Ultra-Sensitive Tilt Displacement Measurements using Photonic Gear

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Precise measurement of angular tilt is critical in a wide range of applications, from advanced metrology to precision alignment and surface profile measurements. Optical techniques are particularly advantageous for angle measurements due to their non-contact nature, which is well suited for delicate or deformable components.
In this work, we demonstrate a compact and ultra-sensitive method for measuring tilt displacements by harnessing the optical encoding concept of photonic gears [1]. The technique generates a NOON-like photonic state, in which a small angular tilt is mapped into the relative phase acquired during the recombination of polarisation components on double pass through a polarisation grating or g-plate. This acquired phase results in an amplified polarisation rotation of the initial linearly polarised light. The resulting power response measured after a polariser follows a super-resolving Malus' law behaviour, with its linear region used for sensitivity extraction. Using a low power laser source, we measured tilt displacements with a maximum sensitivity of 290 ± 18 μW/mrad [2]. The proposed approach offers excellent stability, compactness and ease of implementation while relying on cost-effective optical elements. Our results may have a significant impact on research and industry, particularly in the development of advanced metrological systems.

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References

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