Was M87* really a Kerr black hole, that EHT imaged in 2019?

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Based on
M. Ghasemi-Nodehi, **C. Chakraborty**, Q. Yu, Y. Lu, Eur. Phys. J. **C 81**, 939 (2021)

Introduction: EHT2017 image of M87*

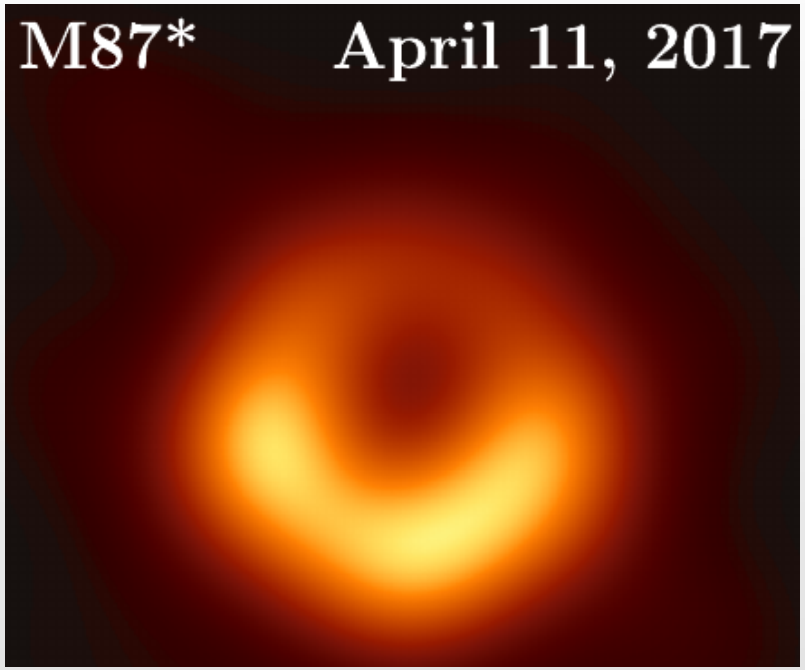

Figure: Event Horizon Telescope (EHT) image of M87* from observations: ApJ 875, L1 (2019)

- EHT mapped M87* to a Kerr black hole (BH), yet alternatives are not ruled out.
- Arguing shadow of a superspinar/Kerr naked singularity (NS) is substantially smaller and very asymmetric compared to a BH, EHT ruled out any superspinar model for M87: ApJ 875, L1 & L5 (2019).

Kerr-Taub-NUT sptm and gravitomagnetic monopole (GMM)

- If Kerr sptm contains GMM (n_*) or vice-versa, it is regarded as the Kerr-Taub-NUT (KTN) spacetime (Newman, Tamburino, Unti 1963).
- Lynden-Bell & Nouri-Zonoz(1998) mentioned that the best place to look for the GMM is in the spectra of supernovae, quasars, or AGN.
- **FIRST** observational indication of gravitomagnetic monopole: GRO J1655-40 could be better described with the more general KTN sptm, instead of Kerr sptm, this makes KTN sptm astrophysically relevant (Chakraborty & Bhattacharyya, JCAP 2019).
- Considering the KTN metric and reported observational constraints by EHT, we constrain the value of GMM/NUT charge in M87*.

Shadow size not smaller if M87* is a NS

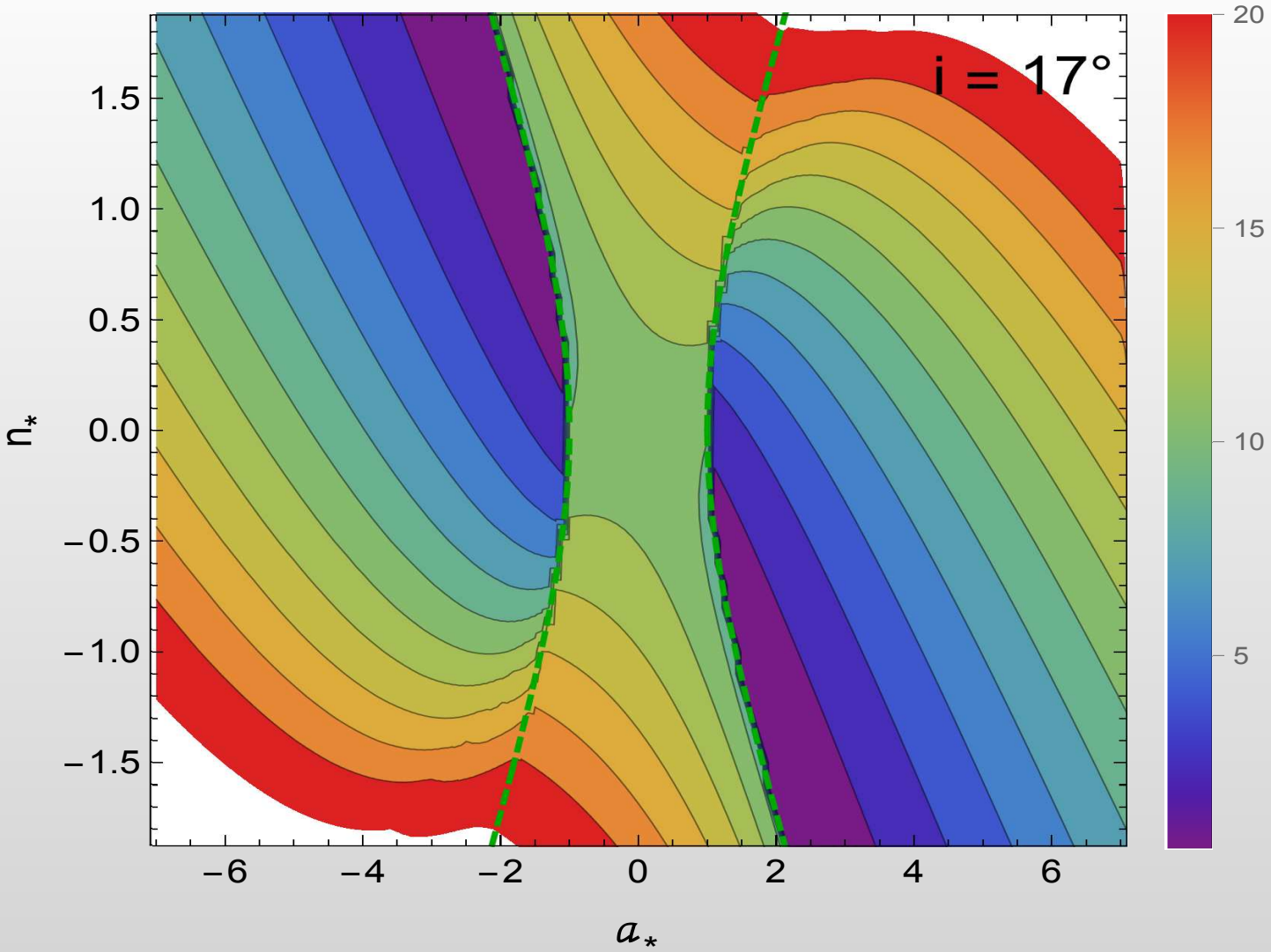

Figure: Shadow sizes for various values of a_* (Kerr parameter) & n_*. Shadow sizes of Kerr NSs ($|a_*| > 1$) are not necessarily smaller.

M87* could also be a Kerr NS or KTN BH/NS

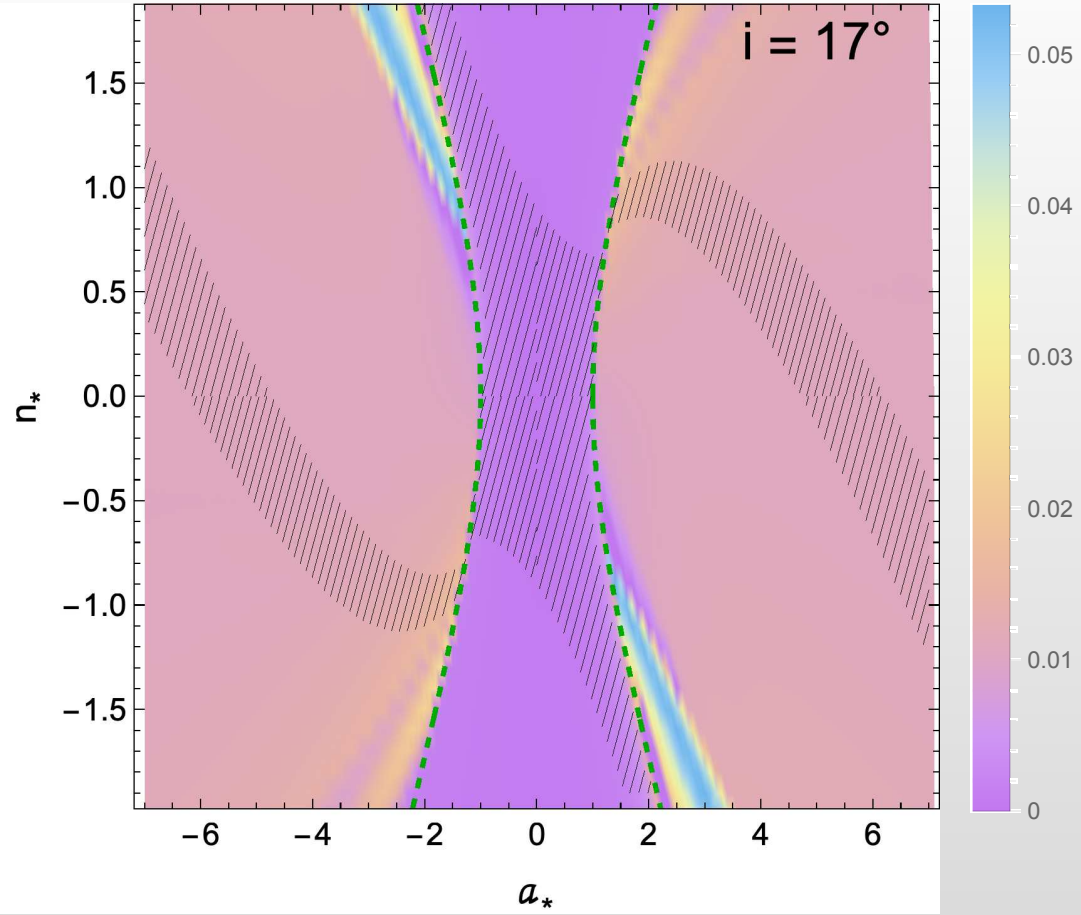

Figure: Hatched region indicates the parameter space allowed by EHT measurement of M87*. Non-zero GMM is still compatible with EHT2017 observations. Shadow of M87* does not exclude the possibility to be a NS. **Kerr NS:** $4.5 \lesssim a_* \lesssim 6.5$ **compatible** with M87* image.

Conclusion: M87* could be a NS and contains GMM

- Observational constraints on the size and circularity of M87* shadow do not exclude the possibility that M87* can be a NS and contains GMM.
- Upper limit: $n_* \lesssim 1.1$ for prograde rotation ($a_* > 0$), whereas lower limit: $n_* \gtrsim -1.1$ for retrograde rotation ($a_* < 0$).
- Important to have accurate measurements of both shadow size and asymmetry, which can be used to put strong constraints on a_* and n_*, and break the degeneracies between the different metrics as well as between the BHs and NSs.
- Even if Kerr/KTN NS is falsifiable, M87* could still be described as a KTN BH with upper limit: $n_* < 0.9$ for $a_* > 0$, and lower limit: $n_* > -0.9$ for $a_* < 0$ (Ghasemi, Chakraborty, Yu, Lu, EPJC 81, 939, 2021).