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Direct Observational Constraints on the Structure and Composition of the Base of the Jet in M87

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It has become commonplace is astronomy to describe the transverse coarse structure of jets in loosely defined terms such as sheath" andspine" based on discussions of parsec scale properties. But, the applicability, dimension and prominence of these features on sub-lt-yr scales has previously been unconstrained by observation. The first direct evidence of jet structure near the source in M\,87 is extreme limb brightening (a double-rail morphology), 0.3 - 0.6 mas from the source, that is prominent in observations with high resolution and sensitivity. Intensity cross-cuts of these images provide three strong, interdependent constraints on the geometry responsible for the double-rail morphology: the rail to rail separation, the peak to nadir intensity ratio and the rail widths. Analyzing these constraints indicates that half or more of the jet volume resides in a thick-walled, tubular, mildly relativistic, protonic jet only ~ 0.25 lt-yr (or ~ 300 M, where M is the central black hole mass in geometrized units) from the source. By contrast, the Event Horizon Telescope Collaboration interprets their observations with the aid of general relativistic magnetohydrodynamic simulations that produce an invisible (by construction) electron-positron jet with a surrounding luminous, thin sheath. Yet, it is shown that synthetic images of simulated jets are center brightened 0.3 - 0.6 mas from the source. This serious disconnection with observation occurs in a region previously claimed in the literature to be well represented by the simulations. The limb brightening analysis motivates a discussion of possible simulation modifications to improve conformance with observations.

Primary author: PUNSLY, Brian (ICRANet)

Presenter: PUNSLY, Brian (ICRANet)

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