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Towards Intelligent Mirrors: A Review of Actuation Strategies in Adaptive

Abstract:

Adaptive optics for today's telescopes relies on actuators that can supply nanometer accuracy and stability in the extremely demanding environment. The types of traditional actuator systems (hydraulic, piezoelectric, voice-coil, and cryogenic hexapods) have all enabled significant advancements in adaptive optics; however, they all come with limitations in terms of hysteresis, thermal sensitivity, scalability, or energy consumption. Hybrid actuator approaches, such as voice-coil and variable reluctance systems (e.g., Kineto), offer improved response and linearity. However, their complexity remains a significant barrier to scalable and practical deployment. This review investigates the progression of actuator technologies, identifying the advantages and disadvantages of various conveniences, and recognizing new smart functional materials as viable alternatives; specifically, actuators based on carbon nanotubes (CNT), significant in its dual sensing- actuation, lightweight hierarchical functional integration, which likely offer a potential way forward toward efficient, adaptive, next-generation optical systems.

Keywords: Adaptive optics, actuators, deformable mirrors, CNT, smart materials, telescopes.

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