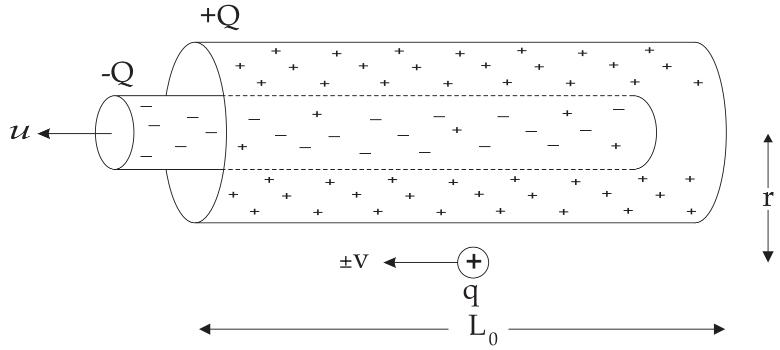

Figure 1. Model for a current.

If a segment of the wire of length L_0 contains a positive charge Q and a free electron charge -Q with a drift speed u, and the test charge q has a speed $\pm V$ (either parallel or antiparallel to the electron drift) at a distance r from the center of the wire, the Coulomb force on the test charge is given by

$$F = \frac{2Kq}{r}\left[\frac{Q}{L_0\sqrt{1-V^2/c^2}} - \frac{Q}{L_0\sqrt{1-(\pm V-u)^2/c^2}}\right]. \qquad (7)$$

Here we have included the apparent relativistic contraction of the two line charges as seen by the moving test charge. This can be binomial expanded to yield

$$F \approx \frac{2Kq}{r}\frac{Q}{L_0}\left[\left(1+\frac{V^2}{2c^2}+\ldots\right)-\left(1+\frac{V^2 \mp 2Vu + u^2}{2c^2}+\ldots\right)\right]. \qquad (8)$$

To first order in u/c this becomes

$$F \approx \pm\frac{2Kq}{rc^2}\left(-\frac{Qu}{L_0}\right). \qquad (9)$$

Although u is small, Q/L_0 is large, and their product can be identified as the current in the wire. Thus we can define

$$I \equiv -Qu/L_0 \;; \qquad B \equiv 2\left(K/c^2\right)I/r \;; \qquad F = \pm qVB \qquad (10)$$

where the plus sign denotes repulsion if the test charge moves in the same direction as the electron, and the minus sign denotes attraction if the test charge moves opposite to the electron drift. This simple model demonstrates that the Biot-Savart Law is a consequence of Coulomb's law and relativity, and not a separate experimental fact.

While this paper is probably the one considered the most radical by the general public, the basic concepts of relativity had been in the scientific air for a very long time. Already in 1887 Woldemar Voigt had studied transformations of the electromagnetic wave equation between space-time coordinate systems for which the wave speed is invariant, and obtained the equations