Seismic-isolation-chain displacement sensing using Digital Interferometry

Y. Zhang [a,b], S. S. Y. Chua[a,b] and B. J. J. Slagmolen[a,b]

[a] *Centre for Gravitational Astrophysics, The Australian National University, ACT 2601, Australia*

[b] *ARC Centre of Excellence for Gravitational-wave Discovery (OzGrav), ANU, ACT 2601, Australia*

Future interferometric gravitational-wave detectors, such as the Cosmic Explorer [1] and the Einstein Telescope [2] will expand the detectable bandwidth to frequencies below 10 Hz. The relative displacement motion of seismic-isolation-chain platforms, via coupling to the auxiliary length controls of the interferometers, are predicted to be a limiting noise source at these frequencies [3]. By measuring and stabilizing the relative displacement motion, it will lead to improved low-frequency performance.

Digitally-enhanced Interferometry [4] is a displacement measurement technique using time-tagged pseudo-random phase modulation to isolate signals based on time-of-flight delay. Over the past decade, this technique has developed and seen application from multiplexed sensing [5] to Light Detection and Radar (LIDAR) [6]. We will present the advantages, sensitivity targets and latest prototype developments towards a digitally-enhanced interferometric sensor for seismic-isolation-chain displacement measurement.

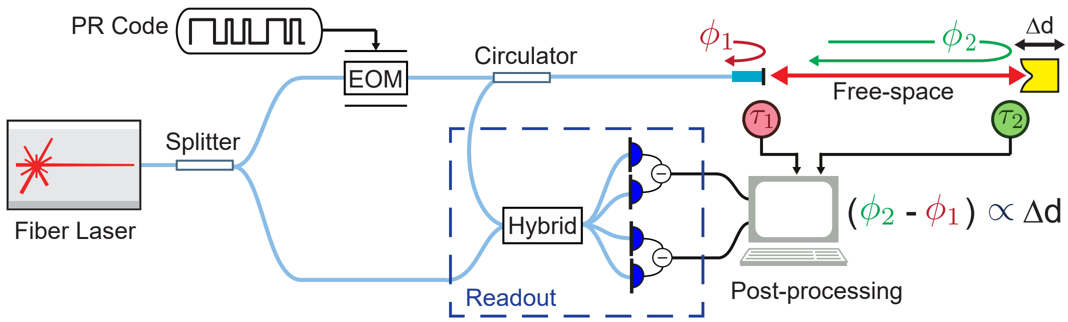

Figure 1: Simplified sensor schematic. The pseudorandom modulation (PR Code) is phase-encoded on to the light using an electro-optic modulator (EOM). By knowing time-of-flight delays (τ_1, τ_2), we can isolate the reflected phase signals (ϕ_1, ϕ_2) in post-processing and determine relative displacement (Δd).

[1] E. D. Hall et al. *Phys. Rev. D* **103** 122004, (2021)

[2] M. Punturo et al. *Class. Quantum Grav.* **27** 194002, (2010)

[3] Y. Aso et al. *J. Phys.: Conf. Ser.* **32** 451, (2006)

[4] D. A. Shaddock, *Opt. Lett.* **32**, 22 (2007).

[5] Y. Zhang et al. *Opt. Exp.* **27**, 13 (2019)

[6] C. Sambridge et al. *Opt. Exp.* **29**, 16 (2021)