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Development of a Key Fibre Optic Component for the Affordable Multiple Aperture Spectroscopy Explorer Prototype (AMASE-P)

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The Affordable Multiple-Aperture Spectroscopy Explorer Prototype (AMASE-P) is a ground-breaking initiative focused on enhancing high-resolution integral field spectroscopy to probe ionised gas in the Milky Way and other nearby galaxies. A pivotal aspect of AMASE-P is the fibre instrument cable (FIC), which is engineered to effectively channel light from the telescope to the spectrographs. Compact fibre bundles are crucial for observing distributed sky sources, necessitating individual fibre positioning precision within a few microns. AMASE-P marks the debut of 80 micron octagonal core multimode fibres, the smallest utilized in astronomy. This research emphasizes the meticulous placement and alignment of optical fibres within a hexagonal aperture, along with the creation of a computational imaging algorithm to assess fibre positioning precision. During manufacturing, 547 fibres are arranged within a 1.858 mm hexagonal hole, achieving a fibre fill factor exceeding 90% to optimize photon capture. The fibres terminate with 0.3 microns of surface roughness, aligning with the optical wavelength. Deviations beyond $\pm 3\mu\text{m}$ can result in a loss exceeding 10% in observation efficiency. Additionally, stress-free fibre mounting is vital to prevent focal ratio degradation at the output. To overcome these challenges, we have devised a fibre assembly technology combining precise fibre positioning with a metrology system, delivering a positioning accuracy of $\pm 3\mu\text{m}$. The high-precision algorithm captures images of the fibre bundles and converts pixel data into micron-scale measurements, considering detector resolution, pixel size, and magnification.

This method automates fibre alignment checks, decreases manual labour, and increases assembly productivity. Our technique for developing and characterizing fibre bundles for AMASE-P ensures minimal light loss, even signal distribution, a compact form, and a high fill fraction, setting a new standard for precision assembly in fibre-fed spectrographs utilized in large-scale astrophysical research.

Abstract Category

Astrophysics & Cosmology

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