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INTERFEROMETRIC MEASUREMENTS AND THERMAL EXPANSION CHARACTERISATION OF DEPLOYABLE TELESCOPE BASED ON COMPOSITE TAPE-SPRINGS

Abstract

Thin carbon fibre reinforced polymer (CFRP) tape-springs are attractive structures for use in space-based optical instruments because of their compact stowed form, and their high dimensional stability when deployed. In this paper we present two inexpensive methods to assess the thermal expansion properties of tape-spring structures: one based on strain gauges to obtain coupon level values, and another based on laser interferometry for structure level measurements. The strain gauge technique is a versatile approach which exploits the thermal output characteristics of the sensors. The thermal expansion characterisation of thin-composite samples measured a longitudinal expansion of 4.44 ppm/°C and transverse expansion 5.95 of ppm/°C. The interferometry system is designed with a view to capturing the displacements and tilts that occur when a structure with a low thermal mass, like a tape-spring, experiences a rapid change in flux, as occurs in the space environment. The homodyne interferometer is developed for three degree-of-freedom (DoF) measurements with a resolution of 10^{-8} m for distances and 10^{-6} rad for angles. The interferometric setup is based on the classical Michelson architecture and consists of few inexpensive commercial optical components. The source is a 0.8 mW Helium-Neon laser with a wavelenght of 632.8 nm. The other elements include two spherical singlets, a right-angle prism, a cubic beamsplitter and a CMOS camera. The recorded interference fringes are analysed by using an algorithm based on Discrete Fourier Transform (DFT). Spectral information on the light intensity signals can be used to determine relative displacements and tilts. The dimensional stability of an optical payload based on high-strain composites was tested. The telescope has a deployable Cassegrain design, which uses six extendable members for the separation of its secondary mirror. Axial deformations between 20-30 m along with angle variations of the order of 0.1 mrad were recorded with good repeatability.