Kinetic Friction at Cryogenic Temperatures

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Cryogenics

Cryogenics is the science of producing and studying low-temperature conditions. It comes from the Greek word *Cryos*, meaning “cold” and the shortened English verb “to generate”. It applies to temperatures from approximately -100°C down to absolute zero (-273°C = 0K)

In the 19th century the development of air-cycle refrigerators to preserve food evolved into the liquefaction of permanent gases by scientists. The last element to be liquefied was Helium at a boiling point of 4.2 K.
The mechanical properties of many materials change dramatically when cooled to 100 K or lower. For example plastics and rubber become brittle and metals lose their electrical resistance (superconductivity).

Applications

New technologies in cryogenic applications like superconductors as well as practical applications such as transportation, astronomy (see fig.1), metallurgy and medicine lead to a growing interest in research for tribological properties at low temperatures.

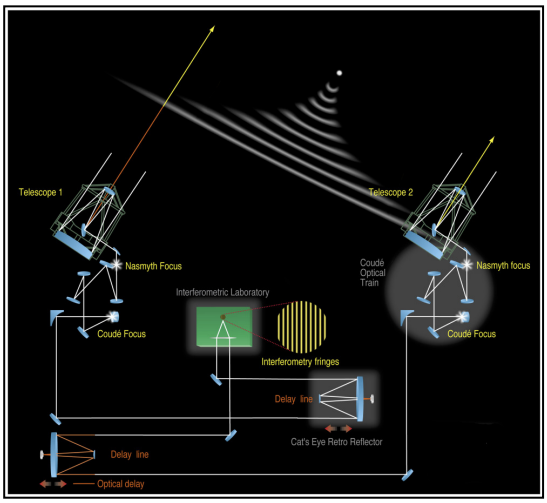

Figure1: Very large telescope interferometer (ESO)

These conditions of ultrahigh vacuum (<10^{-7} mbar) and cryogenic temperatures result in some unique tribological problems.
At low temperatures liquid lubricants will freeze or become too viscous. Furthermore, protective oxide layers formed under ambient conditions will not be restored.

Experiments

In order to measure material properties and friction in a cryogenic environment a friction tester is developed which makes it possible to measure friction forces, hardness and adhesion in vacuum at temperatures down to 60 K.

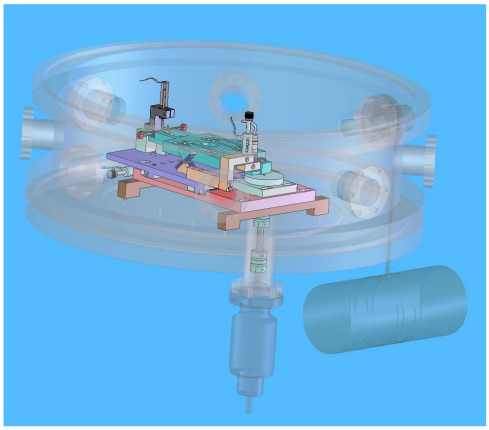

Figure 2: Cryogenic-vacuum tribotester

Model

The existing friction models describing the role of adhesion, deformation and shear of interfacial layer will be extended to include the influence of low temperatures and vacuum.

References

[1] Th.M. Flynn, Cryogenic Engineering, Marcel Dekker, 2005.

[2] Ye.L.Ostrovskaya, Low temperature tribology at the B. Verkin Institute for Low temperature Physics & Engineering, Tribology International 34, 2001.