Science Drivers for a Multiple Entry Probe Mission to Jupiter

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Jovian in situ atmospheric entry probes that penetrate beyond depths corresponding to a few bars pressure can provide more accurate knowledge of interior composition and structure than is available from current remote sensing instruments. Remote sensing and bistatic radar experiments (e.g., radio science atmospheric occultations) have provided high-quality data on Jupiter's atmosphere to near the five-bar level. But the character of jovian atmospheric opacity prevents obtaining IR or visible signals from deeper levels, and prevents grazing-incidence radio experiments below the 1- to 2-bar levels. Jupiter's atmospheric radio opacity is indeed less than at optical wavelengths, and some thermal radio signals (at microwave wavelengths) can propagate to space from levels in the hundreds of bars. At pressures of tens of bars and above, the microwave opacity spectra of gases are pressure-broadened into essentially Debye spectra, so absorption coefficients are proportional to the square of frequency, regardless of species. Thus longer wavelengths can escape from deeper levels. But if all absorbing (and radiating) species exhibit very nearly Debye spectra, reliable interpretation of jovian radiometer data at those wavelengths requires data of extraordinary accuracy. Unfortunately, synchrotron radiation from Jupiter's trapped-particle radiation belts is quite intense in the microwave wavelengths of greatest interest, contributing much noise to the data, and at some wavelengths overwhelming the data.

In situ probes can make accurate measurements of quantities critical to understanding Jupiter's origin, and likewise thus the solar system's origin. Using radio relay links whose frequencies are chosen to avoid both excessive synchrotron radiation noise and high atmospheric attenuation, those data can be relayed to an overflying spacecraft and then to Earth, as demonstrated by the Galileo entry probe. Current technology allows designing probes that send data from the 100-bar level, sampling materials and conditions that represent Jupiter's deep interior, not the upper, weather-affected troposphere. The paper details the most important science measurements to be made at those levels, suggesting candidate instruments to make those measurements, and discusses possible opportunities for Jupiter deep entry probe missions within the next decade.

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the United States' National Aeronautics and Space Administration.