



## A Deep Space Network Portable Radio Science Receiver

**Receiver filters and records IF analog signals.**

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The Radio Science Receiver (RSR) is an open-loop receiver installed in NASA's Deep Space Network (DSN), which digitally filters and records intermediate-frequency (IF) analog signals. The RSR is an important tool for the Cassini Project, which uses it to measure perturbations of the radio-frequency wave as it travels between the spacecraft and the ground stations, allowing highly detailed study of the composition of the rings, atmosphere, and surface of Saturn and its satellites. The RSR is also used to track and detect the signals for important events in other missions such as the Mars Exploration Rover (MER) entry descent and landing (EDL). Some of these events require extra RSRs or require them to be shipped to non-DSN stations such as the 100-meter Greenbank Telescope (GBT) in West Virginia. Sending and installing an RSR consisting of a large DSN rack to one of these sites is a daunting and expensive task. A smaller, more portable equivalent to the RSR was needed both for these special events and to enhance the existing capability of the DSN.

A prototype Portable Radio Science Receiver (PRSR) has been developed that can fit in a standard-size suitcase and uses a laptop PC as its controlling computer. The PRSR chassis is a 2-U steel box with 19-in. (48-cm) rack-mount capability and external connections for power, Ethernet, RS-232 control, 100 MHz reference signal, 1-pulse-per-second reference, and one input port for an IF signal in the range of 0–640 MHz. Inside the PRSR, there is a steel plate that separates the IF digitizer unit from the digital signal-processing board to reduce spurs that may affect the sensitive analog components.

This innovation contains firmware that runs on a Xilinx field-programmable gate array (FPGA), and consists of code that down-converts the DSN's 640-MHz IF spectrum into two channels: a wide bandwidth channel and a narrow bandwidth channel. The wide bandwidth channel can be configured from 160 MHz down to 1.25 MHz with 16 bits of resolution. The narrow channel can be configured from 1.25 MHz down to 10 kHz with 32 bits of resolution.

The present PRSR software consists of a driver, a command processor, and a graphical user interface (GUI) for viewing monitor data and plots. While limited in scope, this software is able to demonstrate on the prototype hardware the key features of a fully operational PRSR. For example, data can be recorded onto a disk from the PRSR's narrowband channel, but recordings only occur in discontinuous snapshots of 4,096 samples each.

The PRSR was shipped to GBT along with an existing DSN RSR rack and recorded signals in parallel with the RSR coming from the Phoenix lander during the May 25, 2008 EDL. This test demonstrated the potential of the PRSR prototype and the value for developing it into a fully operational DSN receiver.

*This work was done by Andre P. Jongeling, Elliott H. Sigman, Kumar Chandra, Joseph T. Trinh, Robert Navarro, Stephen P. Rogstad, Charles E. Goodhart, Robert C. Proctor, Susan G. Finley, and Leslie A. White of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-46289*

## Detecting Phase Boundaries in Hard-Sphere Suspensions

**Liquid and solid phases are distinguished through differences in motions of spheres.**

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A special image-data-processing technique has been developed for use in experiments that involve observation, via optical microscopes equipped with electronic cameras, of moving boundaries between the colloidal-solid and colloidal-liquid phases of colloidal suspensions of monodisperse hard spheres. Such suspensions are used as physical models of thermodynamic phase transitions and of precursors to photonic-band-gap materials. During an experiment, it is necessary to adjust the position of a microscope to keep the phase boundary within view. A boundary typically moves at a speed of

the order of microns per hour. Because an experiment can last days or even weeks, it is impractical to require human intervention to keep the phase boundary in view. The present image-data-processing technique yields results within a computation time short enough to enable generation of automated-microscope-positioning commands to track the moving phase boundary.

The experiments that prompted the development of the present technique include a colloidal equivalent of directional solidification. The interactions between the spheres in these suspensions

closely approximate an ideal hard-sphere potential, so that the phase behavior becomes, to a close approximation, solely a function of volume fraction ( $\phi$ ) of spheres. When  $\phi$  of a given suspension sample is less than a threshold value ( $\phi_f = 0.494$ ) denoted the freezing volume fraction, the suspension is in the colloidal-liquid phase, in which the spheres are disordered and free to diffuse throughout the entire volume of the sample. When  $\phi$  exceeds another threshold value ( $\phi_m = 0.545$ ) denoted the melting volume fraction, the suspension is in the colloidal-solid phase, in which the sample is crystalline in the