cludes chemical models developed at JPL. The products are synthetic images and spectra for comparison with Spitzer measurements.

Radiative transfer in a protostellar disk is primarily affected by absorption and emission processes in the dust and in molecular gases such as H_2, CO, and HCO. The magnitude of the optical absorption and emission is determined by the population of the electronic, vibrational, and rotational energy levels. The population of the molecular level is in turn determined by the intensity of the radiation field. Therefore, the intensity of the radiation field and the population of the molecular levels are inter-dependent quantities.

To meet the computational challenges of solving for the coupled radiation field and electronic level populations in disks having wide ranges of optical depths and spatial scales, the tool runs in parallel on the JPL Dell Cluster supercomputer with C++ and Fortran compiler with a Message Passing Interface. Because this software has been developed on a distributed computing platform, the modeling of systems previously beyond the reach of available computational resources is possible.

This program was written by Paul Von Allmen and Neal Turner of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44467.

Composite Pulse Tube

Axial leakage of heat is reduced.

Lyndon B. Johnson Space Center, Houston, Texas

A modification of the design of the pulse tube in a pulse-tube cryocooler reduces axial thermal conductance while preserving radial thermal conductance. It is desirable to minimize axial thermal conductance in the pulse-tube wall to minimize leakage of heat between the warm and cold ends of the pulse tube. At the same time, it is desirable to maximize radial thermal conductance at the cold end of the pulse tube to ensure adequate thermal contact between (1) a heat exchanger in the form of a stack of copper screens inside the pulse tube at the cold end and (2) the remainder of the cold tip, which is the object to which the heat load is applied and from which heat must be removed. The modified design yields a low-heat-leak pulse tube that can be easily integrated with a cold tip.

A typical pulse tube of prior design is either a thin-walled metal tube or a metal tube with a nonmetallic lining. It is desirable that the outer surface of a pulse tube be cylindrical (in contradistinction to tapered) to simplify the design of a regenerator that is also part of the cryocooler. Under some conditions, it is desirable to taper the inner surface of the pulse tube to reduce acoustic streaming. The combination of a cylindrical outer surface and a tapered inner surface can lead to unacceptably large axial conduction if the pulse tube is made entirely of metal. Making the pulse-tube wall of a nonmetallic, low-thermal-conductivity material would not solve the problem because the wall would not afford the needed thermal contact for the stack of screens in the cold end.

The modified design calls for fabricating the pulse tube in two parts: a longer, nonmetallic part that is tapered on the inside and cylindrical on the outside and a shorter, metallic part that is cylindrical on both the inside and the outside. The nonmetallic part can be made from G-10 fiberglass-reinforced epoxy or other low-thermal-conductivity, cryogenically compatible material. The metallic part must have high thermal conductivity in the cryogenic temperature range and would typically be made of pure copper to satisfy this requirement. The metallic part is bonded to the nonmetallic part with epoxy. Copper screens are inserted in the metallic part to form the cold-end heat exchanger, then the assembled pulse tube is inserted in the cold tip.

This work was done by Jerry L. Martin and Jason H. Cloyd of Mesoscopic Devices, LLC for Johnson Space Center. For further information, contact:

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Refer to MSC-23522

Photometric Calibration of Consumer Video Cameras

In imaging of point sources, dynamic ranges can be extended beyond saturation levels.

Marshall Space Flight Center, Alabama

Equipment and techniques have been developed to implement a method of photometric calibration of consumer video cameras for imaging of objects that are sufficiently narrow or sufficiently distant to be optically equivalent to point or line sources. Heretofore, it has been difficult to calibrate consumer video cameras, especially in cases of image saturation, because they exhibit nonlinear responses with dynamic ranges much smaller than those of scientific-grade video cameras. The present method not only takes this difficulty in stride but also makes it possible to extend effective dynamic ranges to several powers of ten beyond saturation levels. The method will likely be primarily useful in astronomical photometry. There are also potential commercial applications in medical and industrial imaging of point or line sources in the presence of saturation.

This development was prompted by the need to measure brightnesses of debris in amateur video images of the breakup of the Space Shuttle Columbia. The purpose of these measurements is to use the brightness values to estimate relative masses of debris objects. In most of the images, the brightness of the main body of Columbia was found to exceed the dynamic ranges of the cameras. A similar problem arose a few years ago in the analysis of video images of Leonid meteors. The present method is a refined version of the calibration method developed to solve the Leonid calibration problem.

In this method, one performs an end-to-end calibration of the entire imaging system, including not only the imaging optics and imaging photodetector array but also analog tape recording and playback equipment (if used) and any frame grabber or other analog-to-digital converter (if used). To automatically incorporate the effects of nonlinearity and any other distortions into the calibration, the calibration images are processed in precisely the same manner as are the images of meteors, space-shuttle debris, or other objects that one seeks to analyze.

The light source used to generate the calibration images is an artificial variable star comprising a Newtonian collimator illuminated by a light source modulated by a rotating variable neutral-density filter. This source acts as a point source, the brightness of which varies at a known rate. A video camera to be calibrated is aimed at this source. Fixed neutral-density filters are inserted in or removed from the light path as needed to make the video image of the source appear to fluctuate between dark and saturated bright. The resulting video-image data are analyzed by use of custom software that determines the integrated signal in each video frame and determines the system response curve (measured output signal versus input brightness). These determinations constitute the calibration, which is thereafter used in automatic, frame-by-frame processing of the data from the video images to be analyzed.

This work was done by Robert Suggs of Marshall Space Flight Center and Wesley Swift, Jr., of Raytheon Co. Further information is contained in a TSP (see page 1). MFS-32090-1

Criterion for Identifying Vortices in High-Pressure Flows

This criterion could enable appropriate comparisons between experiments and simulations.

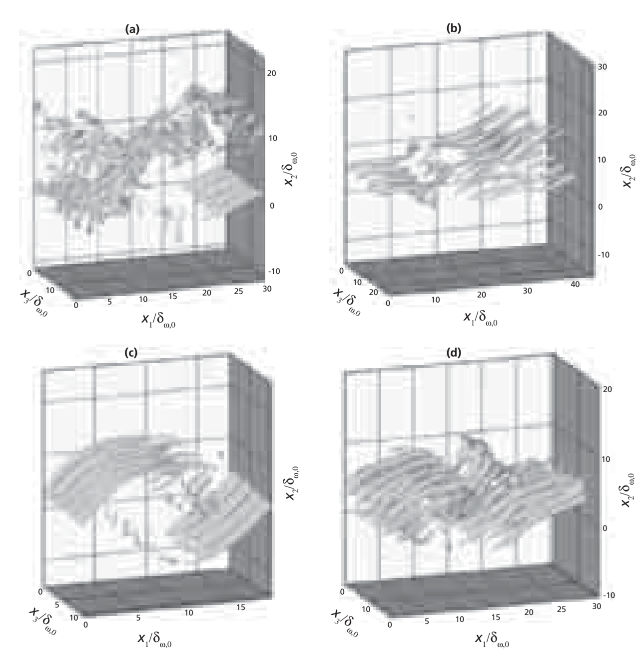
NASA's Jet Propulsion Laboratory, Pasadena, California

A study of four previously published computational criteria for identifying vortices in high-pressure flows has led to the selection of one of them as the best. This development can be expected to contribute to understanding of high-pressure flows, which occur in diverse settings, including diesel, gas turbine, and rocket engines and the atmospheres of Jupiter and other large gaseous planets.

Information on the atmospheres of gaseous planets consists mainly of visual and thermal images of the flows over the planets. Also, validation of recently proposed computational models of high-pressure flows entails comparison with measurements, which are mainly of visual nature. Heretofore, the interpretation of images of high-pressure flows to identify vortices has been based on experience with low-pressure flows. However, high-pressure flows have features distinct from those of low-pressure flows, particularly in regions of high pressure gradient magnitude caused by dynamic turbulent effects and by thermodynamic mixing of chemical species. Therefore, interpretations based on low-pressure behavior may lead to misidentification of vortices and other flow structures in high-pressure flows. The study reported here was performed in recognition of the need for one or more quantitative criteria for identifying coherent flow structures — especially vortices — from previously generated flow-field data, to complement or supersede the determination of flow structures by visual inspection of instantaneous fields or flow animations. The focus in the study was on correlating visible images of flow features with various quantities computed from flow-field data.

The quantities involved in the four criteria considered in the study are the following:

- The discriminant of the deformation tensor;
- The second invariant of the deformation tensor;
- The intermediate eigenvalue of the



These **Plots of Isosurfaces** of positive values of the second invariant were generated from numerical simulations of two high-pressure mixing flows of heptane/nitrogen, (a) and (c), and two high-pressure mixing flows of oxygen/hydrogen (b) and (d).