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Lighting up a black hole: phenomenological reconstruction of particle microphysics around a black hole

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A key open question in astrophysics is how particles are heated and accelerated in accretion flows and how this shapes observed emission. We present a new method for reconstructing the connection between plasma dynamics and particle acceleration in the accretion flow of the LLAGN M87*, using the 2017 Event Horizon Telescope multi-wavelength campaign as a prototype. Our Bayesian framework constrains a multi-dimensional, parameterized lepton distribution in the accretion disk, capturing a range of heating and acceleration mechanisms without relying on specific sub-grid models. By jointly fitting horizon-scale imaging, polarimetric data, and multi-frequency observations, we obtain quantitative constraints on thermal and non-thermal lepton populations, including energetics, spectral indices, and high-energy cutoffs. These results offer new insights into near-horizon acceleration processes and show that multi-wavelength and polarimetric data are essential for breaking degeneracies between microphysical models. The inferred lepton distributions provide data-driven inputs for PIC simulations and can extend to other LLAGN.

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