A Telescope on the Moon using Moon Dust and Superconductors

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Abstract

The lunar environment is unique. Nights on the Moon are long. The motion of stars across the lunar sky is therefore extremely slow. Temperatures can be very cold, ranging from ~35ºK to 100ºK. Power availability is limited. Furthermore, telescopes on the Moon - unlike in space - can potentially last forever.

Telescopes and other pointing instruments on the Moon, whether implemented by humans or by robots, therefore require precision pointing systems uniquely suited for the lunar environment.

We report progress in the development of High Temperature Superconductor bearings for lunar telescopes. In addition to telescopes, these bearings can also accommodate other instruments ranging in size from decimeters (laser communication systems), meters (communication dishes, optical interferometers, solar panels), to decameters and beyond (VLA type radio interferometers).

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Why Telescopes on the Moon?

Astronomers since the time of Galileo and Herschel have recognized the Moon as the nearly ideal place for an astronomical observatory:

- Large area stable platform
- No atmosphere = no absorption
- low but nonzero gravity
- proximity to Earth
- Long dark times (infinite in polar craters, 14 days elsewhere)
- Permits extremely high resolution optical interferometry*
- Coldest place (35K) in the solar system for infrared astronomy*
- Resources to build extremely large telescopes*

* The last three items are unique to the Moon

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Special Requirements for Moon Telescopes

On the Moon the nights are long (14 days), and temperatures range from 100K to 30K inside shadowed craters. Telescopes on the Moon therefore require bearing systems that can position and track precisely over long time periods, preferably with no maintenance and would not fail with loss of power.

Normal mechanical bearings and lubricants do not function well under these conditions.

We report progress in the development of a new type of bearing mechanism for lunar telescopes based on High Temperature Superconductors.

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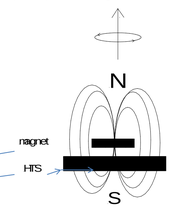
High Temperature Superconductor (HTS) Bearings

Left: Sisters Hannah and Sarah Keyes having fun with levitation and flux pinning of a magnet by a high temperature superconductor (HTS) (Photo P. Chen)



A HTS bearing consists of a permanent magnet and a high Tc bulk superconductor. A unique phenomenon known as 'flux pinning' attaches the two together, almost physically but without contact. The system is passive and has no wear. If the magnetic field has rotational symmetry the magnet can turn freely about its axis of symmetry. This is the basis for HTS bearings.

Artist's concept of a large telescope on the Moon using HTS bearings

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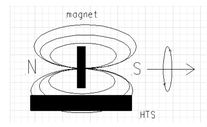
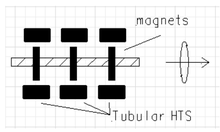
Our Idea

Use HTS Bearing with Horizontal Axis of Rotation



A magnet with a horizontal magnetic axis can rotate freely above a HTS base.



HTS bearings with horizontal axes can increase load capacity by joining multiple units on the same axle. This process can be extended indefinitely.

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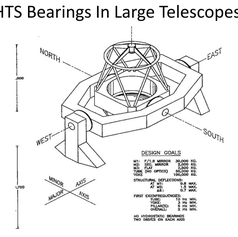
Using HTS Bearings In Large Telescopes



A telescope mount that uses bearings with horizontal axes ('trunnion bearings') is the altitude-altitude (alt-alt) design. This concept has been studied in the past but has not seen much use. The drawing shown is a design by Richardson et al. for a 8m ground telescope. The four bearings, which are driven together, are located at the cardinal points E-W-N-S.

Ref: Richardson, E.H., Grundmann, W.A. & Odgers, G.J. (1990) "Altitude-altitude (alt-alt) mounting for an 8-metre telescope", Proc. SPIE 1236, 896-900.

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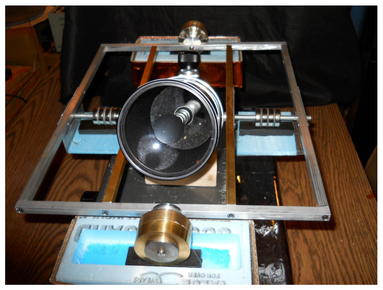
A Prototype Alt-Alt Telescope with HTS Bearings



A proof-of-concept alt-alt telescope nearing completion at NASA GSFC. The optical tube assembly is a Questar telescope. The first stage bearings (middle of picture) consist of multiple ring magnets with iron spacers above superconductors (black rectangular blocks). The lower stage bearings(foreground) use a pair of radially magnetized NeFeB magnets.

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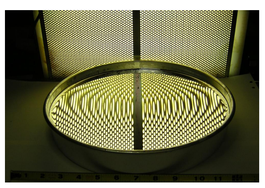
Moon Dust Telescope Mirrors



We are developing the technology to make telescope mirrors using lunar regolith simulants and epoxy. The objective is to demonstrate that extremely large (10 to 100 meter) telescopes can be made on the Moon using local resources.
Left: A 30 cm parabolic mirror made by spincasting
Right: Two sisters holding a spincast moondust mirror.

Acknowledgements

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