Contribution ID: **24** Type: **not specified**

The Black Hole-Jet Connection in M87: Insights from Radiative Simulations

Tuesday 28 February 2023 14:40 (40 minutes)

The Event Horizon Telescope (EHT) has produced images of both total intensity and polarized radiation from plasma around the supermassive black hole in M87 on event horizon scales.
In a large library of simulated images from general relativistic magnetohydrodynamic (GRMHD) simulations, the models most consistent with Event Horizon Telescope (EHT) polarized images of M87 are all magnetically arrested accretion disks (MADs).In MAD systems, near-horizon magnetic fields are coherent and dynamically important; they limit accretion and launch powerful jets via the Blandford-Znajek (BZ) mechanism. The EHT results also suggest that the radiative efficiency in M87's accretion flow is on the order of 1%, suggesting that radiative cooling plays a strong role in determining the temperature of the emitting electrons and affects image morphology at all wavelengths. By including radiative feedback and electron-ion thermodynamics self-consistently in simulations of MADs, we are able to produce images of M87 that are consistent with VLBI observations from EHT images of the black hole shadow at 1 mm to images of the jet at cm wavelengths. While the jet is most prominent at longer wavelengths, most of the observed emission in MAD models originates from a relatively thin equatorial region. In these simulations, the darkest region in the observed image – the black hole's "inner shadow" – approaches the lensed outline of event horizon in the equatorial plane.Measurements of the relative size, shape, and position of the inner shadow and black hole photon ring can break degeneracies in measurements of the black hole mass and spin using submillimeter VLBI images. If time permits, I will briefly discuss a new method in development for simulations that link GRMHD with Force-Free electrodynamics in the jet region, enabling simulations to run without artificial density floors in magnetically dominated regions.

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