Magnetic Confinement Fusion Research in China

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References:
[2] HT-7 team, presented by J.K.Xie, 18th IAEA Inter. Conf. on Plasma Physics and Controlled Nuclear Fusion Research, IAEA-CN-77-OV/4, 2000, Sorrento, Italy
Outline

- Introduce;
- Institutes and existent devices;
- Experiment progresses on the devices;
- New project at present;
- The plan possible proposed in future;
- Summary
Introduce

- Social-economic developed very fast during last 10 to 15 years in China;
- Energy problem will be more serious in near future in China;
- Fusion research is smoothly getting more support;
- The government is interesting ITER program
- Both SWIP and ASIPP would like to promote China participate ITER if it can be built finally
Energy problem in China

• Largest population: around 1.3 billion now and will be 1.5~1.6 billion at 2050;
• Average energy consumption in China is less than 1/2 of world average and 1/10 of developed countries;
• Coal is main energy resources;
• Rapid economic development with annual rate of 6~10% need more and more energy resource;
• China will be faced with the shortage and pollution of energy in near future
Institutes and devices

Two institutes and three groups are working on magnetic fusion research in China:

- Southwest Institute of Physics (SWIP, Chengdu):
  - HL-1M;
  - HL-2A

- Institute of plasma physics, Chinese Academy of Sciences (ASIPP, Hefei)
  - HT-7;
  - HT-6M;
  - HT-7U

- University of Science and Technology of China (USTC, Hefei)
  - KT-5C

- Institute of Physics, Chinese Academy of Sciences, Beijing (IP/CAS, Beijing)
  - CT-6B

- Tsinghua University, Beijing
  - SUNIST
Experiment on HT-7

• LHCD experiments:
  • Full current driven and long pulse discharge;
  • Plasma current ramp up and assistant start up by LHW
  • Confinement improving towards the greenwald density operation;
• Wall conditioning with ICRW instead of glow discharges
  • impurity cleaning and recycling control;
  • New high efficiency Boronizationg and Siliconization
• ICRH and IBW heating;
• Improvement of control systems and material of limiter;

The long pulse discharges with higher performance of plasma have been achieved
Parameters of HT-7

- $R = 1.22\,\text{m}$
- $I_p = 100\sim250\,\text{kA} \quad (220)$
- $B_T = 1\sim2.5\,\text{T} (2.5)$
- $T_i = 0.2\sim0.6\,\text{K eV} (0.8)$
- ICRF: $f = 15\sim45\,\text{MHz}$,
  $P = 0.3\,\text{MW, CW}(0.2, 1.5\,\text{s})$
- LHCD: $f = 2.45\,\text{GHz}$,
  $P = 1.2\,\text{MW, 10s} (0.65\,\text{MW})$
- Pellet injector: up to 8 pellets /per shot
- Supersonic beam injection: $<1.0\,\text{km/s}$
- Pump limiter (Mo head)
HT-7 superconducting tokamak in ASIPP
LHCD Experiments (1)

- Full current drive for > 3 s
- Long pulse discharge sustained by LHCD for > 6 s
Higher performance (I_p = 100 kA, n_e \approx 1 \times 10^{13} \text{ cm}^{-3}, T_e > 1 \text{ keV} \text{ discharges sustained by LHCD for } > 3 \text{ s.}}
The confinement has been improved with very high density which is around the 60~90% Greenwald density limit.

\[ B_T = 1.9T, \ P_{\text{LHCD}} = 300KW, \ N_{||} = 3.0, \ f = 2.45GHz \]
Plasma current ramp-up by LHCD achieved
\[ \Delta I_p = 74\text{kA} \text{ at } P_{LH} = 320\text{kW} \]
ICRF Antenna Configurations on HT-7
ICRF also for Boronization, Siliconization, Isotope control, etc

Leads to:

* Reduced impurity influxes and radiation power
* Improved energy/particle confinement times
* Extended operation limit
The boron film property for the fresh film and the film after 250 shot. The film depth is about 350nm and can last 1500~2000 shots.

The Hugill diagram was extended after ICRF boronization and Siliconization.
IBW Experiment(1)

- Particle confinement improved
- Fluctuation suppressed
IBW Heating(2)

- \( F = 24-30 \text{MHz} \), \( t = 0.2-1.5 \text{s} \),
- \( P = 40-150 \text{kW} \),
- Te heating, \( -100-500 \text{eV} \),
- Ti heating \( 100-300 \text{eV} \),
- Ne increased and Ne(r) peaked,
- Wj increased. \( \tau_E, \tau_p \) increased,
- ITB was observed

ITB were clearly shown at the \( r/a = 0.6 \). The \( \Omega_H \) was observed at \( r/a = 0.27 \).
First wall material tests

- The special graph has been developed in CAS;
- Significant improvement of discharge as well as the improvement of performance of plasma has been achieved with the graph limit on HT-7;
- The experiment give the confident that graph can be used as the first wall material for HT-7U at first stage.