Technology Offer

Precision Microscopy – Interferometric Detector for Light Beam Angle Deviations

Ref.-No.: 0105-5623-BC

Abstract

This invention presents a novel, interferometry-based method for detecting angular changes in light beams with extremely high sensitivity and robustness. Developed for high-precision microscopy, it enables stable and long-term beam alignment by measuring even minute directional deviations that can occur due to environmental fluctuations such as temperature changes. The technique splits the incoming light beam into two paths that interfere with one another on a camera sensor, generating an interference pattern. Variations in the beam's direction cause detectable shifts in this pattern, which are analyzed digitally. The setup is cost-effective, adaptable to various camera types, and suitable for implementation in existing optical systems. This detector significantly enhances imaging resolution and measurement accuracy in advanced microscopy.

Background

High-resolution optical microscopy demands extreme beam stability to achieve nanometer-scale precision. Specifically, the angular alignment of the light beam must be stable within the microradian to nanoradian range, as even minimal deviations can lead to significant imaging errors - especially in scanning applications. Conventional solutions, such as quadrant detectors or segmented photodiodes, estimate angular shifts by monitoring beam displacement. However, their accuracy is limited by detector resolution and strongly influenced by beam intensity, shape, and alignment. These systems also require meticulous calibration and are sensitive to environmental changes, such as temperature fluctuations or mechanical drift. As a result, their reliability in long-term or high-precision applications is constrained. There is a clear scientific need for a more robust, sensitive, and calibration-free method to detect angular beam deviations independently of intensity or beam shape - especially in advanced microscopy and interferometric systems.

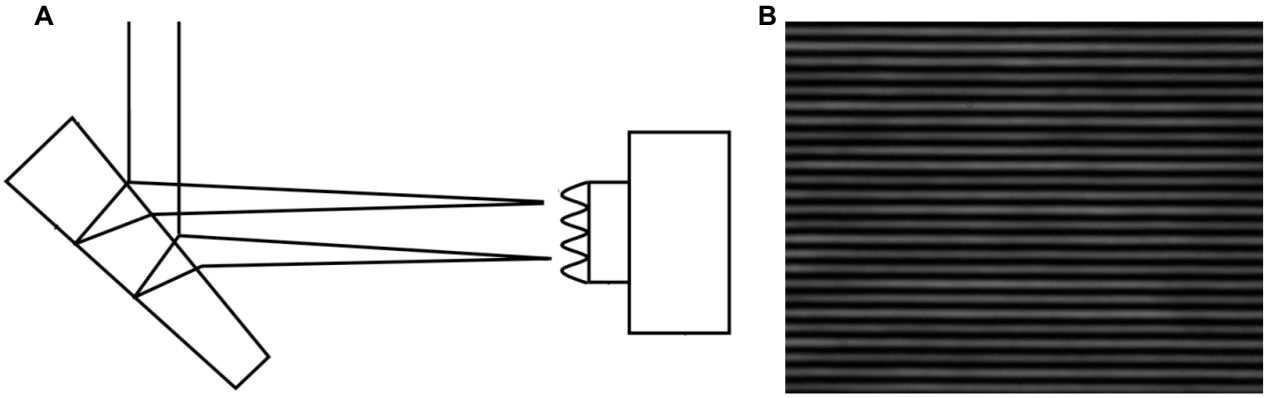

Figure 1: (A) Schematic setup of the interferometric beam angle detection system. A parallel glass plate generates two laterally displaced, parallel beams through front and rear surface reflections. These beams interfere on a camera sensor, producing a fringe pattern **(B)** that shifts laterally in response to angular variations of the incoming light beam.

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de

Technology

This invention introduces a high-precision method for detecting angular deviations in collimated light beams using shear interferometry (schematically shown in Figure 1). The setup incorporates a parallel glass plate within an interferometric module. A beam splitter diverts part of the laser beam — typically used for scanning or illumination in microscopy — into this module. Reflections from the front and rear surfaces of the glass plate generate two parallel beam paths that interfere on a camera sensor, forming a stable fringe pattern.

Any change in the angle of the incoming beam results in a measurable lateral shift of the interference fringes. This shift is directly proportional to the angular variation and independent of lateral beam displacement, allowing robust and highly sensitive detection in real time. Digital image processing evaluates the fringe movement, enabling precise monitoring with picoradian-level sensitivity.

The system can be seamlessly integrated into high-resolution optical or laser-scanning microscopes, positioned after the beam scanner and before the objective. This allows continuous control of beam pointing stability, crucial for consistent imaging resolution. The setup is compatible with standard imaging sensors and can be extended to detect angular deviations in two dimensions or even absolute spot positions, offering flexibility for a wide range of optical applications.

Advantages

- **Extremely high sensitivity** to angular changes, down to the picoradian range
- **Cost-effective** setup using standard optical components and cameras
- **Angle measurement accuracy** of up to one picoradian enables ultra-precise detection
- **Flexible integration** with various camera types and optical systems
- **Expandable design** for two-dimensional angle detection and spot position tracking

Potential applications

- High-precision optical and laser scanning microscopy
- Beam alignment monitoring in interferometric setups
- Quality assurance in optics manufacturing
- Adaptive optics and beam stabilization systems
- Scientific instrumentation requiring ultra-stable beam direction

Patent Information

PCT application *(WO2020083744A1;* 17.10.2019), active in EP, US

Contact

Dr. Bernd Ctortecka
Senior Patent- & License Manager, Physicist
Phone: +49 (0)89 / 29 09 19 – 20
eMail: ctortecka@max-planck-innovation.de

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de