Magnets in an electric field: hidden forces and momentum conservation

Francis Redfern*
Texarkana College, Texarkana, TX 75599
(Dated: March 23, 2016)

The paradox raised by J. J. Thompson in 1891, where an electromagnetic system at rest seemed to contain electromagnetic linear momentum, has led to the belief that such systems must contain what is widely called hidden momentum. This term was first used by Shockley and James in 1967 to describe the mechanical momentum they thought must be contained by an at-rest charge-magnet system to cancel its electromagnetic momentum such that the total momentum is zero. Since then, a magnetic dipole in an electric field has been considered to have this new form of momentum. However, I contend there is no hidden momentum in a magnetic dipole in an electric field. When this system is assembled by an external agent from components that initially contain neither energy of interaction nor momentum, the electromagnetic forces between the components result in the system gaining both mechanical momentum and an equal and opposite amount of electromagnetic momentum. As a result the system is in motion in its original rest frame. When the analysis of such a system is done in its new rest frame, it appears to have electromagnetic linear momentum but, of course, no mechanical linear momentum. This situation has lead to the confusion that I address here with three calculations involving the model of Shockley and James, the analysis of a similar model by Coleman and Van Vleck, and a model involving a magnetic dipole formed in a uniform electric field. These calculations show no hidden momentum.

PACS numbers: 03.50.De

* permanent address: 1904 Corona Drive, Austin, Texas 78723