https://ntrs.nasa.gov/search.jsp?R=20100005251 2018-03-23T11:35:33+00:00Z

Physical Sciences

Integrity Monitoring of Mercury Discharge Lamps

NASA's Jet Propulsion Laboratory, Pasadena, California

Mercury discharge lamps are critical in many trapped ion frequency standard applications. An integrity monitoring system can be implemented using end-of-life signatures observed in operational mercury discharge lamps, making it possible to forecast imminent failure and to take action to mitigate the consequences (such as switching to a redundant system). Mercury lamps are used as a source of 194-nm ultraviolet radiation for optical pumping and state selection of mercury trapped ion frequency standards. Lamps are typically fabricated using ^{202}Hg distilled into high-purity quartz, or other 194-nm transmitting material (e.g., sapphire). A buffer gas is also placed into the bulb, typically a noble gas such as argon, neon, or krypton.

The bulbs are driven by strong RF fields oscillating at ≈200 MHz. The lamp output may age over time by two internal mechanisms: (1) the darkening of the bulb that attenuates light transmission and (2) the loss of mercury due to migration or chemical interactions with the bulb surface. During fabrication, excess mercury is placed into a bulb, so that the loss rate is compensated with new mercury emanating from a cool tip or adjacent reservoir. The light output is nearly constant or varies slightly at a constant rate for many months/years until the mercury source is depleted. At this point, the vapor pressure abruptly falls and the total light output and atomic clock SNR (signal-to-noise ratio) decrease. After several days to weeks, the light levels decrease to a point where the atomic clock SNR is no longer sufficient to stay in lock, or the lamp self-extinguishes.

This signature has been observed in four separate end-of-life lamp failures while operating in the Deep Space Network (DSN). A simple integrator circuit can observe and document steady-state lamp behavior. When the light levels drop over a predetermined time interval by a specified amount (e.g., 20 percent), an alarm is set. For critical operational applications, such as the DSN or in space flight, this warning provides notice that a failure may be imminent, and for operators or control algorithm to take action.

This work was done by Robert L. Tjoelker of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45650

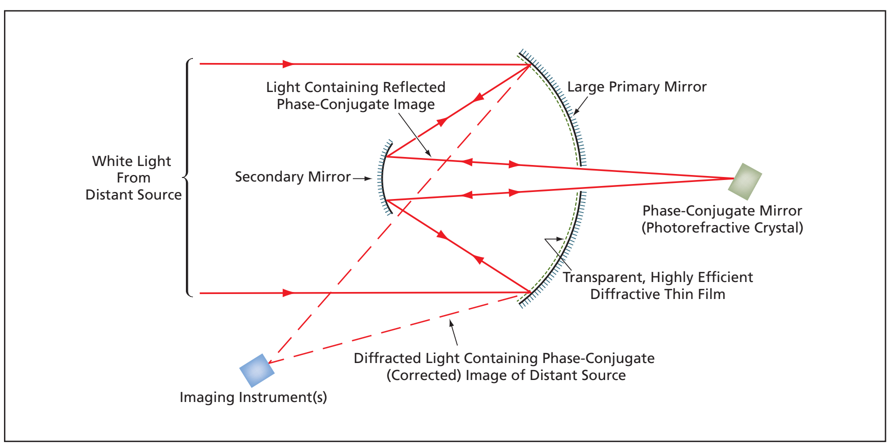
White-Light Phase-Conjugate Mirrors as Distortion Correctors

Optical aberrations of large optical components could be corrected relatively inexpensively.

Marshall Space Flight Center, Alabama

White-light phase-conjugate mirrors would be incorporated into some optical systems, according to a proposal, as means of correcting for wavefront distortions caused by imperfections in large optical components. The proposal was given impetus by a recent demonstration that white, incoherent light can be made to undergo phase conjugation, whereas previously, only coherent light was known to undergo phase conjugation.

This proposal, which is potentially applicable to almost any optical system, was motivated by a need to correct optical aberrations of the primary mirror of the Hubble Space telescope. It is difficult to fabricate large optical components like the Hubble primary mirror and to ensure the high precision typically required of such components. In most cases, despite best efforts, the components as fabricated have small imperfections that introduce optical aberrations that adversely affect imaging quality.



A **Phase-Conjugate Mirror** would be added to a conventional primary-and-secondary-mirror telescope in the position ordinarily occupied by the imaging instrument(s). A transparent diffractive thin film would also be added to the primary mirror. The phase-conjugate (corrected) image would be diffracted onto the repositioned imaging instruments.

Correcting for such aberrations is difficult and costly. The proposed use of white-light phase conjugate mirrors offers a relatively simple and inexpensive solution of the aberration-correction problem. Indeed, it should be possible to simplify the entire approach to making large optical components because there would be no need to fabricate those components with extremely high