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# Optical instruments for space-to-ground laser communication

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Satellite-based communications and services have become a critical piece of infrastructure for our modern society by enabling a range of new bandwidth hungry applications. Communication from space using radio-frequency communication bands have been critical infrastructure for remote operations including scientific data transfer, defence operations, aircraft communications for safety, and maritime connectivity. Current radio-frequency technology is reaching the limit of its capacity to transmit an increasing volume of data from space, such as from the next generation of space science including space telescopes for astronomy, Earth observation, and crewed missions to nearby planetary bodies scheduled for this decade.

Optical communication to space is an emerging technology that promises to similarly revolutionise space-based data transmission and communication [1]. Demonstrations from global leaders including the German Aerospace Centre (DLR) [2], NASA [3], European Space Agency (ESA) [4] and Japan Aerospace Exploration Agency (JAXA) [5] have successfully demonstrated the concept and fundamental technology behind transmitting optical space-to-ground signals. Commercial entities are currently engaged for inter-satellite optical links with the market leader Tesat SpaceCom conducting thousands of optical links from low Earth orbit Sentinel satellites to geosynchronous satellites [6]. I present an overview of advanced optical instruments and technology under development at the Australian National University (ANU) to aid the deployment and maturation of space-based optical communication.

The majority of space-based optical communications today are inter-satellite links to aid in data relay. While the focus has been on satellite optical communication technology there are, however, very few optical communication ground stations to receive data from space-based laser communication equipped satellites. This lack of access to optical ground stations is preventing growth of the space-based optical communications market with direct ground station access. ANU is building a dedicated optical ground station to address this issue, with the specific aim of providing both research and commercial access to hardware to drive technology and industry growth.

The ANU has decades of experience in building and deploying world-leading optical instruments for astronomy, telescopes, space situational awareness [7], and adaptive optics. ANU has an Advanced Communication research program which includes development of optical instruments for high-speed optical and quantum communication to and from space.

Adaptive optics (AO) are required to improve transmission of optical signals through the atmosphere in the presence of atmospheric turbulence [8]. ANU is developing an advanced adaptive optics system capable of both projecting and receiving optical signals to and from low Earth orbit and into deep-space. This system will be optimised for physical size and cost so that it can be deployed on a future optical ground station networks to enable a global quantum communication network [9].

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