Zeeman Effect Encyclopedia Article

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According to classical electromagnetic theory, a charge rotating with a simple harmonic frequency should emit electromagnetic radiation of the same frequency. And when an external magnetic field is applied to this system, the frequency of oscillation should change. Depending on the orientation of the **atom** with respect to the magnetic field, the frequency should either increase, decrease, or remain the same. The observed splitting of the spectral lines into three components, which is now called the normal Zeeman effect (named after the Dutch physicist Pieter Zeeman who discovered it), provided one of the earliest estimates of the charge-to- **mass** ratio of the **electron**.

It is now known that this so-called normal Zeeman effect arises from electronic transitions between singlet states (i.e., states in which the contribution to angular momentum from the electron's intrinsic angular momentum, or spin, is zero and in which the total angular momentum is equal to the orbital angular momentum of the electron). Quantum mechanically, the change in angular frequency should be equal to the one-half the electron charge times the magnetic field divided by the mass of the electron, which is exactly the result predicted by classical electromagnetic theory.

In many cases, the frequency of the electron is split into more than three components under the application of an external magnetic field. This behavior is called the anomalous Zeeman effect. It arises when the contribution of electron spin to the total angular momentum is not zero, i.e., when the total magnetic moment is not parallel to the total angular momentum. A spin-orbit splitting of the **energy** levels arises from the interaction of the electron's spin magnetic moment with the internal magnetic field seen by the electron due to its orbital motion (even in the absence of an applied field). When an external magnetic field is applied, the Zeeman effect depends on the quantization of the electron orbital angular momentum, the total angular momentum, and the spin angular momentum. It is not possible to account for the anomalous Zeeman effect classically, as the complications that it introduces arise solely from quantum effects.