



Contribution ID: 6

Type: Oral Presentation

Expansion of the Radar Link Budget Equation: Improving the number of estimated Lunar Laser Ranging returns for the HartRAO-LLR station

Thursday, 28 June 2018 11:20 (20 minutes)

The Lunar Laser Ranger (LLR) system under development at HartRAO in South Africa will be used to measure the Earth-Moon distance through the use of laser pulses, single photon detection system and other system components. The Earth-Moon distance measurements is achieved through accurate measurements of the round trip time-of-flight (TOF) of each returned laser signal, which is weak. At HartRAO, laser pulses will be transmitted through a 1 metre aperture optical telescope directed to hit one of five lunar reflector arrays (also known as retroreflectors) placed on the Moon between 1969 and 1973. The returned signal is expected to be reflected from a targeted lunar array and thus received through the Earth “fixed” optical telescope. The existing radar link budget equation is normally used to estimate the number of returned photons from a laser pulse aimed to hit a suitcase sized reflector array mounted on the Moon. In this work, the existing radar link budget equation is expanded to improve the estimations of the number of returned LLR photons: this has a direct relationship with the total LLR system efficiency. An improved LLR system reduces adverse effects such as beam divergence on the transmitted laser beam that result from atmospheric thermal and density fluctuations.

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Session Classification: Space Science

Track Classification: Track D2 - Space Science