Plasma Physics with Applications

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## What is a plasma

A plasma is defined via the **ionization degree** $\alpha$ defined as the fraction of ionized particles. At $\alpha > 0.01$ we say it is **fully ionized**, while for smaller $\alpha$:s its **weakly / partially ionized**.

## Single particles in EM-field

The most fundamental equation of motion for a charged particle in an EM-field is the **Lorentz Force Equation:**

$$m\frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} = q(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})$$

A constant, nonzero E-field with no B-field gives constant acceleration along $\boldsymbol{E}$. A constant, nonzero B-field with no E-field gives rise to helical motion with **cyclotron frequency** $\omega_c = |q|B/m$ and **Larmor radius** $r_L = v_\perp/\omega_c$. A constant, nonzero B-field with a constant force $\boldsymbol{F}$ gives a constant acceleration from the component of $\boldsymbol{F}$ along the B-field, while the component perpendicular to $\boldsymbol{B}$ gives rise to a constant **drift velocity**

$$\boldsymbol{v}_D = \frac{1}{q}\frac{\boldsymbol{F}_\perp \times \boldsymbol{B}}{B^2}$$

An *inhomogeneous* B-field gives rise to the so called **grad B drift**. The motion parallel to the B-field lines is governed by

$$m\frac{\mathrm{d}\boldsymbol{v}_\parallel}{\mathrm{d}t} = -\mu\nabla_\parallel B,$$

and for the motion perpendicular we get a drift velocity

$$\boldsymbol{v}_D = \frac{\mu}{q}\frac{\boldsymbol{B} \times \nabla B}{B^2}$$

in addition to the Larmor rotation, just like before.