

# Kerr Black Holes with Synchronised Scalar Hair and Higher Azimuthal Harmonic Index

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## Abstract

Kerr black holes with synchronised scalar hair and azimuthal harmonic index  $m > 1$  are constructed and studied. The corresponding domain of existence has a broader frequency range than the fundamental  $m = 1$  family; moreover, larger ADM masses,  $M$ , and angular momenta  $J$  are allowed. Amongst other salient features, non-uniqueness of solutions for fixed global quantities is observed: solutions with the same  $M$  and  $J$  co-exist, for consecutive values of  $m$ , and the ones with larger  $m$  are always entropically favoured. Our analysis demonstrates, moreover, the qualitative universality of various features observed for  $m = 1$  solutions, such as the shape of the domain of existence, the topology of ergo-regions, and the horizon geometry, which is studied through its isometric embedding in Euclidean 3-space.

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