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On

Mechanical Amplifier For A Piezoelectric Transducer

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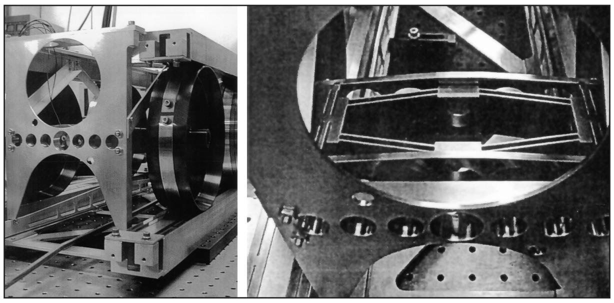
Mechanics

Mechanical Amplifier for a Piezoelectric Transducer

In addition to multiplication of stroke, the design affords momentum compensation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mechanical amplifier has been devised to multiply the stroke of a piezoelectric transducer (PZT) intended for use at liquid helium temperatures. Interferometry holds the key to high angular resolution imaging and astrometry in space. Future space missions that will detect planets around other solar systems and perform detailed studies of the evolution of stars and galaxies will use new interferometers that observe at mid- and far-infrared wavelengths. Phase-measurement interferometry is key to many aspects of astronomical interferometry, and PZTs are ideal modulators for most methods of phase measurement, but primarily at visible wavelengths. At far infrared wavelengths of 150 to 300 μm, background noise is a severe problem and all optics must be cooled to about 4 K. Under these conditions, piezos are ill-suited as modulators, because their throw is reduced by as much as a factor of 2, and even a wavelength or two of modulation is beyond their capability. The largest commercially available piezo stacks are about 5 in. (12.7 cm) long and have a throw of about 180 μm at room temperature and only 90 μm at 4 K. It would seem difficult or impossible to use PZTs for phase measurements in the far infrared were it not for the new mechanical amplifier that was designed and built.



A **Four-Bar Linkage** provides stroke amplification and momentum compensation for the PZT mounted inside it.

To compensate for the loss of travel at cryogenic temperatures, the PZT is mounted in a novel mechanical amplifier that supports one of the mirrors of the interferometer. The mechanical amplifier, shown in the figure, was designed based on an original concept at JPL dating from 1993. The mechanical amplifier resembles an elongated parallelogram with pairs of parallel flexures along each side. The PZT is compressed along the axis of the long diagonal of the parallelogram by support flexures at each end. The expansion of the PZT along the long diagonal causes the ends of the short diagonal to move towards each with a motion amplified by a factor of 3 or 4. The parallel flexures are used to eliminate unwanted twisting and vibration modes such that a small mirror will not tilt when translated by the amplifier. The support flexures that hold the PZT allow a symmetrical expansion of the piezo within the amplifier. The amplifier is designed to be completely symmetric and balanced such that inertia forces are nulled. This provides mechanical stability that allows rapid (100-Hz) sampling without inducing vibrations. Optical interferometers normally obtain the mechanical stability and momentum compensation by using an additional piezo stack mounted back-to-back with the first piezo so that the second one has motions that are equal but opposite in direction. By mounting the stack symmetrically with the support flexures the stack expands equally about its center, does not induce vibrations, and does not require momentum compensation.

This new mechanical amplifier provides both a longer stroke for standard piezo stacks and the necessary mechanical stability through an ingenious mounting arrangement. The device is made of titanium and machined using a wire EDM (electrical-discharge machining) process so as to be as strong and lightweight as possible. It is compact using only a single piezo stack, making it ideally suited for phase-measurement in a cryogenic environment.

This work was done by James Moore, Mark Swain, Peter Lawson, and Robert Calvet of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

NPO-30289

NTR INVENTOR'S REPORT
NTR: 30289

PLEASE BE AS CLEAR AND SPECIFIC AS POSSIBLE, AS THIS REPORT MAY BE MADE AVAILABLE THROUGH TECH BRIEFS

Section 1 (Novelty), 2A (Problem), and 2B (Solution) must be completely fully. Your published paper may be attached to satisfy Section 2C (Description and Explanation).

1. Novelty- Describe what is new and different about your work and its improvements over the prior art. Attach supporting material if necessary.

To our knowledge, the mechanical arrangement we propose is the best solution to the problem we describe below. We could not otherwise have implemented phase measurement in the cryogenic delay line we are constructing, as no commercially available components are suitable for use.

2. Technical Disclosure

A. Problem-Motivation that led to development or problem that was solved.

We require the use of a piezo actuator to provide path-modulation of about 100 microns while operating at cryogenic temperatures. We also require that the device be momentum compensated so as not to induce vibrations in the optical delay line. The normal solution would be to use two very large piezo stacks operated back-to-back. Large piezos would be required to obtain the necessary throw at low temperatures, when a large fraction of the throw would be lost. The normal solution therefore requires a cumbersome combination of large components, which would overly complicate the design of the delay line for which the modulator was intended.

B. Solution

A mechanical linkage was designed to compensate for the losses in throw of a piezo actuator. The mounting of the piezo through the linkage was also designed such that the piezo would not push against any fixed mount point, and moreover the expansion of the piezo occurs from its midpoint outward, obviating the need for momentum compensation.

C. Detailed Description and Explanation

A mechanical 4-bar linkage was developed to amplify the throw of the piezo. This way, the losses in throw due to the drop in temperature could be recovered by the linkage. The piezo is placed inside and diagonally across the linkage, such that when the piezo expands, two opposing corners of the linkage approach each other, but with an amplified motion. Mirrors are mounted on these corners, and the device is made symmetric about the axis of the piezo. The device is made from titanium so as to be as strong and lightweight as possible. Because the piezo is now placed transverse to the direction of path modulation, and does not push against any fixed part of the structure, it is by itself momentum compensated.

***PUBLICATION**

P.R. Lawson, M.R. Swain, P.J. Dumont, J.D. Moore and R.F. Smythe, "Cryogenic Optics for Long- Baseline Interferometry in the Far Infrared," Poster 45.03, 199th Meeting of the American Astronomical Society Meeting 6-10 January 2002, in Washington DC.

http://huey.jpl.nasa.gov/~lawson/aas199_4503.pdf

*Please obtain publications from sources listed.

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