



Laser Ablation Electrodynamic Ion Funnel for *In Situ* Mass Spectrometry on Mars

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A front-end instrument, the laser ablation ion funnel, was developed, which would ionize rock and soil samples in the ambient Martian atmosphere, and efficiently transport the product ions into a mass spectrometer for *in situ* analysis.

Laser ablation creates elemental ions from a solid with a high-power pulse within ambient Mars atmospheric conditions. Ions are captured and focused with an ion funnel into a mass spectrometer for analysis. The electrodynamic ion fun-

nel consists of a series of axially concentric ring-shaped electrodes whose inside diameters (IDs) decrease over the length of the funnel. DC potentials are applied to each electrode, producing a smooth potential slope along the axial direction. Two radio-frequency (RF) AC potentials, equal in amplitude and 180° out of phase, are applied alternately to the ring electrodes. This creates an effective potential barrier along the inner surface of the electrode stack. Ions entering the

funnel drift axially under the influence of the DC potential while being restricted radially by the effective potential barrier created by the applied RF. The net result is to effectively focus the ions as they traverse the length of the funnel.

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High-Altitude MMIC Sounding Radiometer for the Global Hawk Unmanned Aerial Vehicle

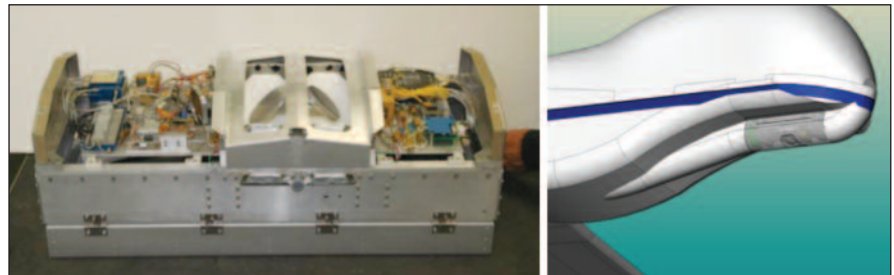
This instrument can be used for improved weather forecasting and environmental monitoring.

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Microwave imaging radiometers operating in the 50–183 GHz range for retrieving atmospheric temperature and water vapor profiles from airborne platforms have been limited in the spatial scales of atmospheric structures that are resolved not because of antenna aperture size, but because of high receiver noise masking the small variations that occur on small spatial scales. Atmospheric variability on short spatial and temporal scales (second/km scale) is completely unresolved by existing microwave profilers.

The solution was to integrate JPL-designed, high-frequency, low-noise-amplifier (LNA) technology into the High-Altitude MMIC Sounding Radiometer (HAMSR), which is an airborne microwave sounding radiometer, to lower the system noise by an order of magnitude to enable the instrument to resolve atmospheric variability on small spatial and temporal scales.

HAMSR has eight sounding channels near the 60-GHz oxygen line complex, ten channels near the 118.75-GHz oxygen line, and seven channels near the 183.31-GHz water vapor line. The HAMSR receiver system consists of three heterodyne spectrometers cover-



The HAMSR Instrument (left) is deployed in a forward bay under the nose of the Global Hawk aircraft (right).

ing the three bands. The antenna system consists of two back-to-back reflectors that rotate together at a programmable scan rate via a stepper motor. A single full rotation includes the swath below the aircraft followed by observations of ambient (roughly 0 °C in flight) and heated (70 °C) blackbody calibration targets located at the top of the rotation.

A field-programmable gate array (FPGA) is used to read the digitized radiometer counts and receive the reflector position from the scan motor encoder, which are then sent to a microprocessor and packed into data files. The microprocessor additionally

reads telemetry data from 40 onboard housekeeping channels (containing instrument temperatures), and receives packets from an onboard navigation unit, which provides GPS time and position as well as independent attitude information (e.g., heading, roll, pitch, and yaw). The raw data files are accessed through an Ethernet port. The HAMSR data rate is relatively low at 75 kbps, allowing for real-time access over the Global Hawk high-data-rate downlink. Once on the ground, the raw data are unpacked and processed through two levels of processing. The Level 1 product contains geo-located, time-stamped, calibrated brightness tempera-