Long Title

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Table of Contents

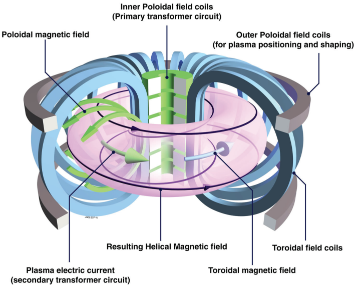
insert title name

insert text

Outline

Example of figure and block environments

Confinement requires toroidal magnetic fields with a poloidal twist



Tokamak configuration

- Toroidal field coils $\Rightarrow B_\phi$
- Plasma current $\Rightarrow B_\theta$
- Poloidal field coils for shaping
- Transformer $\Rightarrow$ pulsed operation

Image: obtained from `http://www.alternative-energy-action-now.com/tokamak-fusion-reactor.html`

Outline

Example of table environment (tabular with booktabs)

	NSTX	ITER
Parameters		
Major radius R [m]	$0.8 - 1.0$	6.2
Minor radius a [m]	$0.5 - 0.787$	2
Aspect ratio R/a	$1.27 - 1.6$	3.1
Magnetic field B [T]	$0.8 \sim 1.6$	3.1
Max plasma volume [m^3]	14	700
Max T_i, T_e [keV]	2.5, 4.1	30, 30
Max current I [MA]	1.5	15
Max power density [MW/m^3]	1.1	0.7
Shot length [s] at B_{max}	1.5	400
PFCs	CFC/Graphite	W, C and Be
	Li coating	

Reproduced from MIT PSFC

Example of itemize environment

$\boxed{\text{Theory}} \Leftrightarrow \boxed{\text{Computation}} \Leftrightarrow \boxed{\text{Experiment}}$

Computer simulations are indispensible in contributing to the understanding of magnetically confined plasmas

- Numerical simulations help guide experiments by
  - simulating and fine-tuning proposed experiments
  - producing results that have not yet been explored
  - post-processing can simulate diagnostic measurements
  - numerical solutions can aid design of devices (e.g. stellarators)
- Numerical simulations can access costly ventures (e.g. the *burning plasma* experiment)
- As more detailed and higher fidelity computational models are developed, the utility of computation increases and the feedback cycle becomes more efficient and useful.

Example of enumerate environment

1. **Multiple species**: electrons, multiple ions, neutrals
2. **Time scales** span $9-12$ orders of magnitude
   - $\Omega_{ce}^{-1} \gtrsim 10^{-10}$ s : RF heating time scale
   - $\tau \lesssim 10^{2}$ s : discharge time scale
3. **Spatial scales** span $4-6$ orders of magnitude
   - $\lambda_{e,\nabla T} \gtrsim 10^{-5}$ m : ∇T length scale for electron conduction
   - $L \lesssim 40$ m : connection length
4. **Velocity scales** span ~ 7 orders of magnitude
   - $v_n \sim 0$ re-emitted neutrals adsorbed on wall
   - $v_{Ti} \sim 36.12$ m/s for H^+ thermal ions $T_i = 0.025$ eV
   - $v_{Te,SOL} \sim 10^6$ m/s for e^- in edge $T_e = 10-50$ eV
   - $v_{Te} \sim 7.26 \times 10^7$ m/s for e^- at max $T_e \sim 30$ keV

Fully dimensional simulation requires 10^{11} phase space cells with 10^8 time steps over full discharge.

Outline

Example of math environment

The action of each operator = convection along characteristics!

$$\begin{aligned} \frac{\partial f_\alpha}{\partial t} + v\frac{\partial f_\alpha}{\partial x} + \frac{q_\alpha E}{m_\alpha}\frac{\partial f}{\partial v} &= 0 \\ \frac{\partial f_\alpha}{\partial t} - \underbrace{\frac{1}{m_\alpha}\{H_T(v), f_\alpha\}}_{=\Lambda_x f_\alpha} - \underbrace{\frac{1}{m_\alpha}\{H_V(x), f_\alpha\}}_{=\Lambda_v f_\alpha} &= 0 \end{aligned}$$

The Vlasov equation is equivalent to

$$\frac{\partial f_\alpha}{\partial t} - \Lambda_x f_\alpha - \Lambda_v f_\alpha = 0$$

And, these operators are used to solve the split problems

$$\frac{\partial f_\alpha}{\partial t} - v\frac{\partial f_\alpha}{\partial x} = 0 \qquad \Rightarrow f_\alpha(\tau, x, v) = e^{\tau\Lambda_x} f_\alpha(0, x, v) = f_\alpha(0, x - v\tau, v)$$

$$\frac{\partial f_\alpha}{\partial t} - \frac{q_\alpha E}{m_\alpha}\frac{\partial f}{\partial v} = 0 \qquad \Rightarrow f_\alpha(\tau, x, v) = e^{\tau\Lambda_v} f_\alpha(0, x, v) = f_\alpha(0, x, v - \frac{q_\alpha E}{m_\alpha}\tau)$$

Outline

Thanks!

Thank you!