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TARGET ACQUISITION AND TRACKING OF EXTREMELY LONG DISTANCE TARGETS USING MULTIPLE RISLEY PRISM SYSTEMS

Abstract

Recently, the need arose for a mounted optical system that can detect the location of a distant object and track its movements, for application on the LISA gravitational wave detection experiment. In response, our team has designed and built a dual Risley prism system for high speed target acquisition and tracking. This system was designed to be robust enough to monitor the dynamics of a medium sized object up to 2.5 Gm away, as needed for the interferometer arms. Various design alternatives were also analysed to increase the versatility of the device, including for applications in free space optical communications, defence, high speed internet, astronomy, and more.

The operation of the device is conceptually simple. A 1064 nm laser is directed into a dual Risley prism system with 10° angle of deflection input faces. By rotating the prisms coaxially in the same or opposite directions at different speeds, a scan pattern is traced out across the field of interest. When the laser hits the target, a retroreflector sends a signal back, giving a timestamp of the point in the scan that the target was hit by the laser. The Risley prisms are then rotated back to the position they were in at that timestamp to find where the target was. In most cases, this would then lead to a more fine scan about this new point of interest, considering expected target dynamics, until the target is acquired.

At this stage, only proof of concept testing has been undertaken. Dynamic simulations with differing levels of simulated noise and disturbance have been written, and the results produced are promising, even when the deleterious effects are greatly exaggerated. Preliminary optical table based experiments have also been run, with early data closely matching that from simulations.

While the current Risley prism set up had reasonable success in simulation, as well as in the laboratory and other controlled conditions, there is uncertainty about how this setup will transfer to practical application. Testing is planned to soon be undertaken in experimentally controlled simulated turbulence soon, before being tested in more challenging situations, like long distance laser ranges at local facilities and on tracking low altitude drones.