Corbino Disk

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Abstract

When a disk with concentric inner and outer electrical contacts is placed in a magnetic field parallel to its axis, and current is made to flow through the disk, the lines of current flow have a spiral shape. This spiral current flow produces its own magnetic field, which interferes constructively or destructively with the applied field, depending upon whether the carriers spiral inward or outward, respectively. For ordinary conductors and ordinary currents the effect of the self-field of the current is very small. But the effect should be large in materials of very high mobility such as has been recently reported for bismuth at 4.2°K. In this paper the theory of the effect is given for the case in which the mean free path of the carriers is small compared to the inner radius of the disk. The analysis shows that the disk behaves as a rectifier. The easy direction of flow corresponds to outward spiraling of the carriers, which at large currents results in the explusion of the magnetic field from the disk. In the hard direction of flow the magnetic field at the center of the disk may be several orders of magnitude larger than the applied field. It is suggested that the corbino disk may be a useful rectifier in applications requiring extremely low impedance. It may also be a useful voltage regulator in a very low-voltage high-current power supply. A device consisting of the disk and a coil to provide the magnetic field is discussed in some detail. The static characteristics when the coil is connected through a suitable resistance in parallel with the disk exhibits a negative resistance. This negative resistance is useful in ac operation if a condenser is also connected in series with the coil. The equations and boundary conditions which determine the electrical properties of the disk in the time-dependent case are formulated. In the small-signal approximation the complex impedance is obtained for the limiting cases of low and high frequency. At low frequency the reactance is that of a negative inductance ($-i\omega L$). At high frequencies there is a skin effect on the tangential component of current, which causes most of the signal current to be radial and causes the impedance to reduce to the resistance of the disk.