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Force-free electrodynamics near the rotation axis of a Kerr black hole

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Despite their potential importance for understanding astrophysical jets, physically realistic exact solutions for magnetospheres around Kerr black holes have not been found, even in the force-free approximation. Instead, approximate analytical solutions such as the perturbative solution in the spin parameter proposed by Blandford and Znajek, as well as numerical solutions, have been constructed. I will introduce a new approach to the analysis and construction of such magnetospheres by considering force-free electrodynamics close to the rotation axis of a magnetosphere surrounding a Kerr black hole assuming axisymmetry. This is the region where the force-free approximation should work the best and where the jets are located. I will illustrate a systematic study of the asymptotic region with (split-)monopole, paraboloidal and vertical asymptotic behaviors. In the (split-)monopole case, I will show that by demanding regularity in the asymptotic region, at the rotation axis and the event horizon, restricts solutions of the stream equation so much that it is not possible for a solution to be continuously connected to the static (split-)monopole around the Schwarzschild black hole in the limit where the rotation goes to zero. This provides independent evidence to the issues discovered with the asymptotics of the Blandford-Znajek (split-)monopole from which it follows that its perturbative construction is inconsistent.

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