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Towards space-to-ground coherent optical links for space science and communications

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The transmission of optical signals over free-space laser links, particularly between satellites and the ground, will revolutionize applications ranging from fundamental and applied sciences to satellite navigation and communications. However, the measurement precision and data rates of free-space laser links are severely limited by scintillation and phase fluctuations caused by atmospheric turbulence. We report on recent developments by the Astrophotonics research group at the International Centre for Radio Astronomy Research on advancing technologies for coherent free-space laser links. Specifically, we are developing active-optics equipped laser terminals and optical phase stabilization systems to overcome the limitations imposed by atmospheric turbulence and enable the transfer of high-precision optical and microwave frequencies for space science applications, and more robust free-space coherent data communications.

We have demonstrated phase-stable optical frequency transfer across a 2.2 km horizontal link through the atmosphere, without active-optics, achieving a fractional frequency stability of 2×10^{-18} at 600 s of integration time, sufficient for the comparison of atomic clocks [1, 2]. This optical frequency transfer technique has been expanded into a dual optical- and microwave-frequency stabilization system. The performance of the active-optics terminals has also been characterized over this 2.2 km link. The performance of the combined phase stabilization and active-optics systems has been tested over a 300 m point-to-point link between buildings in collaboration with the French space agency, CNES. With support from the SmartSat Coorperative Research Centre [https://smartsatcrc.com/], we are working towards demonstrating phase-stable optical frequency transfer, and high-rate data transmission, across 10 km horizontal and 5 km vertical free-space links to develop the capability for ground-to-space transmission.

Figure 1. Optical terminal for the free-space phase-stabilized frequency transfer system.

References

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