Compact Fusion Reactor - CFR

Overview, Status And Development Plan
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CFR – Diamagnetic Sheath Confinement

LaB6 Divertor

T4B Magnetic Field Map

Neutral Beam

Divertor

neutral beam heat

ring cusp losses to stalks

axial cusp losses

sheath losses exit ax

center line

alpha heating from DT fusion plasma

trapped magnetized sheath

diffusion loss to coil

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CFR - Compact Fusion Reactor Concept

Applications

100 MW electric output - 80,000 homes
Compact and elegant, 15.5 m X 6.5 m OD
200-1000 metric tons
Cheap and safe to build and operate
Burns < 20 kg DT fuel/year
Ultimate goal: Achieve reactor conditions

T5 Goal: Show plasma heating and inflation, measure sheaths and losses
- Demo high density plasma source
- Demo neutral beam capture / confinement
- Measure sheath size, cusp losses
- Characterize kinetic and fluid instabilities

T6 High temperature experiment
- Magnetic shielding of stalks
- High field superconducting coil design

T7 DD reactor conditions demonstration
- Full power and size

T8 DT ignited reactor demonstration
- Alpha product confinement / stability

TX reactor development
- Modular, survivable blanket
- Tritium breeding and processing
- Robust subsystems development
- Regulatory regime and deployment
CFR - T4B Heating Experiment

Experiment parameters
- $B_p = 0.1$ T, vacuum plasma edge field
- $B_{\text{ring}} = 0.23$ T, $MR_{\text{ring}} = 1.3$
- $B_{\text{mirror}} = 0.47$, $MR_{\text{mirror}} = 2.6$
- $V = 0.2$ m$^3$
- $E = 1170$ J, plasma energy at high Beta
  - $P_{in} = 500$ kW $\rightarrow \tau > 2.3$ ms
- Source/target predicted parameters:
  - $n = 5 \cdot 10^{19}$ m$^{-3}$, $T_e = 5$ eV, $E = 12$ J, $P \sim 150$ kW $\rightarrow t = 80$ $\mu$s
- Heating predicted parameters:
  - $n = 5 \cdot 10^{19}$ m$^{-3}$, ($T_e = 200$ eV, $T_i = 120$ eV at high Beta)
  - 18 ms energy confinement time
- $P_{\text{heat}} = 500$ kW should be sufficient to get high Beta
  - Over 3 ms, $E_{in} = 1500$ J
  - $t_{\text{fle}} = 13$ $\mu$s @ $T_e = 10$ eV $t_{\text{fle}} = 1.8$ ms @ $T_e = 250$ eV
- $\rho_i = 6.7$ mm @ $T_i = 75$ eV fits well within field geometry
  - 3.7 cm minimum gap between ring cusp null line and wall

Source Parameters
- $P_{\text{LaB6}} = 70$ kW
- $n_e > 2 \cdot 10^{19}$ m$^{-3}$
- $T_e = 4$ eV
- $t = 1$ ms

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Potential accelerator and collaborative efforts

**Fusion Physics Demonstration**
- Modeling and predictive capabilities
- Source development
- Diagnostics
- Neutral beam development
- Internal coil support magnetic shielding

**Fusion Engineering Development**
- High temperature superconducting coils
- Blanket and power plant concept design
- Tritium regulatory planning
- Reactor material development
CFR – The Path to Clean, Unlimited Energy

• CFR concept - efficient & stable magnetic confinement

• Rapid design cycles build toward self-heating system and 100 MW\textsubscript{e} scale power plants in 2020s

• Results to date are promising - stable cold, dense target plasma suitable for neutral beam heating

• Upcoming heating experiments will investigate transition to high beta, sheath mode of confinement

• Modeling, diagnostics, and long lead subsystems are good opportunities for collaboration and parallel development to accelerate progress