Diagnosing accretion with polarimetry

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M87*

M = 6.5e9 Msol D = 17 Mpc LLAGN with a prominent jet



EHT Collaboration 2021

Sagittarius A*

M = 4.3e6 Msol D = 8 kpc dormant BH



EHT Collaboration 2024

$\overrightarrow{P} \propto \overrightarrow{k} \times \overrightarrow{B}$ (emitter's frame)



but no too high fractional polarization

 $\overrightarrow{P} \propto \overrightarrow{k} \times \overrightarrow{B}$ (emitter's frame)



reality = intuition + spacetime curvature + relativistic aberration



Narayan et al. + EHTC 2021 Vincent, Wielgus et al. 2024

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Linear polarization - Faraday effects matter



Linear polarization - Faraday effects matter



reality = intuition + spacetime curvature + relativistic aberration + plasma effects





Linear polarization - one zone model for M87*



Figure 2. Allowed parameter space in number density and dimensionless electron temperature (n_e, Θ_e) (red region) for the one-zone model described in Section 3.1 for three constant values of $\beta_e = 8\pi n_e m_e c^2 \Theta_e / B^2$. We require that the optical depth $\tau_I < 1$ (green region), the Faraday optical depth $\tau_{\rho_V} > 2\pi$ (blue region), and the total flux density $0.2 < F_{\nu} < 1.2$ Jy (black region). Contours of constant magnetic field strength are denoted by labeled dashed lines.

A uniform synchrotron-emitting ball, with size and flux density constrained by the EHT measurements

(green) optically thin ball (we see the shadow) (blue) large Faraday depth (we see depolarisation) (gray) matching flux density to VLBI

One zone model predictions: B = 2-10 G; Te =1e10-1e11 K; ne ~= 1e5 /cm3

Te lower than expected ions temperature => two temperature collisionless plasma



$$\Theta_{\rm e} = 1 \rightarrow 6 \times 10^9 \, {\rm K}$$

Linear polarization - GRMHD



1

 R_{high}

Rhigh







Unresolved / resolved averaged P Shape / twistiness of the P pattern





OBSERVATION





Rlow ~ Tion / Telectron in the jet



Conclusions

- O M87* and Sgr A* both appear as strongly magnetized MAD systems
- O Poloidal magnetic fields present (dominant?) near the event horizon
- O Depolarizing effects of Faraday rotation can not be neglected
- O Plasma around M87^{*} most likely rotates clockwise on sky
- O Electrons relatively colder than ions by 1-2 orders of magnitude
- O Spin unclear

O reality = intuition + spacetime curvature + relativistic aberration + plasma effects + emission geometry