was collected near the periapsis of each aerobraking pass. Periapses occurred at a range of altitudes, latitudes, longitudes, seasons, and local solar times. Each aerobraking pass returned a few hundred seconds of data, revealing upper atmospheric densities along a track which extended 10s of degrees south and north of periapsis and from approximately 160 km down to 110 km at periapsis, then back up to 160 km. Changes in longitude, season, and local solar time were negligible during any individual aerobraking pass as the spacecraft was in a near-sunsynchronous orbit.
Data coverage, quality, and processing will be discussed.

Preliminary data analysis reveals that zonal mean densities are not well predicted by current models and that densities measured at essentially fixed latitude, local solar time, and season vary by factors of a few with longitude. This zonal variation is stable from orbit to orbit (timescales of a few hours) and on timescales of a few weeks. Changes with altitude, latitude, season, and local solar time could be studied in a perfect data set. This zonal variation is believed to be caused by atmospheric tides. Tidal modes exist in the martian atmosphere with a variety of temporal and spatial frequencies. Many alias to a longitudinally-fixed structure when viewed by a sun-synchronous observer like MGS.
Tidal theory will be discussed.

This presentation outlines ways to reduce the infinite number of possible aliasing modes to a finite number. Knowing the dominant tidal modes in the martian upper atmosphere gives a better understanding of martian atmospheric dynamics throughout the whole atmosphere and is of immediate interest to mission planners.

1) Examine latitudinal and vertical structure of possible aliasing modes as predicted by tidal theory. Discard those whose latitudinal structure is not broad, as observed, and those whose vertical structure does not permit propagation to the thermosphere.

2) For the restricted part of the mission for which data exists at more than one local time, discard those modes whose temporal structure is inconsistent with the observations.

3) Individual aerobraking passes show oscillatory structure superimposed on a background profile. Discard those modes whose vertical structure is inconsistent with the observed oscillatory structure.

Finally, when the spacecraft's orbital period is a simple fraction of the planetary rotation period, periapsis returns to same latitude, local solar time, and longitude every martian day. This resonance typically lasts for a few days as the orbit evolves. This allows study of the intrinsic variability of the martian upper atmosphere without contamination by the substantial zonal structure. This variability is not predicted by any atmospheric model and is of immediate interest to mission planners.