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Developing a critical component of a fiber cable for the Affordable Multiple Aperture Spectroscopy Explorer Prototype (AMASE-P)

The Affordable Multiple-Aperture Spectroscopy Explorer Prototype (AMASE-P) is an innovative project aimed at improving high-resolution integral field spectroscopy for investigating ionised gas in the Milky Way and nearby galaxies. A critical component of AMASE-P is the fibre instrument cable (FIC), designed to efficiently transmit light from the telescope to the spectrographs. Compact fibre bundles are essential for observing distributed sources in the sky, requiring precise positioning of individual fibres with a tolerance of better than a few microns. AMASE-P will be the first use of octagonal core 80 micron multimode fibres, the smallest of their kind in astronomy.

This study focusses on the careful placement and alignment of optical fibres in a hexagonal aperture and the development of a computational imaging algorithm to evaluate fibre positioning accuracy. The manufacturing process involves positioning 547 fibres in a 1.858 mm hexagonal hole, achieving a fibre fill factor greater than 90% to maximise photon collection. The fibres are terminated with surface roughness of 0.3 microns, matching the optical wavelength. Deviations exceeding $\pm 3\mu$m can lead to a loss of more than 10% in observing efficiency. Furthermore, stress-free mounting of the fibres is essential to avoid deterioration of the focal ratio at the output.

To address these challenges, we have developed a fibre assembly technology that combines high-accuracy fibre positioning with a metrology system. This system achieves a positioning precision of $\pm 3\mu$m. The high-precision algorithm images the fibre bundles and translates the pixel data into micrometre-scale measurements, accounting for detector resolution, pixel dimension, and magnification. This approach automates fibre alignment verification, reduces manual effort, and improves overall assembly efficiency.

Our method for developing and characterising fibre bundles for AMASE-P ensures minimal light loss, uniform signal capture, compact design, and high fill fraction, establishing a new benchmark for precision assembly in fibre-fed spectrographs for large-scale astrophysical studies.

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