

**Introduction to
Nuclear Fusion
(409.308A, 3 Credits)**

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- OH, NBI, RF, Adiabatic Compression,
and Alpha Self-heating

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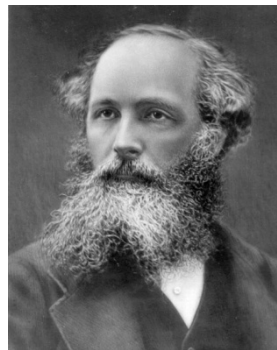
Kinetic Approach of Plasmas

- Boltzmann Equation

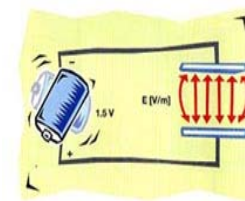
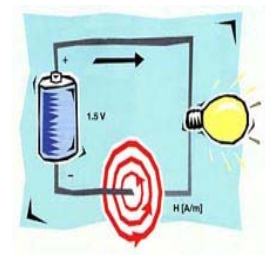
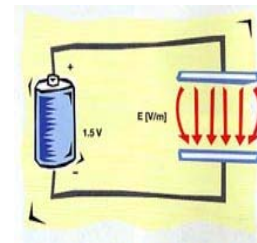
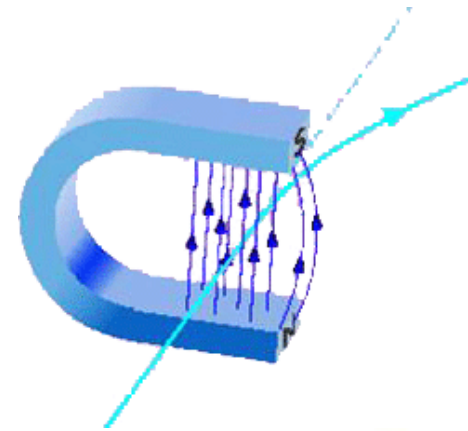
$$\frac{\partial f_\alpha}{\partial t} + \vec{u} \cdot \nabla f_\alpha + \frac{q_\alpha}{m_\alpha} (\vec{E} + \vec{u} \times \vec{B}) \cdot \nabla_u f_\alpha = \left(\frac{\partial f_\alpha}{\partial t} \right)_c$$



Ludwig Boltzmann
(1844-1906)



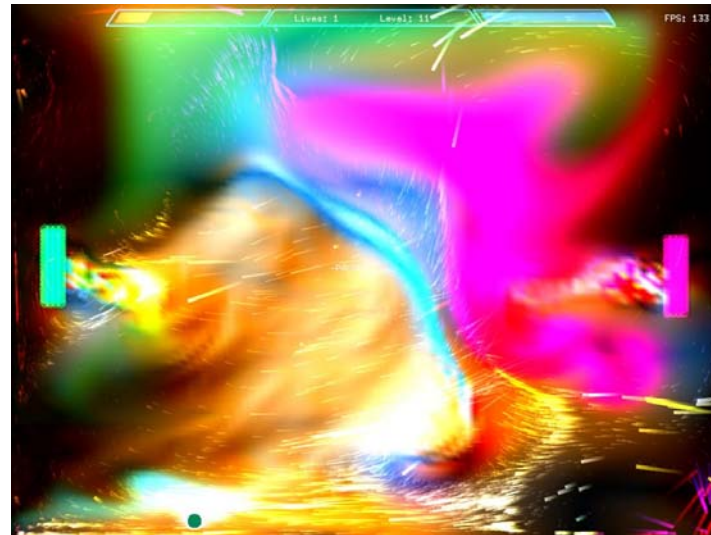
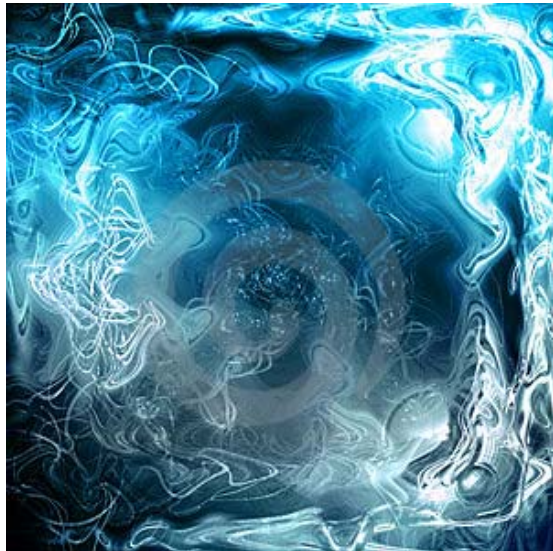
James Clark Maxwell
(1831-1879)



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

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

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

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

References

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