INTEGRATED ASSESSMENT OF HIGH-PERFORMANCE SCENARIOS FOR HL-2M
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ABSTRACT
HL-2M is the new tokamak of SWIP, generating the first plasma in 2020. It is dedicated to support the critical physics and engineering issues of ITER and future fusion reactors. As one of the major missions of the machine, exploring key physics for the high-performance plasma is emphasized. This paper will firstly introduce the assessment of high-performance scenarios analyzed by Integrated Modeling. Simulation results show that the high-performance operation can be realized at plasma current as high as 2.5 mega-ampere. In such regime, the normalized beta can reach 3, the triple-product can reach about 10\(^2\). In a moderate Greenwald density fraction, the central ion temperature can reach 10keV. This enables HL-2M to own the capability to carry out ITER relevant plasma physics. In support of ITER pre-fusion phase operation (Hybrid and Steady State), the advanced scenarios, such as the hybrid and the steady state regimes can be achieved. For the non-inductive regime, the normalized beta can reach 3.4, and the confinement enhancement factor can exceed 1.3.

INTRODUCTION
☐ HL-2M is able to address the following key physics and technology issues:
  - Tests and qualification of various advanced divertor concepts, such as Snow Flake (SF) and Tripod, on both physics and technological aspects;
  - Tests and validation of high heat flux plasma-facing components;
  - Investigation of advanced plasma physics with high performance, and design of scenarios compatible with advanced divertor configurations.
  - Three Heating & Current Drive (H/CD) systems with maximum power of 27MW, including 15MW NBI, 8MW ECRF and 4MW LHW, support high-performance operation.

CAPABILITY ASSESSMENT OF DN CONFIGURATION
The operation capabilities (such as the inductive, hybrid and full non-inductive regimes), based on the double-null (DN) configuration with elongation of 1.8, is assessed by METIS. During the simulation, the engineering limits, of the auxiliary heating duration and of the heating loads in the coils, are assumed to be free. Thus, performing H-mode plasmas at these conditions is limited by the available poloidal flux of 14Wb.

☐ Conventional inductive regime (\(I_p=2.5MA, B_t=2.2T\))
  - High performance operation with \(\beta_n \sim 3\) (\(P_{\text{load}} \sim 25MW(27MW)\))
  - \(n(\theta)/\theta\) can reach 10\(^9\) m\(^3\)s\(^-1\)keV level
  - Central plasma temperature can reach around 10keV with \(f_{\chi}=0.5\)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional Inductive</th>
<th>(I_p=2.5MA, B_t=2.2T)</th>
</tr>
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<tbody>
<tr>
<td>(I_p/I_B)</td>
<td>2.5/2.2</td>
<td>2.5/2.2</td>
</tr>
<tr>
<td>(\alpha/\beta)</td>
<td>1.8/0.5</td>
<td>1.8/0.5</td>
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<tr>
<td>(n(\theta)/\theta)</td>
<td>0.6/1.78</td>
<td>0.6/1.78</td>
</tr>
<tr>
<td>(f_{\chi})</td>
<td>0.6</td>
<td>0.6</td>
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<tr>
<td>(P_{\text{load}})</td>
<td>0.6/0.5</td>
<td>0.6/0.5</td>
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<td>0.6</td>
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PRELIMINARY ANALYSIS OF SN PLASMA PERFORMANCE
The performance of the standard single-null plasma with elongation of 1.5 and triangularity of 0.43 is further analyzed by the integrated modelling suite—CRONOS with QLKz transport model.

☐ Conventional inductive regime (\(I_p=1.8MA, B_t=2.2T\) with \(f_{\chi}=0.69\))
  - \(H/CD: 15MW NBI+8MW ECRF\)
  - \(q_{95} \sim 3.0\).
  - The thermal energy of the plasma \(W_{\text{th}}\) reaches 2.0MJ with the high \(\beta_n\) of 3.0
  - Both the ion and the electron temperature of the center can reach around 5keV

☐ Hybrid regime (\(I_p=1.4MA, B_t=2.2T\) with \(f_{\chi}=0.5\))
  - \(H/CD: 8MW NBI+8MW ECCD\)
  - \(q_{95} \sim 3.9\).
  - \(f_{\chi} \sim 0.6\).
  - \(H_{B_{\text{lim}}} \sim 1.3\).
  - The ion and the electron temperature of the center can reach 6.4keV and 8.5keV respectively.
  - The thermal energy of the plasma reaches 1.4MJ with \(\beta_n\) of 3.1

SUMMARY
☐ HL-2M operation capability with DN plasma is assessed by METIS
☐ Performance of SN plasma is preliminary analyzed by CRONOS with QLKz transport model.
☐ Results indicate that HL-2M is a high-performance plasma research platform for the next-step fusion devices. It has the capability to carry out ITER relevant plasma physics, supporting ITER pre-fusion phase operation.

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