and the other coronagraphic optics so that at the pump wavelength, the PSF is centered on the occulting spot.

The figure shows the optical layout according to one possible design of the proposed coronagraphic filter for a pump wavelength of 550 nm. The dispersive element would be a 500-line-per-millimeter diffraction grating, of which the first-order diffraction would be utilized. After passing through an aperture, the incoming light would strike the grating, followed by a flat steering mirror. An air-spaced doublet lens incorporating an aspherical element would generate a PSF at the occulter (intermediate-image) plane. A spherical-surface doublet lens would reimage the light onto a detector plane. On its way to the detector plane, the light would pass though a Lyot stop. In principle, a linear array of photodetectors could be placed in the final image plane to measure the Raman spectrum. The depth of the notch at the pump wavelength, as well as other parameters of the performance of the coronagraphic filter, could be tailored through the choice of the parameters of the optical components, including especially the dispersion of the grating; the aperture diameter, focal length, and aberrations of the first doublet lens; the length of the occulting spot along the axis of dispersion; and the diameter of the Lyot stop.

This work was done by David Cohen and Robert Stirbl of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30504

On-the-Fly Mapping for Calibrating Directional Antennas

Source-size corrections are not necessary in this method.

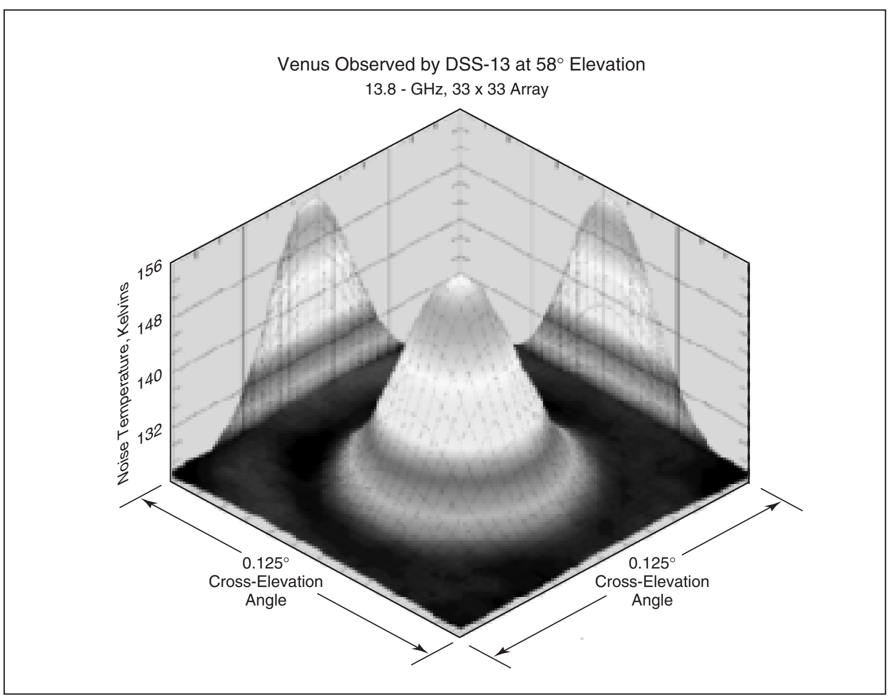
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of calibrating a large directional radio antenna of the type used in deep-space communication and radio astronomy has been developed. This method involves a raster-scanning-and-measurement technique denoted on-the-fly (OTF) mapping, applied in consideration of the results of a systematic analysis of the entire measurement procedure. Phenomena to which particular attention was paid in the analysis include (1) the noise characteristics of a total-power radiometer (TPR) that is used in the measurements and (2) tropospherically induced radiometer fluctuations. The method also involves the use of recently developed techniques for acquisition and reduction of data. In comparison with prior methods used to calibrate such antennas, this method yields an order-of-magnitude improvement in the precision of determinations of antenna aperture efficiency, and improvement by a factor of five or more in the precision of determination of pointing error and beam width.

Prerequisite to a meaningful description of the present method is some background information concerning three aspects of the problem of calibrating an antenna of the type in question:

- In OTF mapping measurements in which a TPR is used, the desired data are the peak temperature corresponding to a radio source, the pointing offset when the antenna is commanded to point toward the source, and the shape of the main lobe of the antenna beam, all as functions of the antenna beam elevation and azimuth angles. These data enable one to calculate the (1) antenna aperture efficiency by comparing the measured peak temperature with that expected for a 100-percent-efficient antenna, (2) the mechanical pointing error resulting from small misalignments of various parts of the antenna structure, and (3) misalignments of the antenna subreflector and other mirrors.
- For practical reasons having to do with obtaining adequate angular resolution and all-sky coverage, it is necessary to perform azimuth and elevation scans fairly rapidly.
- Many natural radio sources used in calibrating antennas are only approximately pointlike: some sources subtend angles greater than the beam width of a given antenna. In such a case, the antenna partially resolves the source structure and does not collect all of the radiation emitted by the source. This makes it necessary to estimate how much of the total known radiation from the source would actually be collected by the antenna if it were 100-percent efficient. The resulting estimate, leading to a source-size correction factor, introduces another degree of uncertainty to the measurements. OTF mapping can remove this uncertainty.

The key to using OTF mapping to solve all three aspects of the calibration problem



The **TPR Readout Data** plotted here were acquired in a test raster scan of a portion of the sky, near an elevation angle of 58°, that contained the planet Venus when it was relatively close to Earth. The horizontal axes on this plot correspond to elevation and cross-elevation angles. The vertical axis represents noise temperature in Kelvins.

is to maintain a constant, known angular velocity when scanning the antenna along a given direction. To ensure alignment of the individual subscans within the full raster, the angular position of the first data point of each subscan is determined from readings of azimuth- and elevation-angle encoders, while the angular positions of the rest of the subscan data points are determined by timing at the constant angular velocity. Hence, if the TPR reading is sampled at a constant known rate, then the relative angular position at which each datum is taken is known with high accuracy, and antenna-settling time is no longer an issue. The data-acquisition algorithms used in OTF mapping provide for computation of the angular positions of radio sources, such that at any given time, the position of the antenna relative to a source is known.

The acquisition of data in the OTF mode necessarily entails attenuation of high-frequency information as a consequence of the integration that occurs during the sampling intervals. The high-frequency information can be recovered in an inverse-filtering computation.

Even though the antenna beam does not sample all of the radiation from an extended radio source at a given instant, the completed raster scan does cover the entire solid angle subtended by the source and, hence contains a sampling of all the radiation from that source. Consequently, no source-size correction is necessary in OTF mapping. The resulting set of data registered on a two-dimensional field of sampling points (see figure) can be used to determine a least-squares-best-fit main beam pattern. The calibration parameters can then be determined from the main beam pattern.

This work was done by David Rochblatt, Paul Richter, and Philip Withington of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30648

Working Fluids for Increasing Capacities of Heat Pipes

Fluids are formulated to make surface tensions increase with temperature.

John H. Glenn Research Center, Cleveland, Ohio

A theoretical and experimental investigation has shown that the capacities of heat pipes can be increased through suitable reformulation of their working fluids. The surface tensions of all of the working fluids heretofore used in heat pipes decrease with temperature. As explained in more detail below, the limits on the performance of a heat pipe are associated with the decrease in the surface tension of the working fluid with temperature, and so one can enhance performance by reformulating the working fluid so that its surface tension increases with temperature. This improvement is applicable to almost any kind of heat pipe in almost any environment.

The heat-transfer capacity of a heat pipe in its normal operating-temperature range is subject to a capillary limit and a boiling limit. Both of these limits are associated with the temperature dependence of surface tension of the working fluid. In the case of a traditional working fluid, the decrease in surface tension with temperature causes a body of the liquid phase of the working fluid to move toward a region of lower temperature, thus preventing the desired spreading of the liquid in the heated portion of the heat pipe. As a result, the available capillary-pressure pumping head decreases as the temperature of the evaporator end of the heat pipe increases, and operation becomes unstable.

Water has widely been used as a working fluid in heat pipes. Because the surface tension of water decreases with increasing temperature, the heat loads and other aspects of performance of heat pipes that contain water are limited. Dilute aqueous solutions of long-chain alcohols have shown promise as substitutes for water that can offer improved performance, because these solutions exhibit unusual surface-tension characteristics: Experiments have shown that in the cases of an aqueous solution of an alcohol, the molecules of which contain chains of more than four carbon atoms, the surface tension increases with temperature when the temperature exceeds a certain value.

There are also other liquids that have surface tensions that increase with temperature and could be used as working fluids in heat pipes. For example, as a substitute for ammonia, which is the working fluid in some heat pipes, one could use a solution of ammonia and an ionic surfactant.

This work was done by David F. Chao of **Glenn Research Center** *and Nengli Zhang of Ohio Aerospace Institute. Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland Ohio 44135. Refer to LEW-17270.