Preliminary Analysis of HL-2A Global Energy Confinement*

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Abstract  Energy confinement time taken from 135 discharges of the 2006 campaign in HL-2A is studied. The data obtained from the measurements are verified by comparing diamagnetic energy with the electronic kinetic energy calculated from both the electron temperature and density profiles. Two data sets for supporting the ITER L-Mode confinement database are generated from the 2006 campaign. The dependence of \( \tau_E \) on the line-averaged electron density during ohmic phases is analysed. The comparison of \( \tau_E \) in electron cyclotron resonance heating (ECRH) plasma as well as the existing ITER L-mode scalings is made. The results show that the energy confinement time is consistent with the ITER L-mode scalings.

Keywords: energy confinement time, diamagnetic flux, electron density, scaling

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1 Introduction

Energy confinement study is an important issue for fusion research. The global energy confinement time \( \tau_E \) is one of the most direct and routine data for tokamak experiments. It also directly reflects the capability of plasma confinement. \( \tau_E \) is defined as the ratio of the plasma’s total stored energy to the power absorbed by the plasma. To understand the energy transport, the dependence of \( \tau_E \) on some parameters, namely, line-averaged electron density, plasma current, toroidal magnetic field, and input power, has to be studied. The dependence of \( \tau_E \) on these discharge parameters gives rise the empirical energy confinement scaling. The study of the empirical energy confinement scaling not only serves as a benchmark of tokamak operation, but also helps in optimizing the confinement of plasmas and predicting the performance of the proposed tokamak devices [1].

In order to predict the performance of the next generation tokamak, like ITER, a world-wide confinement database has been built up. The ITER confinement database consists of six parts which are assembled for different purposes [2]. To understand the characteristics of energy confinement on HL-2A and make contributions to the ITER database [3], it is necessary to build our own confinement database. Furthermore, it can predict the performance of our next generation tokamak. The data presented in this paper are as submitted to the ITER L-mode confinement database.

In a plasma experiment, there are several ways to obtain \( \tau_E \). On HL-2A, basically we obtain \( \tau_E \) and plasma energy by measuring the diamagnetic flux. This provides the time evolution of plasma stored energy while the profiles of \( T_e, T_i, n_e, n_i \) are not needed [4]. The purpose of this paper is to present the features of plasma energy confinement and have an empirical understanding of the parametric dependence of \( \tau_E \) upon discharge parameters. In section 2, the plasma operation conditions and diagnostics applied are described. In section 3, the reliability of the diamagnetic measurement is demonstrated by a comparison between diamagnetic energy and electronic kinetic energy. In section 4, the preliminary analysis results of HL-2A plasma energy confinement time are given.

2 Experimental setup and diagnostics

HL-2A is a divertor tokamak with a major radius of \( R = 1.65 \) m and a minor radius of \( a = 0.4 \) m. The experimental data presented here are obtained with configurations of lower single null divertor and limiter discharge. The cross-section of plasmas on HL-2A is almost circular. The operational parameters are as follows, the plasma current \( I_p = 100 \sim 350 \) kA, toroidal field \( B_T = 1.4 \sim 2.5 \) T, line average electron density \( n_e = 0.5 \sim 7.0 \times 10^{19} \text{ m}^{-3} \) and ECRH power \( P_{ECRH} = 0 \sim 1.5 \) MW. Hydrogen and deuterium are employed as the working gas in the experiment. In Ohmic discharges, the working gas can be hydrogen or deuterium, but in ECRH discharges, the working gas consists mainly of deuterium with remaining hydrogen as a minority. The energy confinement time taken from 135 discharges is used for the statistical analysis, among which there are 53 Ohmic shots and 82 ECRH shots, respectively. In each shot one time slice is selected to ac-

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