A Toy Model for the Magnetic Connection

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abstract A magnetic field connecting a Kerr black hole to a disk rotating around it can extract energy and angular momentum from the black hole and transfer them to the disk if the black hole rotates faster than the disk. The energy can be dissipated and radiated away by the disk, which makes the disk shine without the need of accretion. In this paper we present a toy model for the magnetic connection: a single electric current flowing around a Kerr black hole in the equatorial plane generates a poloidal magnetic field which connects the black hole to the disk. The rotation of the black hole relative to the disk generates an electromotive force which in turn generates a poloidal electric current flowing through the black hole and the disk and produces a power on the disk. We will consider two cases: (1) The toroidal current flows on the inner boundary of the disk, which generates a poloidal magnetic field connecting the horizon of the black hole to a region of the disk beyond the inner boundary; (2) The toroidal current flows on a circle inside the inner boundary of the disk but outside the horizon of the black hole, which generates a poloidal magnetic field connecting a portion of the horizon of the black hole to the whole disk. We will calculate the power produced by the magnetic connection and the resulting radiation flux of the disk in the absence of accretion, and compare them with that produced by accretion.