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GRB 250129A: linking late-time afterglow polarisation to jet Structure and viewing geometry

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Gamma-Ray Burst (GRB) afterglows arise from the interaction of relativistic ejecta with the circumburst medium and are observed across the electromagnetic spectrum. Polarisation is expected during the early and late phases of the afterglow depending on the presence of reverse shocks and the viewing geometry of the jet. Polarimetric observations of GRB afterglows serve as a unique diagnostic tool to investigate the geometry and structure of magnetic fields in the emitting region, which cannot be directly inferred from photometric or spectroscopic data alone. We present late-time spectropolarimetric observations of GRB˜250129A using the Robert Stobie Spectrograph on the Southern African Large Telescope (SALT), obtained ∼19 hours post-burst. We detect a remarkably high linear polarisation of 5–10 % and a 180° rotation in polarisation angle across wavelength—an unprecedented result for this late afterglow phase. This indicates turbulence with large-scale toroidal and radially stretched magnetic-field structures in the late-time forward shock regime. Such high polarisation levels are typically expected during the early afterglow (∼100 s) when reverse shocks dominate. However, multi-wavelength observations from LCO, DOT, ZEISS, and Swift-XRT show no indication of reverse shock contribution at this epoch. XRT data reveal high-latitude emission with flaring activity between 5.5 and 11 hours. Afterglow modeling incorporating both forward and reverse shocks confirms that the reverse shock component fades rapidly after ∼100 s. The multi-wavelength afterglow is best explained by an off-axis viewing geometry of a Gaussian jet in a uniform ISM environment. GRB 250129A thus provides rare observational evidence linking late-time polarisation to geometric and jet-structure effects.

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