The self-force in five-dimensions

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Abstract

There is currently a lack of intuition regarding the electromagnetic self-force experienced by a charged particle when it is placed near a black hole. To further probe the nature of this force, we generalize the self-force calculation to a static five-dimensional spherically symmetric spacetime and attempt to relate it to an analogue model. By decomposing the electrostatic potential into a sum of higher-dimensional spherical harmonics and performing a regularization method based on a Hadamard Green's function, we are able to obtain the self-force as a convergent mode-sum. Our calculation was implemented in three different ways. Firstly, we used a numerical algorithm in Maple. Secondly, we expressed the self-force as an series expansion about infinity, and finally, we derived a closed-form solution from the power series. In contrast to the four-dimensional model, we find the self-force to depend on a regularization parameter s which can we interpreted as the radius of the particle. At large distances, the self-force is repulsive and is related to an elementary electrostatic model, however, as the distance between the event horizon and the article decreases, the force becomes attractive and the model fails.