Introduction to Nuclear Fusion (409.308A, 3 Credits)

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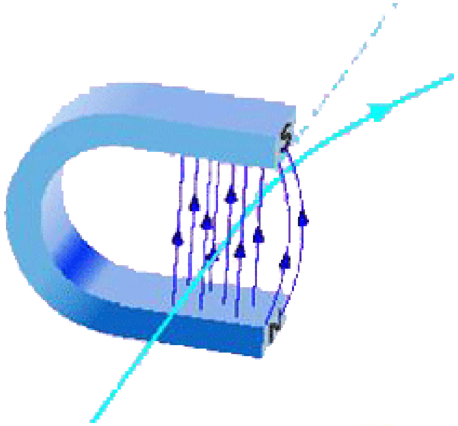
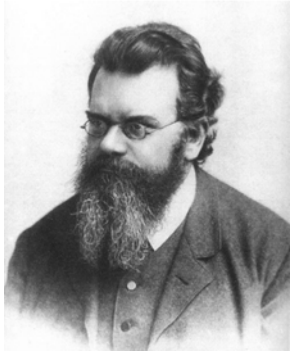
Kinetic Approach of Plasmas

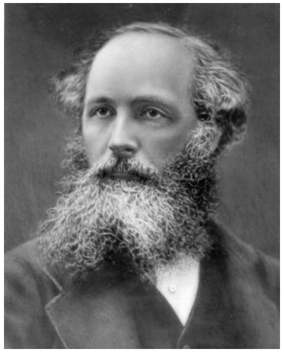
- **Boltzmann Equation**

$$\frac{\partial f_\alpha}{\partial t} + \vec{u}\cdot\nabla f_\alpha + \frac{q_\alpha}{m_\alpha}(\vec{E}+\vec{u}\times\vec{B})\cdot\nabla_u f_\alpha = \left(\frac{\partial f_\alpha}{\partial t}\right)_c$$

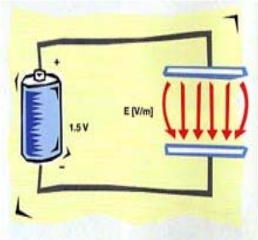


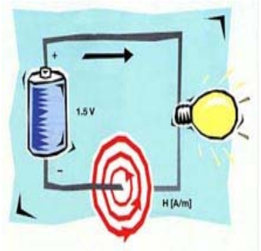


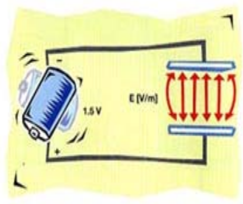
Ludwig Boltzmann
(1844-1906)



James Clark Maxwell
(1831-1879)



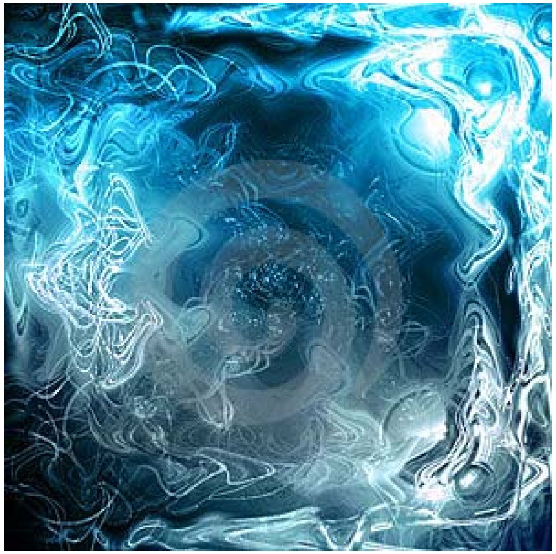


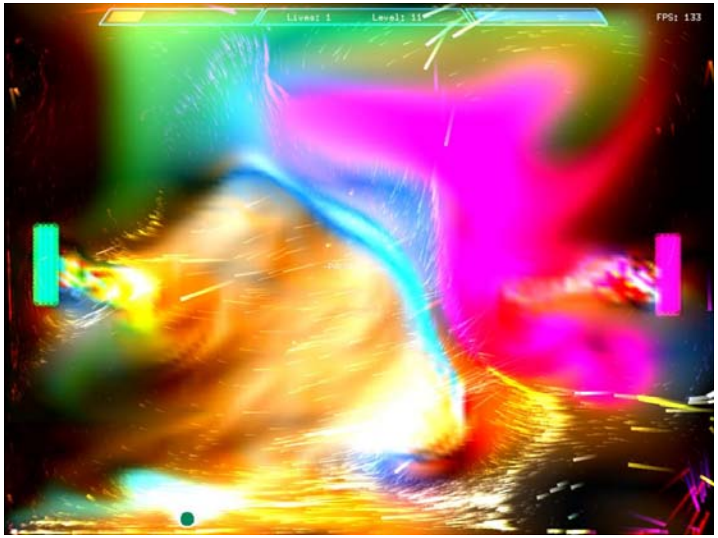


Fluid Approach of Plasmas

- **Plasmas as fluids**

  - The single particle approach gets to be complicated.
  - A more statistical approach can be used because we cannot follow each particle separately.
  - Introduce the concept of an **electrically charged current-carrying fluid.**





Plasmas as Fluids

- **Fluid Equations**

$$\int Q_i \left[\frac{df_\alpha}{dt} - \left(\frac{\partial f_\alpha}{\partial t} \right)_c \right] d\vec{u} = 0$$

$Q_1 = 1$	mass
$Q_2 = m_\alpha \vec{u}$	momentum
$Q_3 = m_\alpha u^2 / 2$	energy

$$\frac{\partial n_j}{\partial t} + n_j \nabla \cdot \vec{u}_j = S_{nj}$$

$$m_j n_j \frac{d\vec{u}_j}{dt} + \nabla \cdot \overleftrightarrow{P}_j - q_j n_j (\vec{E} + \vec{u}_j \times \vec{B}) = \sum_k^l \vec{R}_{jk} - m_j \vec{u}_j S_{nj}$$

$$\frac{3}{2} n_j \frac{dT_j}{dt} + \overleftrightarrow{P}_j : \nabla \vec{u}_j + \nabla \cdot \vec{h}_j = \sum_k^l Q_{jk} + S_{Ej} + \left(\frac{m_j u_j^2}{2} - \frac{3}{2} T_j \right) S_{nj}$$

References

- *http://www.dreamstime.com/stock-images-blue-3d-plasma-fluid-image698604*
- *http://www.runme.org/project/+plasmapong/*