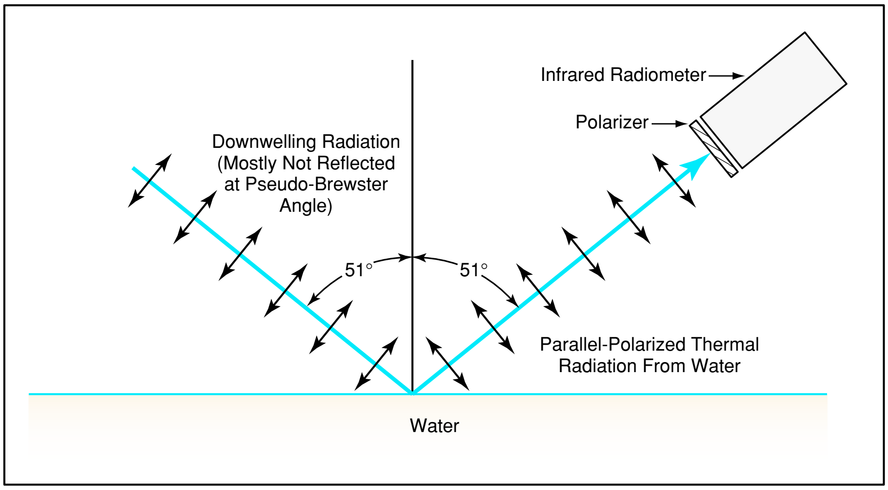
sides of the aerogel transpiration membrane: Each silicon chip contains a dense array of 20-µm-diameter through holes, made by deep reactive-ion etching, that serve as tubes for heating or cooling the gas in them. Thin gold film heaters are patterned on both silicon chips; hence, either silicon chip can be the hot-side thermal guard. The aerogel has an average pore size of 20 nm and a very low thermal conductivity (17 W/K at atmospheric pressure), and thus satisfies the essential requirements for thermal transpiration to occur when a voltage is applied to one of the heaters.

This work was done by Stephen Vargo, E. Phillip Muntz, and Geoff Shiflett of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP [see page 1].*
NPO-21110

Instrument for Measuring Temperature of Water

An infrared radiometer is able to view water as an almost pure blackbody source.

Stennis Space Center, Mississippi



An **Infrared Radiometer** would be aimed toward water at the pseudo-Brewster angle and would respond to radiation polarized parallel (but not perpendicular) to the plane of incidence.

A pseudo-Brewster-angle infrared radiometer has been proposed for use in noncontact measurement of the surface temperature of a large body of water (e.g., a lake or ocean). This radiometer could be situated on a waterborne, airborne, or spaceborne platform.

The design of the pseudo-Brewster-angle radiometer would exploit the spectral-emissivity and polarization characteristics of water to minimize errors attributable to the emissivity of water and to the reflection of downwelling (e.g., Solar and cloud-reflected) infrared radiation. The relevant emissivity and polarization characteristics are the following:

- The Brewster angle is the angle at which light polarized parallel to the plane of incidence on a purely dielectric material is not reflected. The pseudo-Brewster angle, defined for a lossy dielectric (somewhat electrically conductive) material, is the angle for which the reflectivity for parallel-polarized light is minimized. For pure water, the reflectivity for parallel-polarized light is only 2.2×10^{-4} at its pseudo-Brewster angle of 51°. The reflectivity remains near zero, several degrees off from the 51° optimum, allowing this angle of incidence requirement to be easily achieved.
- The wavelength range of interest for measuring water temperatures is 8 to 12 µm. The emissivity of water for parallel-polarized light at the pseudo-Brewster angle is greater than 0.999 in this wavelength range.

The radiometer would be sensitive in the wavelength range of 8 to 12 µm, would be equipped with a polarizer to discriminate against infrared light polarized perpendicular to the plane of incidence, and would be aimed toward a body of water at the pseudo-Brewster angle (see figure). Because the infrared radiation entering the radiometer would be polarized parallel to the plane of incidence and because very little downwelling parallel-polarized radiation would be reflected into the radiometer on account of the pseudo-Brewster arrangement, the radiation received by the radiometer would consist almost entirely of thermal emission from the surface of the water. Because the emissivity of the water would be very close to 1, the water could be regarded as a close approximation of a blackbody for the purpose of computing its surface temperature from the radiometer measurements by use of the Planck radiation law.

This work was done by Robert Ryan, Thomas Nixon, and Mary Pagnutti of Lockheed Martin Corp. and Vicki Zanoni of **Stennis Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center [see page 1]. Refer to SSC-00134.

Improved Measurement of Coherence in Presence of Instrument Noise

The coherence function can be measured more accurately by accounting for the effects of instrument noise.

John F. Kennedy Space Center, Florida

A method for correcting measured coherence spectra for the effect of incoherent instrument noise has been developed and demonstrated. Coherence measurements are widely used in engineering and science to determine the extent to which two signals are alike. The signals may come from two different sources or from the same source at different times. The coherence of time-lagged signals from a single source is an excellent indication of the effective lifetime of the signal components as a function of their frequency. Unfortunately, incoherent instrument noise will bias the measurement to lower values and may lead the user of the data to false conclusions about the longevity of significant features.

The new method may be used whenever both the signal and noise power spectra are known and the noise is incoherent both with the signal and with itself at the applicable time delays. It provides a corrected coherence spectrum given the measured coherence and power spectra. For power-law signal spectra and instrumental white noise, the correction formula takes a particularly simple and explicit form. Since many geophysical signals exhibit power-law behavior and most instrument noise spectra approach white noise, the simplified form should be widely applicable in meteorology, oceanography, geology, and planetary geophysics.

The derivation of the method and the resulting formulas for both the general case and the power-law/white-noise case may be found in the Appendix to "The Coherence Time of Mid-Tropospheric Wind Features as a Function of Vertical Scale From 300 m to 2 Km", *Journal of Applied Meteorology*, Vol. 39, pp 2409-2420, December 2000.

This work was done by Francis J. Merceret of **Kennedy Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (321) 867-4879. Refer to KSC-12267.

Compact Instruments Measure Helium-Leak Rates

Compact, lightweight instruments have been developed for measuring small flows of helium and/or detecting helium leaks in solenoid valves when the valves are nominally closed. These instruments do not impede the flows when the valves are nominally open. They can be integrated into newly fabricated valves or retrofitted to previously fabricated valves. Each instrument includes an upstream and a downstream thermistor separated by a heater, plus associated analog and digital heater-control, signal-conditioning, and data-processing circuits. The thermistors and heater are off-the-shelf surface mount components mounted on a circuit board in the flow path. The operation of the instrument is based on a well-established thermal mass-flow-measurement technique: Convection by the flow that one seeks to measure gives rise to transfer of heat from the heater to the downstream thermistor. The temperature difference measured by the thermistors is directly related to the rate of flow. The calibration curve from temperature gradient to helium flow is closely approximated via fifth-order polynomial. A microprocessor that is part of the electronic circuitry implements the calibration curve to compute the flow rate from the thermistor readings.

This work was done by Stephen Stout and Christopher Immer of Dynacs, Inc., for **Kennedy Space Center**.
KSC-12216

Books and Reports

Irreversible Entropy Production in Two-Phase Mixing Layers

This report presents a study of dissipation (irreversible production of entropy) in three-dimensional, temporal mixing layers laden with evaporating liquid drops. The purpose of the study is to examine the effects of evaporating drops on the development of turbulent features in flows. Direct numerical simulations were performed to analyze transitional states of three mixing layers: one without drops, and two that included drops at different initial mass loadings. Without drops, the dissipation is essentially due to viscous effects. It was found that in the presence of drops, the largest contribution to dissipation was made by heating and evaporation of the drops, and that at large length scales, this contribution is positive (signifying that the drops reduce turbulence), while at small scales, this contribution is negative (the drops increase turbulence). The second largest contribution to dissipation was found to be associated with the chemical potential, which leads to an increase in turbulence at large scales and a decrease in turbulence at small scales. The next smaller contribution was found to be that of viscosity. The fact that viscosity effects are only third in order of magnitude in the dissipation is in sharp contrast to the situation for the mixing layer without the drops. The next smaller contribution — that of the drag and momentum of the vapor from the drops — was found to be negative at lower mass loading but to become positive at higher mass loading.

This work was done by Josette Bellan and Nora Okong'o of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Irreversible entropy production in two-phase flows with evaporating drops," see TSP's [page 1].*
NPO-30586

Subsonic and Supersonic Effects in Bose-Einstein Condensate

A paper presents a theoretical investigation of subsonic and supersonic effects in a Bose-Einstein condensate (BEC). The BEC is represented by a time-dependent, nonlinear Schroedinger equation that includes terms for an external confining potential term and a weak interatomic repulsive potential proportional to the number density of atoms. From this model are derived Madelung equations, which relate the quantum phase with the number density, and which are used to represent excitations propagating through the BEC. These equations are shown to be analogous to the classical equations of flow of an inviscid, compressible fluid characterized by a speed of sound $(g/\rho_0)^{1/2}$, where g is the coefficient of the repulsive potential and ρ_0 is the unperturbed mass density of the BEC. The equations are used to study the effects of a region of perturbation moving through the BEC. The excitations created by a perturbation moving at subsonic speed are found to be described by a Laplace equation and to propagate at infinite speed. For a supersonically moving perturbation, the excitations are found to be described by a wave equation and to propagate at finite speed inside a Mach cone.

This work was done by Michail Zak of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the paper, "Sub- and supersonic effects in Bose-Einstein condensate," see TSP's [page 1].*
NPO-30637