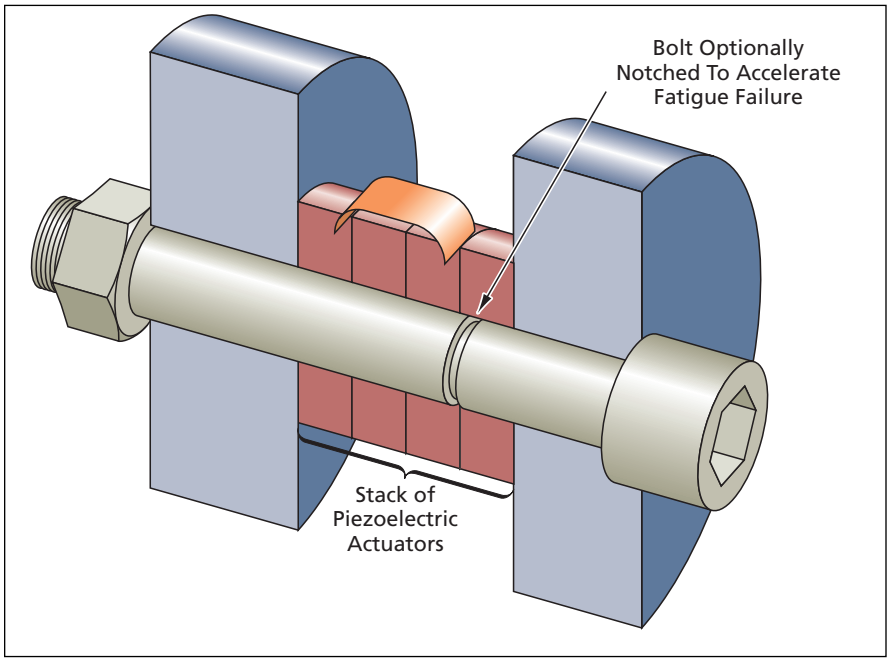
The static tension in the tightened bolt would apply not only the clamping force to hold the joined structures (if any) together but also the compression necessary for proper operation of the piezoelectric actuators as parts of a resonant structural assembly. The constant-amplitude dynamic stress would be applied to the bolt by driving the piezoelectric actuators with a sinusoidal voltage at the resonance frequency of longitudinal vibration of the assembly. The amplitude of the excitation would be made large enough so that the vibration would induce fatigue in the bolt within an acceptably short time.



A **Bolt To Be Fatigue-Tested** or simply broken by accelerated fatigue would be tightened as an integral part of a resonant assembly that would also include piezoelectric actuators that would apply an oscillatory component of tensile stress.

In the spacecraft applications or in similar terrestrial structural-separation applications, devices of the proposed type would offer several advantages over explosive bolts: Unlike explosive bolts, the proposed devices would be reusable, could be tested before final use, and would not be subject to catastrophic misfire. In fatigue-testing applications, devices of the proposed type would offer advantages of compactness and low cost, relative to conventional fatigue-testing apparatuses. In both structural-separation and fatigue-testing applications, bolts to be broken or tested could be instrumented with additional ultrasonic transducers for monitoring of pertinent physical properties and of fatigue failure processes.

This work was done by Stewart Sherrit, Mircea Badescu, Yoseph Bar-Cohen, Jack Barengoltz, and Vanessa Heckman of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). *NPO-43977*

Improved Measurement of B_{22} of Macromolecules in a Flow Cell

Invention helps researchers understand conditions that affect protein crystallization.

Marshall Space Flight Center, Alabama

An improved apparatus has been invented for use in determining the osmotic second virial coefficient of macromolecules in solution. In a typical intended application, the macromolecules would be, more specifically, protein molecules, and the protein solution would be pumped through a flow cell to investigate the physical and chemical conditions that affect crystallization of the protein in question.

Some background information is prerequisite to a meaningful description of the novel aspects of this apparatus. The osmotic second virial coefficient, customarily denoted by the algebraic symbol B_{22}, appears in the equation for the osmotic pressure of a macromolecular solution:

$$\pi = RT\rho(M^{-1} + B_{22}\rho + \text{higher-order terms})$$

where π is the osmotic pressure, R is the ideal-gas constant, T is the absolute temperature, ρ is the concentration (more specifically, the mass density) of the macromolecule solute, and M is the mass of one mole of the solute. The osmotic second virial coefficient quantifies the degree of attraction or repulsion between the macromolecules under various solution conditions. Therefore, this coefficient is a valuable part of a method of determining optimum conditions for formulation of a protein solution and crystallization of the protein from the solution.

A method of determining B_{22} from simultaneous measurements of the static transmittance (taken as an indication of concentration) and static scattering of light from the same location in a flowing protein solution was published in 2004. The apparatus used to implement the method at that time included a dual-detector flow cell, which had two drawbacks:

- The amount of protein required for analysis of each solution condition was of the order of a milligram — far too large a quantity for a high-throughput analysis system, for which microgram or even nanogram quantities of protein per analysis are desirable.
- The design of flow cell was such that two light sources were used to probe different regions of the flowing solution. Consequently, the apparatus did not afford simultaneous measurements at the same location in the solution and, hence, did not guarantee an accurate determination of B_{22}.

This concludes the background information.

The present improved apparatus includes a flow cell wherein the required simultaneous transmittance and scattering measurements can be made at the same location. For the purpose of these measurements, light from two sources (a laser and an ultraviolet lamp) is delivered simultaneously to the designated location in the cell via a bifurcated optical fiber. The flow cell in this apparatus is narrower than that of the prior appa-

ratus, such that the volume of solution needed for each analysis is of the order of microliters and the mass of protein needed for each analysis at typical concentrations is of the order of micrograms.

The capability of the improved apparatus to yield measurements from which accurate B_{22} values could be calculated was demonstrated in experiments on several different aqueous lysozyme and concanavalin A solutions for which B_{22} values had been determined by other means. The apparatus has also been used to screen a series of potential crys albumin, and to evaluate B_{22} as an indication of the solubility of proteins.

This work was done by Wilbur Wilson, Joseph Fanguy, Steven Holman, and Bin Guo of Mississippi State University for Marshall Space Flight Center. Further information is contained in a TSP (see page 1).
MFS-32536-1

Measurements by a Vector Network Analyzer at 325 to 508 GHz

NASA's Jet Propulsion Laboratory, Pasadena, California

Recent experiments were performed in which return loss and insertion loss of waveguide test assemblies in the frequency range from 325 to 508 GHz were measured by use of a swept-frequency two-port vector network analyzer (VNA) test set. The experiments were part of a continuing effort to develop means of characterizing passive and active electronic components and systems operating at ever increasing frequencies. The waveguide test assemblies comprised WR-2.2 end sections collinear with WR-3.3 middle sections. The test set, assembled from commercially available components, included a 50-GHz VNA scattering-parameter test set and external signal synthesizers, augmented with recently developed frequency extenders, and further augmented with attenuators and amplifiers as needed to adjust radio-frequency and intermediate-frequency power levels between the aforementioned components.

The tests included line-reflect-line calibration procedures, using WR-2.2 waveguide shims as the "line" standards and waveguide flange short circuits as the "reflect" standards. Calibrated dynamic ranges somewhat greater than about 20 dB for return loss and 35 dB for insertion loss were achieved. The measurement data of the test assemblies were found to substantially agree with results of computational simulations.

This work was done by King Man Fung, Lorene Samoska, Goutam Chattopadhyay, Todd Gaier, Pekka Kangaslahti, David Pukala, Yuenie Lau, Charles Oleson, and Anthony Denning of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-44694