

A Robust, Symmetric Grating Angular Sensor for Space Missions

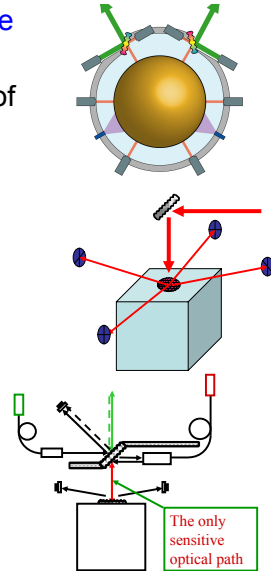
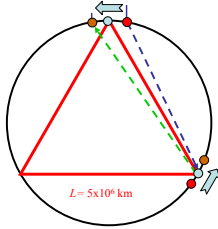
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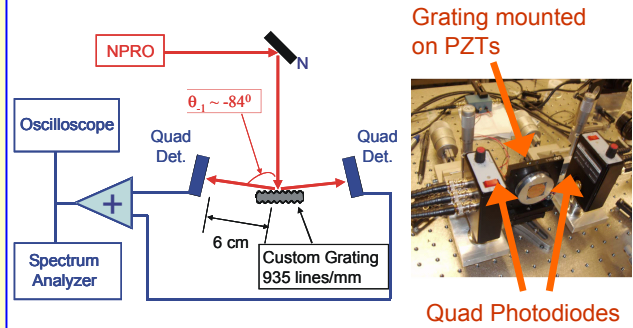
Angular Sensing Applications

- Gravitational Reference Sensor
- Cubic or spherical proof mass orientation
- Telescope steering
- Point ahead angle actuation
- Laboratory rotation measurements

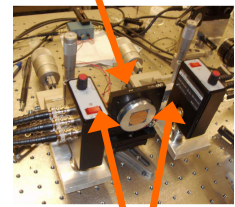


Experimental Setup

- Custom designed holographic grating
 - 935 lines/mm
 - +1/-1 orders diffract at 84°
- Quad photodetectors on *two* sides
- Combination amplifier to maximize signal, canceling common mode noise

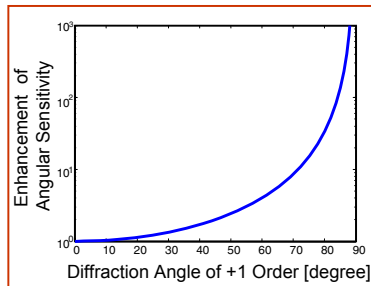


Grating mounted on PZTs



Quad Photodiodes

Grating Enhancement of Angular Sensitivity

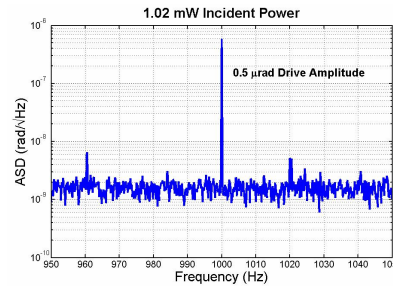


- Grating angle amplification
- Beam cross section compression

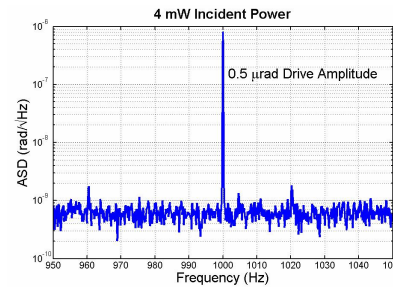
$$P_m = K' \left(\frac{\cos(\theta_m)}{\cos(\theta_{in})} \right)^2 P_{in}$$

Angular Sensitivity Measurements

1 nrad/Hz^{1/2} or better demonstrated



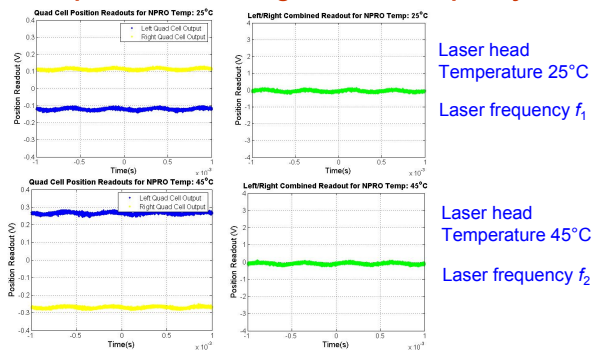
- 1 mW Input power
- Noise floor < 2 nrad/Hz^{1/2}



- 4 mW Input power
- Noise floor < 1 nrad/Hz^{1/2}

Two-Side Detection Enhances Common Mode Noise Rejection

Example: Robustness against laser frequency noise



Single side detector outputs shift

Combined output of two detectors stay stable

Future Work

- LISA sensor applications
- 2-D grating sensor
- All reflective grating displacement and angular sensor
- Explicit low frequency measurement

Acknowledgement: We thank the help from Graham Allen and Aaron Swank in data acquisition.

The research is partially funded by JPL DRDF program. Dr. Robert Spero is our JPL PI.

Reference: Ke-Xun Sun, Sasha Buchman, Robert L. Byer, "Grating Angle Magnification Enhanced Angular and Integrated Sensors for LISA Applications," *Journal of Physics CS*, 32:167-179, 2006.