IAF SPACE EXPLORATION SYMPOSIUM (A3)
Space Exploration Overview (1)

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ASYMMETRIC FRICTION LOCOMOTION FOR DEEP EXPLORATION OF EXTRATERRESTRIAL BODIES

Abstract

One of the challenges of deep exploration of geology of extraterrestrial bodies is the necessity to use deep boreholes. Borehole drilling requires heavy equipment, periodic drill string lifting and drill bit replacement, which still requires manual labour. On top of that, the drilling equipment relies on gravity, which prevents its use on the bodies with microgravity.

We propose to utilise the natural fractures, where available, to reach the body interior by using flexible locomotion devices. Such a locomotion device can utilise asymmetric or directional [1] friction, that is a phenomenon of developing markedly different friction forces resisting the movements in opposite direction. Asymmetric friction effect can be achieved by using anisotropic blocks with an anisotropy axis inclined to the direction of sliding; when moving in a constrained environment the inclined anisotropy produces different compressive stresses when moving in opposite direction thus imposing different friction forces. The blocks can be made of inclined flexible layers thus delivering sufficient flexibility to negotiate the interior of natural fractures. (A similar locomotion principle is now understood to be realised in living nature.)

The proposed device consists of two asymmetric friction segments with an oscillating mass in between. The oscillations can be enforced either by an internal engine or through external vibrations, surprisingly even by the tidal effect. In the latter case the slow locomotion will allow collection and transmission of the geological data. Furthermore, such a device will provide a method of utilising renewable tidal energy.

Potentially these locomotion devices can also be employed for delivering strengthening or cementation agents into the fracture thus forming ground competent enough to serve as foundation for permanent bases.

1. Bafekrpour, E., A.V. Dyskin, E. Pasternak, A. Molotnikov and Y. Estrin (2015), Internally architectured materials with directionally asymmetric friction. Scientific Reports, 5, Article 10732.