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A new type of telescope pointing system designed specifically for space and lunar applications will be discussed, based upon a prototype advanced technology telescope [1,2] under investigation. The focus here will be the system of hybrid superconductor magnetic bearings (HSMB) used to provide isolation support and steering functions. HSMB's are combinations of high temperature superconductors, permanent magnets, and coils, being passive (requiring no power), noncontact, and essentially frictionless. These also are well suited to long-term unattended operation in the space environment. The characteristics of these subsystems, their expected behavior under space vacuum, and thermal and radiation environments are discussed.

The prospect of important new technology emerging from the discovery in physics of high-temperature superconducting (HTS) materials [3,4] has important implications in its space applications. A recent record-high HTS temperature was 150° K [5], and that has since reached 164° K. Although one common goal of research in HTS material is to find a "room-temperature" superconductor, it has become increasingly obvious that the deep-space "cold-soaked" environment of many spacecraft is within reach of several of the existing record-high HTS temperatures.

One pertinent application would be the Moon or lunar orbit. A summary of the lunar surface temperature environment is given in Table I.

Table I. Approximate Lunar Surface Temperatures

	Apollo 15	Apollo 17[6]	Earth-Based Measurement[7]	Polar[8]
Maximum	374° K	384° K	380° K	84° K
Minimum	92° K	102° K	104° K	

From these data, one can surmise that the ambient thermal environment supports HTS material during the lunar night, but that a telescopic HTS system would have to be actively cryogenic in order to operate during the lunar day. Alternatively, the system could be totally passive and forego daytime operations, provided there were protective conventional bearings (pseudo-bearings) within the design when the HTS components cycle in and out of their superconducting state. For the polar case in Table I, within permanently shadowed craters or with appropriate light baffling/shielding, the ambient temperature may be as low as 40°-50° K.

Based upon early, preliminary prototypes of Meissner quadrupole bearings [9], hybrid superconductor magnetic bearings (HSMB's) have been designed, and are illustrated in Figure 1 for a telescope's azimuth. The proposed ultra-lightweight telescope utilizes such HSMB's. The related telescope structure is made from very lightweight but stiff silica-alumina composite material recently developed by NASA Ames. This will reduce the mass of the instrument considerably, which is estimated to be <20 kg for a fully steerable 1-meter telescope.

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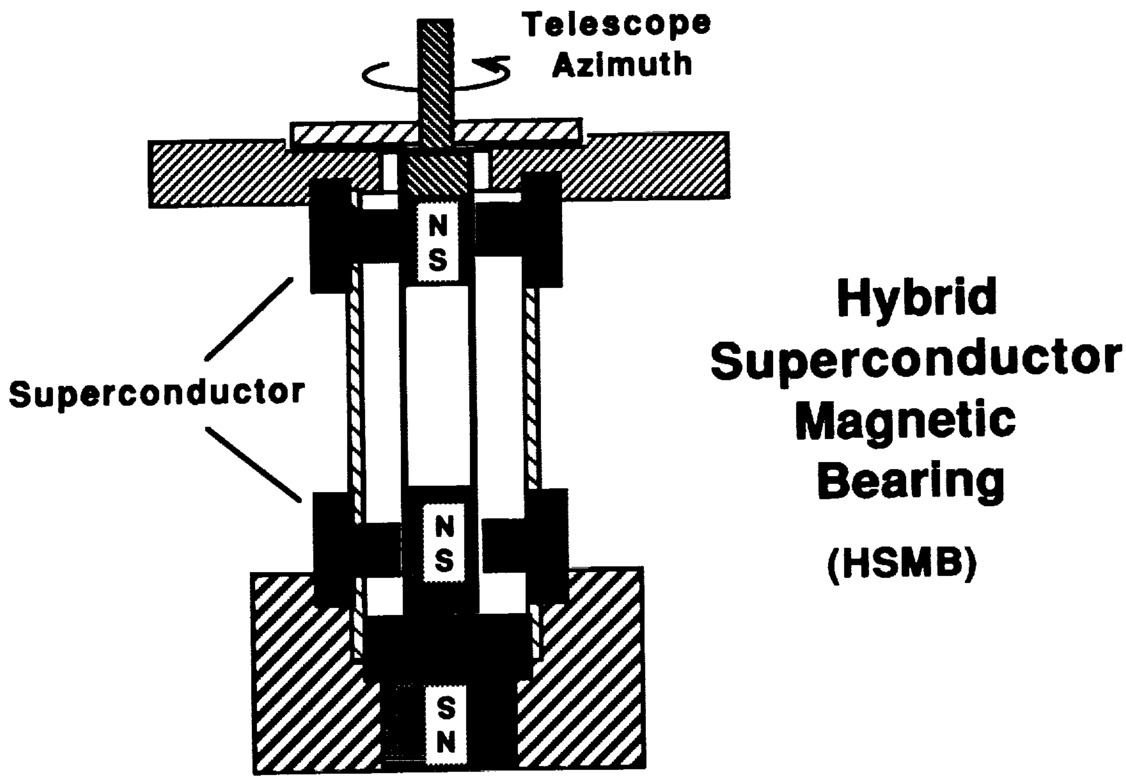

Figure 1

The HSMB's in Figure 1 comprise the three-degree-of-freedom actuation system for pointing the instrument in azimuth and elevation. In the passive thermal mode, they require no power and are frictionless in a vacuum (since only an atmosphere can apply a frictional drag). Due to the light weight or mass of the instrument, a highly accurate pointing capability is envisioned by employing a CD-ROM-drive or disk-drive type of actuation feedback control system on the HSMB's.

In conclusion, this discussion shows that an ultra-lightweight superconducting telescope is a feasible application for several space-based environments. Its reduction in weight and inertia is consistent with the proposal for smaller automated robotic lunar telescopes and light-weight beryllium mirrors, while its improved bearing design preserves the small, classical research telescope as a viable candidate alongside transit concepts [10] or Hubble era technology [11].

References

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