Magnetized accretion disks around Kerr black holes with scalar hair

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ABSTRACT

Testing the true nature of black holes – the no-hair hypothesis – will become increasingly more precise in the next few years as new observational data is collected in both the gravitational wave channel and the electromagnetic channel. In this work we consider numerically generated spacetimes of Kerr black holes with synchronized scalar hair and build stationary models of magnetized thick disks (or tori) around them. Our approach assumes that the disks are not self-gravitating, they obey a polytropic equation of state, and they are marginally stable, i.e. the disks completely fill their Roche lobe. Moreover, contrary to existing approaches in the literature, our models are thermodinamically relativistic, as the specific enthalpy of the fluid can adopt values significantly larger than unity. We study the dependence of the morphology and properties of the accretion tori on the type of black hole considered, from purely Kerr black holes with varying degrees of spin parameter, namely from a Schwarzschild black hole to a nearly extremal Kerr case, to Kerr black holes with scalar hair with different ADM mass and horizon angular velocity. Comparisons between the disk properties for both types of black holes are presented. The sequences of magnetized, equilibrium disks around Kerr black holes with scalar hair discussed in this study are morphologically and thermodynamically different than their Kerr black hole counterparts, namely their vertical size is larger, the high-density central region is more extended, and the fluid is more relativistic. Therefore, we expect significant differences to appear when these sequences are used as initial data for numerical relativity codes to investigate their dynamical (non-linear) stability and used in tandem with ray-tracing codes to obtain synthetic images of black holes (i.e. shadows) in astrophysically relevant situations where the light source is provided by an emitting accretion disk.