

## Abstract

With the continuously growing interest in active galactic nuclei (AGN) and the propagation of their associated jets, the subject of energy extraction from rotating Kerr black holes is still highly relevant today. By now, several general relativistic magnetohydrodynamic simulations validate the Blandford-Znajek process which is a black hole energy extraction mechanism first proposed by Blandford and Znajek in 1977 [1] that was greatly inspired by the similar case of the pulsar magnetosphere. Unlike the example of a slowly rotating black hole, which Blandford and Znajek considered, most observed AGN are found to spin at rates close to extremality. This means that it is necessary to construct a new perturbative approach for near-extreme and extreme black holes much like Menon and Dermer did in the Kerr background [2]. This thesis reviews the near-horizon extreme Kerr (NHEK) limit of rotating black holes. Consequently, an expansion of the field in orders of the scaling parameter  $\lambda$  is performed in order to construct a magnetically-dominated field strength from the NHEK attractor solution found by Camilloni et al. [3]. Although this solution is null everywhere, calculating the first two post-NHEK order corrections to the field allows one to show that it is indeed possible to construct a magnetically-dominated magnetosphere, at least in some regions. The near-NHEK limit of the Kerr solution, which is more astrophysically correct than the NHEK limit, is also reviewed. Again, the field is expanded but now in orders of  $\lambda$  and  $\sigma$  which measures the deviation from extremality ( $\sigma = 0$ ). With a novel expansion of the field variables, I find corrections to the near-NHEK attractor to the second order in  $\lambda$  (and  $\sigma$ ), and present the field variables that are determined along the way. I show that the field strength is null in the first order in  $\lambda$  and present the general field strength in the second order in  $\lambda$  with field variables that are left unfixed. Lastly, the novel general expansion is compared with a known solution [4].