This talk will outline a new approach to mitigating Brownian coating thermal noise in optical cavities using multiple higher order TEM gaussian modes [1]. Optical cavities are the gold standard in laser frequency feedback and control but are bounded in their ultimate stability by the random $1/\sqrt{f}$ thermal motion in their thin film reflective coatings. By blending the readout signals of multiple higher order modes incident on the cavity, the effective sampling area of laser mirrors is increased. This improves the averaging of localised random thermal motion, thereby lowering the overall length noise sensed. We propose scheme where a top-hat like beam is effectively synthesised from a carefully weighted combination of signals fed back to a laser. We will present results of a theoretical study into this new sensing scheme and plans for an experimental implementation.

We will show that an experimentally feasible implementation of a three-mode lock – combining modes TEM$_{00}$, TEM$_{02}$, and TEM$_{20}$ – can reduce overall coating thermal noise by a factor of 1.6, equivalent to cooling the mirrors to 120 K. Such improvements are in addition to advancements in materials, cryogenics, cavity lengths, and shortened wavelength approaches.

We will also outline the achievable bounds on thermal noise improvements for many higher order modes (more than three) and prospects for implementation in the laboratory.