§6. Simulation Study on Optimization of LHD Magnetic Field by Vertical Magnetic Field Configuration

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i) Optimization of magnetic surface controlling the leakage magnetic field strength

Volume of the last closed flux surface $V_{\rm lcfs}$ is an important index of a magnetic configuration for plasma confinement performance. A computer code is constructed to search the optimized vertical magnetic field configuration controlling the intensity of the far filed of the LHD magnetic system. Fig. 1 shows an example of the numerical results.

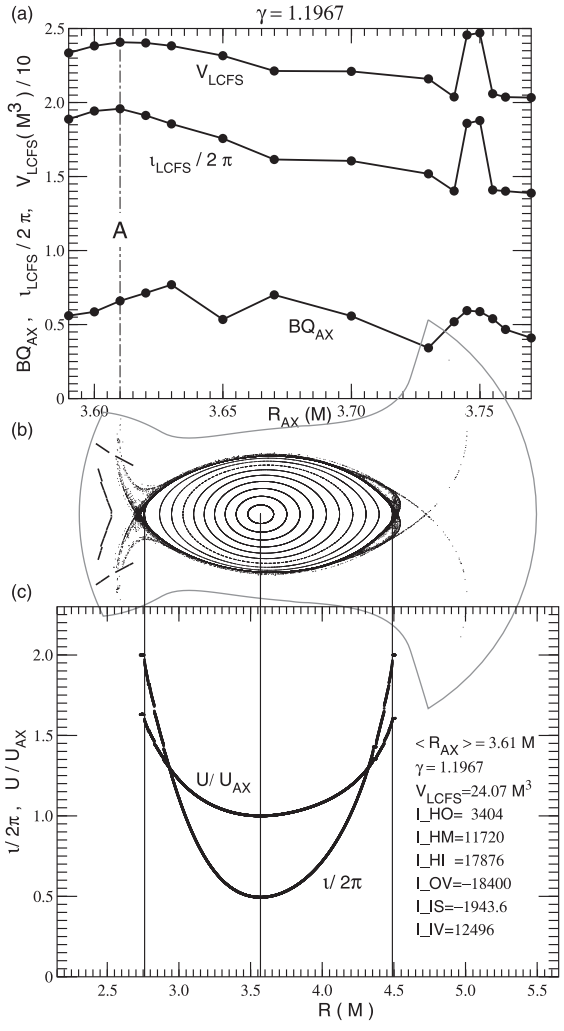

Fig. 1: (a) Relation of the magnetic axis position $R_{\rm ax}$ and the $V_{\rm lcfs}$. The rotational transform of the last closed magnetic surface $\iota_{\rm lcfs}/2\pi$ and the index of the quadratic field component $Q_{\rm ax}$ are also shown. An optimized magnetic surface specified by "A" is shown in (b: Poincaré plots) and (c: distributions of $\iota/2\pi$ and the specific volume U).

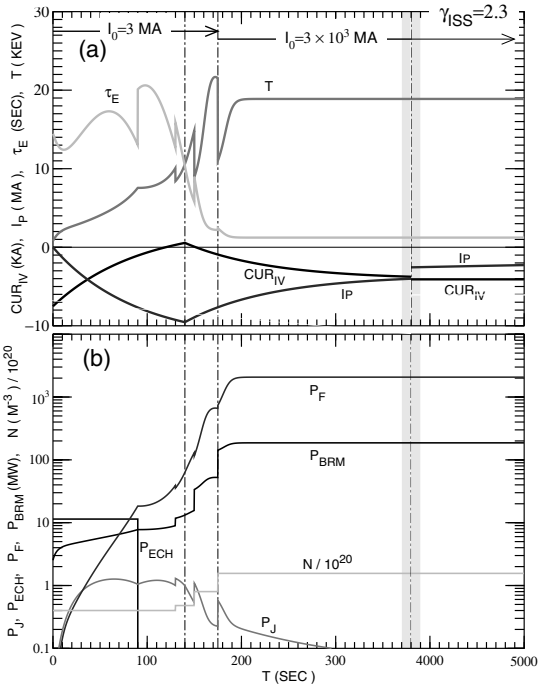

Fig. 2: Current-driven and current-less hybrid operational scenario for an LHD-type helical reactor.

ii) Current drive and DT fusion ignition of LHD-type helical reactor by Joule heating associated with magnetic axis shift[1)]

A new concept to achieve current drive with magnetic axis shift, which is caused by vertical magnetic field coil current change in LHD-type magnetic configuration, is proposed. It is confirmed numerically that an LHD-type helical fusion reactor can be ignited by high-current Joule heating. MHD stability of the plasma current in a helical system is analyzed theoretically. Large plasma current that flows in the opposite direction of the helical coil current is MHD stable. Currents with a hollow current profile are more stable than those with a flat-top profile. The central peak current profile will be redistributed to the hollow current profile.

iii) Current-driven and current-less hybrid operational scenario of an LHD-type helical reactor[1)]

In addition to Joule heating, the plasma current also improves the plasma confinement performance as shown in the IPB98y2 scaling. This leads to a possibility of "current-driven and current-less" hybrid operational scenario for an LHD-type helical reactor. Fusion ignition of a low-density current carrying plasma is relatively easy because of a high confinement performance. Strong alpha heating after the ignition enables the transfer to a steady-state burning of high-density plasma in current-less mode. To confirm the "current-driven and current-less" hybrid operational scenario for an LHD-type helical reactor, we have studied numerically. A numerical result is shown in Fig. 2.

1) Watanbe, T., Plasma Fusion Res. Special issues (2011) to be appear.