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A kinetic view at black hole magnetospheres

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Spinning black holes have long been suspected to be involved in some of the most extreme astrophysical phenomena such as AGN and their relativistic jets for supermassive black holes, and gamma-ray bursts for stellar-mass black holes. The activity of black holes is often associated with the creation and the launching of a relativistic magnetized plasma jet accompanied by efficient particle acceleration and non-thermal radiation. Horizon-scale observations of supermassive black holes reveal that these processes occur in the closest vicinity to the black-hole horizon: the magnetosphere, the inner parts of the accretion flow and the jet. Yet, the underlying physical mechanisms are still poorly understood because they result from a complex interplay between general relativity, electrodynamics and plasma physics. I will review our current efforts to model black hole magnetospheres from first principles with the help of general relativistic radiative particle-in-cell simulations. These numerical methods can capture plasma processes at a microscopic kinetic level where particle acceleration takes place, and therefore they may hold the key to bridge the gap between theoretical models and horizon-scale observations of black holes.

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