Update to the CSO Submillimeter Active Optics System

Melanie M. Leong
Caltech Submillimeter Observatory, 111 Nowelo Street, Hilo, Hawaii 96720, USA
http://puuoo.caltech.edu/dsos/DSOS_MLeong.html

The Caltech Submillimeter Observatory (CSO) Submillimeter Active Optics System is an open loop actively updating system that corrects the dish surface figure for imperfections and gravitational deformations as the dish moves in elevation during observations. This improvement in the telescope's aperture efficiency aids observations in the shorter wavelengths, specifically in the 350-μm-wavelength range. Empirical measurements, attention to detail, and perseverance were the keys to the success of this unique system.

The Dish Surface Optimization System (DSOS) was designed and built to operate at the CSO, on Mauna Kea, Hawaii. The CSO's primary is part of a Robert Leighton telescope design, consisting of 84 hexagonal panels forming a 10.4-meter primary dish. There are 99 steel rod standoffs that interface the backing structure to the back of the primary. It is on these standoffs where heating and cooling assemblies are mounted and implemented to lengthen or shorten the standoffs to desired lengths. Holography maps were used to build a correction table to determine the amount of length change and their locations on the primary. Implementation of thermal electric devices enables the adjustability for each standoff.

The benefits of an open loop system are the degrees of freedom each standoff can be acted upon. When the DSOS is off, the primary moves back to it's originally tuned shape. It is potentially faster than a closed loop system. With well developed lookup tables, distortion feedback electronics are not needed. It is less expensive. It is simpler. This system works.

From holography, the latest measured optimum surface accuracy of the telescope is less than 10 μm RMS, with the DSOS on. Measurements taken by the 850 GHz Heterodyne Receiver yielded the best percent improvement in signal gain of 71% with an average improvement of 60% over a zenith angle range of 22 to 63 degrees. These improvements translate to an aperture efficiency of 68% in the 350-μm-wavelength range. Before the DSOS, the aperture efficiency was 33%.

Signal gain and FWHM performance measurements were taken with the SHARCII and 850 GHz Heterodyne Receiver on the CSO's cassegrain platform mount. (The SHARCII is a 384-pixel Submillimeter High Angular Resolution Camera.) Since then, their mounting location has changed from the cassegrain behind the primary, to a second Nasmyth location, N2. N2 is off to the right behind the primary. Preliminary performance improvements have been found to compensate for the new mounting location. More measurements are needed to determine proper revisions to the correction tables. The change in performance could be due to the added weight of the N2 platform and the new optical path to the instruments on it. Even with the decreased performance out on N2, the SHARCII still benefits when the DSOS is on.

The DSOS has been in operation since February 2003. Since then, new discoveries of weak and/or distant objects and never before seen details of known objects have been obtained with the help of this active optics system.