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Substantial winds from the accreting supermassive black hole in M87 revealed by Faraday rotation observations

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Active galactic nuclei (AGNs) often produce highly collimated relativistic jets, one of the most energetic phenomena in the Universe. Theoretical models predict that AGN jets can be accelerated to nearly speed-of-light by magnetic fields, if they are confined by an external medium. Winds, nonrelativistic un-collimated gas outflows launched from accretion flows onto the supermassive black holes in AGNs, are primary candidates for this medium. Recent observations have indeed revealed a gradual collimation and acceleration of the jet in M87, a nearby AGN that possesses a black hole with a mass of three to six billion Suns which provides a unique opportunity to investigate the region under the influence of the black holes gravity. However, it has not been possible to either probe the external medium by observations or verify the general picture of jet collimation and acceleration. Here we report radio observations of Faraday rotation (the rotation of the plane of polarization by intervening magnetic fields) in the M87 jet, where information on the external medium (which is not directly observable) is imprinted. The Faraday rotation systematically decreases with increasing distance from the black hole from 5,000 to 200,000 Schwarzschild radii, in good agreement with the gas density being inversely proportional to the distance. This behavior matches the theoretically expected signature of moderately magnetized winds, which can naturally serve as the external confining medium. The sign of the Faraday rotation is predominantly negative, suggesting that jet and accretion axis are misaligned and the jet emission exposes only one side of the toroidal magnetic fields in the winds. Our results demonstrate that winds are indeed a key element of the black hole inflow-outflow system.