Prototype Superconducting Lunar Telescope Mount; **[1]Mark Lamb, Ki Bu Ma, Rodger Cooley, Daniel Mackey, Ruling Meng, Ching Wu Chu, Wei-Kan Chu; [2]Peter C. Chen; and [3]Thomas L. Wilson. [1]Texas Center for Superconductivity, University of Houston, Houston, Texas. [2]Computer Sciences Corporation, Calverton, Maryland. [3]NASA Johnson Space Center, Houston, Texas.**

A prototype high-temperature superconducting (HTS) bearing mount for a light-weight (<20kg) lunar telescope has been developed in the laboratory (Figure 1) [1]. It consists of hybrid superconducting magnetic bearings (HSMB) which are a natural candidate for operation in the extended lunar nights (14.5 Earth-nights) where ambient temperatures are 84°-102° K, easily within the range of existing HTS technology [2]. These bearings are passive (requiring no active cryogenic thermal control), ceramically stable, light, and frictionless.

Conventional bearings will not work well for long periods on the Moon, because the ambient night-time temperature is very low and lubricants tend to freeze. Since the ambient pressure is zero, this will cause the process to happen more rapidly. Furthermore, lunar dust will migrate into conventional bearing or actuation systems on the Moon and degrade their performance. For the HTS bearing, on the other hand, these ambient conditions are harmless and even beneficial. The ambient temperature is below the superconducting temperature T_c, making the HTS magnetic bearing work, and the zero ambient pressure eliminates aerodynamic drag on the bearing assembly (which otherwise slows it down on Earth). Because the HTS bearing is a levitation bearing, it has a gap of a few millimeters and the problem of lunar dust mitigation is virtually eliminated.

To track the position of an object across the celestial sphere, the telescope must be able to change orientation as the Moon rotates in inertial space. The bearing module discussed here is an azimuth mount providing free rotation about the vertical gravitational plumb line on the lunar surface. Its detailed construction has been described elsewhere [1]. The relevant performance parameter at this phase of the present study has been the degree of steadiness with which the telescope maintains its line of sight to the target, providing a desired pointing accuracy smaller than the spatial resolution of the telescope which has been assumed for these purposes to be 0.1 arcsecond.

The HTS bearing performance has been measured, and is reported as follows.

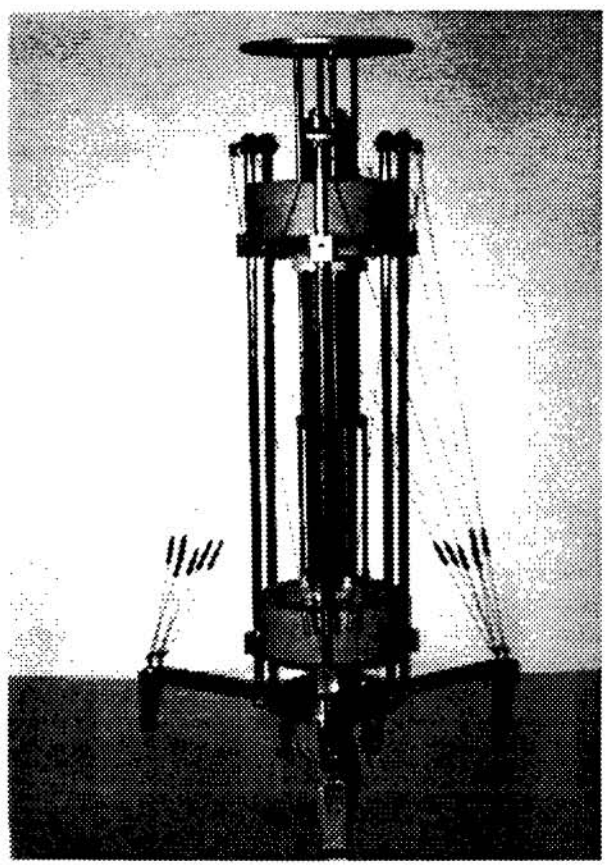

Fig. 1. The prototype HTS bearing module. Lunar telescope to be mounted on the platform at top of levitating assembly (1.0 m x 0.5 m).

HTS System Stability

The axial force as a function of axial separation distance is shown in Figure 2. The curves represent the force response of the bearing at four different field-cooled gaps (using liquid nitrogen) between the HTS and rotor magnet obtained by adjusting the position of the cold stage along the support truss. For an initial measurement of the stability, the HTS gap was set arbitrarily at 8 mm giving a total axial stiffness of 10 N/mm

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(60 lbs/in) to the entire assembly. As can be seen in Figure 2, a 6 mm gap will double this number and, as is well known, the smaller the gap, the higher the stiffness. If necessary, a much higher stiffness can be obtained from this prototype module.

Pointing Accuracy

To measure the steadiness, the telescope module was prepared on a laboratory floor with the addition of a very small maqnet, approximately 10 mm^3 in volume, to one of the rotor magnets on the side facing the HTS. This served to add friction to the bearing in order to keep the assembly from rocking back and forth during measurement. The entire assembly has been observed to spin continuously under its own inertia for over 45 minutes after being

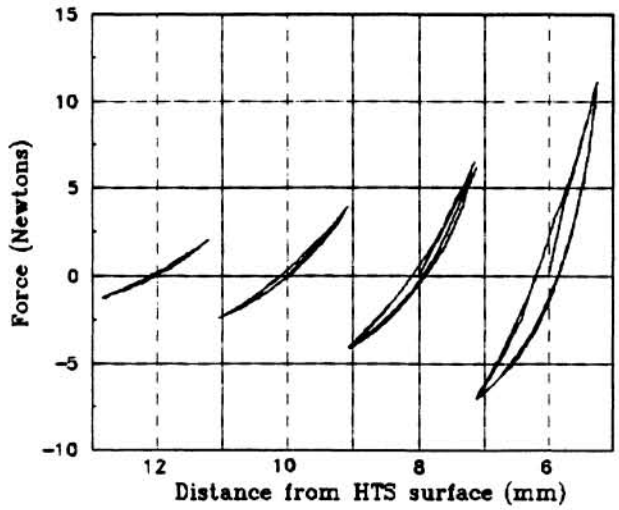

Fig. 2. The field-cooled axial force vs axial separation between rotor magnet and HTS, at gaps of 12 mm, 10 mm, 8 mm, and 6 mm.

started by hand, and will rock back and forth about the azimuthal plumb line due to small drafts of air.

Laser observations of the pointing direction, reflected off of a mirror (mounted on the platform) to an x-y position sensor, were made for various time-scales. A typical trace for the laser spot is reproduced in Figure 3. The spot size, measured as the standard deviation of the angular position from the mean, as a function of the total observation period, was determined to increase monotonically, from about 0.2 arcseconds after 8 msec of time to 4 arcseconds after 32 sec of time.

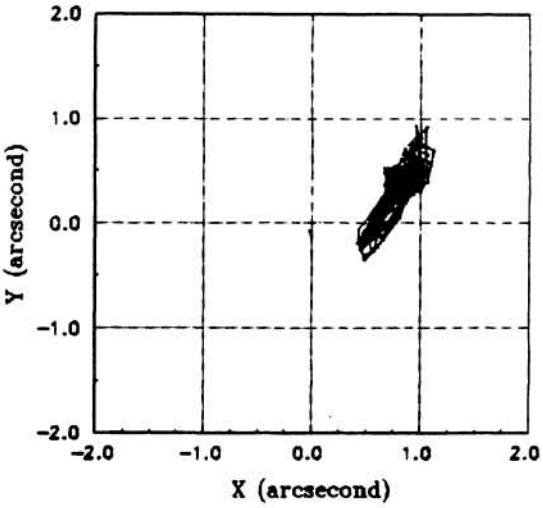

Fig. 3. Trace of reflected laser spot angular position for observation period of approximately 0.5 sec.

Conclusions

This prototype study has demonstrated that an HTS bearing is a "natural" candidate for the lunar-based environment. However, before the telescope can track stars, the drive mechanism and its associated control system still have to be developed and integrated into the bearing module. The next phase of the study hopes to focus upon this problem while attempting to reduce the bearing to its minimum practical size. The larger size illustrated in the laboratory prototype of Figure 1 (approximately 1.0 m high and 0.5 m in cylindrical diameter) was due to the brief period of developmental time (45 days) used to construct it.

References

[1] Lamb, M., *et al.*, in *IEEE Trans. on Appl. Superconductivity*, to appear (1995). [2] Wilson, T.L., Chu, W.-K., and Chen, P.C., *Lunar and Planetary Science XXV*, Vol. **3**, 1501 (Lunar and Planetary Institute, Houston, 1994).